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Climatic change and Human-marine interactions in the uttermost tip of South America in late Holocene

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Abstract

Palaeoclimatic records from southern tip of South America during the Last Holocene, indicate important climate intervals, such as the Medieval Climate Anomaly and Little Ice Age, which offered new scenarios to hunter-gatherer groups who inhabited the region. The aim of this paper is to explore the social practices carried out by hunter-fisher-gatherer societies of the southern part of the Atlantic Coast of Tierra del Fuego island (53-55°S, 66-74°W) in order to deal with these environmental changes. From our perspective, foragers have played an active role in designing strategies to cope with environmental fluctuations. Consequently, we argue that in a context of ecological uncertainty, these societies would have developed flexible strategies in terms of subsistence, technology and settlement patterns. In order to test this proposal, zooarchaeological and technological analysis of different archaeological assemblages dated between the 1300 to 220 BP were undertaken.

The results show that these hunter-fisher-gatherer societies exploited a broad range of faunal resources using a versatile technology which encompassed tools with low production values and high use values. Likewise, the analysis of landscape organization revealed a settlement strategy centered on the most productive habitats, which were preferentially reoccupied.

We suggest that these strategies, supported by cumulative knowledge and material conditions, could have enhanced social resilience and sustainability.

Keywords: Climate change, Hunter-Fisher-Gatherer societies, Tierra del Fuego, Late Holocene, Flexible strategies,

1. Introduction

This work addresses human-environment interactions on the southern part of the Atlantic Coast of Isla Grande de Tierra del Fuego (IGTF) during Late Holocene. IGTF (between 53-55°S and 66-74°W) lies in the Subantarctic zone and constitutes the highest latitude landmass in the Southern Hemisphere populated by hunter-gatherer groups during the Early Holocene. The marine landscape includes 3200 km of coastlines (Bujalesky et al., 2014) and encompasses a variety of ecological and geomorphological settings shaped by the combined effect of tectonic activity, glaciers and climatic processes (Rabassa et al., 2000). Marine ecosystems display a high biodiversity and primary productivity associated with the upwelling of Malvinas current and kelp forests of *Macrocystis pyrifera* [Agardh 1820] (Miloslavich et al., 2011). Intertidal zones are more diverse than those found in northern latitudes of the Atlantic shoreline, due to high prey availability of the marine front (Acha et al., 2004). In contrast, terrestrial faunal resources exhibit a scarce diversity.

Archaeological research until now has shown diverse historical trajectories along IGTF shorelines in relation to both fishing activities and the intensity of the use of coastal landscapes and resources by human groups (Borrero, 1986; 2011; Lanata, 1995; Borrero and Barberena, 2004; Morello et al., 2009; Zangrando et al., 2009; Orquera et al., 2011; San Román et al., 2016; Bas and Lacrouts, 2017). Current reconstructions reveal that the process of human colonization of IGTF included several migrations of terrestrial and aquatic hunter-gatherer societies who arrived to the island at different times (Orquera et al., 2011; Morello et al., 2012). The arrival of hunter-fisher-gatherer societies (HFG), with nautical technology, and specialized in marine resources exploitation took place around 6000 BP. They would have approached IGTF from the Continental Pacific Coast channels and established themselves on the south of this large island up to the Cape Horn (Orquera et al., 2011).

In the case of the Atlantic littoral, the first evidence of marine resource consumption date to about 5500 BP as revealed by two sites on the northern region: Cerro Bandurrias and La Arcillosa (Favier Dubois and Borrero, 2005; Salemme et al., 2014). During the Late Holocene, the subsistence of these hunter-gatherers groups appears to be based on guanaco hunting with minor contributions by coastal resources (Borrero, 1986; Morello et al., 2012; Salemme et al., 2014).

Conversely, in our case study (around 54º lat. onwards) current evidence points out the presence of HFG who exploited marine resources without seafaring technology. Previous dietary reconstructions based on faunal assemblage composition (Savanti, 1994; Lanata, 1995; Muñoz, 2005; Muñoz and Belardi, 2011; Bas and Lacrouts, 2017) and stable isotope analysis on human bones (Yesner et al., 1991; 2003; Barberena, 2004) indicate that their subsistence relied mainly on sea mammals, sea birds, mollusks and fish, although the frequencies of guanaco remains are important. Their technology includes lithic and bone artifacts made on local raw materials, and manufacturing activities were carried on the sites (Pal et al., 2016). The analysis of the relationship between archaeological sites and geomorphological features (see details in Negre et al., 2018) suggest that HGF preferentially selected their settlement areas at forest cover locations near the coasts, between 20-50 m.a.s.l. Over the coastal landforms range, most sites tend to occur next to closed bays. The analysis of cost-based distances allow us to establish that sites are located at a maximum radius of approximately 1500 m of distance in a straight line from these landforms, implying 20 minutes-walking at a speed of 5 km/h.

The earliest evidence of human occupation in the study area is dated around the 1500 BP in the Late Holocene and extents until the arrival of Europeans to Tierra del Fuego. During this time-frame several important climate fluctuations and landscape changes were identified, such as Medieval Climate Anomaly (MCA), Little Ice Age (LIA) and fluctuations in the forest distribution (i.e. Heusser, 1995; Mauquoy et al., 2004; Koch and Kilian, 2005; Borromei et al., 2010; Waldmann et al., 2010; Kilian and Lamy, 2012). This scenario presents an outstanding framework to assess human-environment interactions as well as to disentangle the social practices developed by hunter-gatherer societies in order to solve potential problems related to changes in resources distribution.

The general aim is to identify the economic pathways developed by hunter-fisher-gatherer societies (HFG) in order to deal with these minor Holocene climatic fluctuations. Hence, we study different Late Holocene archaeological samples retrieved from several shell middens that were occupied during the MCA and LIA events. We will focus on subsistence and technological strategies elaborated by those societies during both periods to investigate these economic pathways in greater detail than that afforded until recently. These analyses will be integrated with results of the research on landscape organization that has been presented elsewhere (Negre et al., 2018). We propose as hypothesis that the development of flexible strategies would have enhanced hunter-gatherer society resilience increasing the potential to deal with environmental changes.

2. Theoretical framework and archaeological expectations

The analysis of hunter-gatherer responses to environmental fluctuations has been a central issue in archaeological research, prompting fruitful discussions and adding weight to theoretical and methodological considerations. Mobility and technological innovations have been traditionally considered, by a great amount of researchers, as key variables to understand strategies that hunter-gatherer employed in dealing with ecological variability. From the onset of New Archaeology onwards, a wide variety models have been focused on the role played by both practices in coping with resource stress. One of the most influential approach, within this line of research, was developed by L. Binford (Binford, 1980) who linked the spatial and temporal variations in resource structure with seasonal or short-term hunter-gatherer mobility. Similarly but based on assumptions of optimal foraging theory, several authors also have argued that technology offered and effective way to reduce risk, caused by limited availability of resources, by increasing the effectiveness of food-getting (amog others,Torrence, 1989; Bamforth and Bleed, 1997). According to this framework, tool assemblage composition as well as technological diversity and complexity are responses to variations of short-term risk (Torrence, 1989). Although, both approaches raised interesting ideas about human-environment interactions, their use in the archaeological research have often led to a typological characterization or an oversimplification of the variables embedded in technological decisions, providing reductionist explanations.

Current approaches, in contrast, emphasize that the underpinnings in the study of human ecosystems interactions are far from straightforward or simplistic. Recent research has acknowledged that hunter-gatherer responses to environmental changes were diverse and not necessarily implied their collapse, the emergence of a novel economic system (e.g. plant and animal domestication), migrations or radical technological changes (Fitzhugh, 2012; Roberts et al., 2017). Learnt experience, long-term memory, interaction and/or changes in cooperation strategies, among others, were also relevant resources for social sustainability in a context of ecological vulnerability (Whallon, 2006; Rosen and Rivera-Collazo, 2012; Pereda et al., 2017).

From our perspective, human agency has played an active role in the design of strategies in order to cope with climatic fluctuations (Dobres and Robb, 2000). Environmental variables constrain human behavior but they are not its cause (Ingold, 1981); accordingly, the ability of a system to absorb disturbance and continue to exist largely relies on the actions of agents (Sauer, 2015).

Human creativity, accumulation of knowledge and previous material conditions have a paramount importance for system resilience in a context of resource uncertainty. Material conditions include the ecological setting (resource distribution and productivity) as wells as the technological devices available for a human group in a particular time-frame. Knowledge transmission is the process by which information is passed from individual to individual via learning mechanisms (Mesoudi, 2013). According to different ethnographic studies, vertical or parent-to-child transmission is the most frequent mechanism between hunter-gatherer populations (Shennan, 2000; Hewlett et al., 2011)

On this case study, the material conditions of the south-eastern coast of Tierra del Fuego has been characterized by a high biodiversity, offering HG population different options that includes large and small prey populations with overlapping habitats near the shorelines.

It is reasonable to assume that HFG societies who inhabited this region would have had a well-developed knowledge of these resources as well as the techniques to procure them since that fishing activities date back to the Middle Holocene in IGTDF. Likewise climatic changes have occurred during the entire Holocene. Consequently, the technological knowledge coupled with the information of resource fluctuation should have been stored in the collective long-term memory of the group, shaping their decisions about subsistence and technological strategies. In this sense, several authors have pointed out that environmental uncertainty enhance more conservative strategies that were already tried and tested (Rosen and Rivera-Collazo, 2012; Roberts et al., 2017).

Following these expectations, we hypothesize that, human populations who inhabited the south-eastern coast of Tierra del Fuego would have developed flexible strategies (Briz et al., 2009) to cope with environmental fluctuations; these strategies included: a) diverse subsistence options which involved the procurement of marine and terrestrial resources; b) a versatile technology (Nelson, 1991) which encompasses tools with low production values and high use values (Alvarez, 2003).

3. Geographical settings and paleoenvironmental changes during Late Holocene

The southern portion of the Atlantic façade is characterized by different environments that include a forest-steppe ecotone and the Subantarctic Deciduous Forest, represented by two species of southern beech: *Nothofagus pumilio* [Krasser 1896] and *Nothofagus antarctica* [Orest 1871] (Musotto et al., 2016a).

The climate is temperate cold, dominated by the influx of humid air masses brought in from the Pacific Ocean by the prevailing South Hemisphere Westerly Winds (SWW): mean annual temperature is 5.4 C with small changes between summer and winter temperatures, especially along the coast (Tuhkanen, 1992).

The coast line undergoes a macrotidal range with semidiurnal regime (Bujalesky, 2007): the mean tidal range is of 4.6 m at Cabo San Pablo (around 40 km far from the study area). Therefore, the intertidal zone is extensive and plenty of resources such as shellfish, seaweed and fishes are easily accessible in tide pools during low tides. Strandings of marine mammal are also frequent (Fig. 1).

In the Late Holocene (post 3000 BP), several important climate events and environmental transformations have been identified according to different proxy data. Pollen records, collected from different peat bogs next to the study area, show changes in the distribution of vegetal palaeo-vegetation in this region. For instance, as a consequence of a drying trend around 2400 BP, the landscape shifted to an open ecosystem formed by Nothofagus forests and associated with the expansion of mesic grassland (Heusser, 1995; Musotto et al., 2016a; 2016b). These fluctuations correlated with the weakening of SWW and were replicated during the MCA. This later event was recognized in different locations around IGTF between 1000 and 500 cal years, involving dryer and a warmer climatological conditions (Waldmann et al., 2010).

After ca. 400 cal years, the palaeoenvironmental records show that Nothofagus forests expanded again, in association with an increase in rain fall and colder conditions. These changes were also related to the latitudinal position and strength of the SWW as well as Neoglacial Advances such us the LIA (Heusser, 1995; Musotto et al., 2016a).

The effects of these Holocene climate events on marine productivity are scarcely known in the region. Studies carried out on the central basin of the Strait of Magellan, based on the quantification of several proxies from sediment cores, indicate that productivity reached the highest values during the Late Holocene, although an abrupt reduction was detected between 3000 and 2200 BP related to an intense period of freshwater supply (Aracena et al., 2015). Thereafter, productivity showed a fast recover.

Conversely, in the Beagle Channel region, the analysis of $d^{15}N$ values from shells from archaeological shell middens, have shown that coastal primary productivity during the Late Holocene decreased in comparison with Middle Holocene, exhibiting actually a rising trend during LIA (Saporiti et al., 2014). According to these stable isotopes analysis, sea surface temperature (SST) also increased during the Late Holocene, except for the LIA period (Saporiti et al., 2013). Different topographic and environmental conditions could explain the disparities between both of these areas.

The information presented here clearly indicates that Late Holocene palaeoenvironmental changes around the IGTF were complex and differed at a temporal and geographical scale. The lack of complete records in the region and the differences in the data obtained in adjacent areas hamper an accurate assessment of the intensity of such climatic changes and their impact on ecological and social dynamics. Notwithstanding, what is clear from the above review, is that several climatic and environmental fluctuations occurred along the Atlantic coast of IGTF and adjacent areas during Late Holocene, thus providing probably new affordances (Costall, 1997) to hunter-fisher-gatherer societies. In the next sections, we explore these strategies in the archaeological record.

4. Materials and methods

The archaeological research in the study area were concentrated on the ’80 up to the middle of the `90 (Lanata, 1995; 1996a; 1996b) and then they were not continued until recently when two lines of archaeological inquiry were undertaken addressed to heritage survey (Vázquez et al., 2017), and to explore changes in technological, subsistence and spatial patterns in HGF societies (Pal et al., 2016). In the historical period (from XIX century), this region was proposed as a contact area between hunter-gatherer groups identified by Ethnography as *Selk'nam* and *Haush*; however, according to those ethnographic sources, their social boundaries remains unclear (Furlong, 1917; Lanata, 1996a).

For the purposes of this paper we focus on the data retrieved by the authors from Teis X (TEX), Teis XI (TEXI) and Okon XXI (OKXXI) archaeological sites as well as on the work by J. Lanata and his group on ML5, ML7, MLA3 and MLB5 sites (Savanti, 1994; Lanata, 1995; 1996a; Muñoz, 2005; Muñoz and Belardi, 2011) (Fig.2). All of these sites consist of shell bearing deposits displaying distinct sizes, extensions and distributions (Table 1). We distinguish: a) dome shell middens that encompass variable accumulations of waste that form a raised mound; b) flat shell middens which exhibit a plane topography, and c) shell midden lenses which consist of thin layers of broken shells. These sites were dated to the Late Holocene and were located in different microenvironmental settings around 54°29'17.13"S - 66°26'5.37"W (Table 1). According to radiocarbon determinations, the occupation of OKXX, MLB5, MLA3 and ML7 occurred during the MCA while TEXI, ML5 and TEX span nearly the LIA event.

Table 1
Archaeological samples analyzed in this paper: ^{14}C dates, site types and current environmental conditions

Site	Uncal. ^{14}C date	Cal. ^{14}C date* BP	Lab code	Site type	Environment
OKXXI	1344±38	1226	AA106347	Shell midden lens	Open grassland
MLB5	1110+60	974	LP 254	Flat shell midden	Open grassland
MLA3	1020±80	871	Teledyne 13994	Flat shell midden	Open grassland
ML7	690±50	609	LP 194	Flat shell midden	Forest
TEXI	374±29	442	AA106348	Shell midden dome	Forest
ML5	360±50	407	LP 223	Shell midden dome	Forest
Teis X	222±23	194	D-AMS 024549	Flat shell midden	Forest

* For radiocarbon date calibration Calib program were used (Stuiver et al., 1986-2016; Stuiver and Reimer, 1993), taking into account South Hemisphere Calibration Curve (Hogg et al., 2013).

With the aim to test our hypothetical scenarios, we integrate different analytical lines, such as zooarchaeological and technological studies. In terms of zooarchaeological analysis procedures, these consisted of the identification of remains to the lowest possible taxon by comparison with available reference collections. However, when a species could not be determined, the bone specimen was placed in size class category. The abundances of the taxa were quantified using the abundance index (AI), the number of identified specimens (NISP) and the minimum number of individuals (MNI) (Grayson, 1984; Lyman, 1994; 2003; 2008).Taxonomy of marine invertebrates were carried out on the basis of sediments samples of 4 dm^3 collected in every layer (Orquera and Piana, 2000). The MNI of bivalves was calculated dividing total number of shells with umbo by two given their poor preservation and difficulty in determining left from right valves. In the case of limpets, MNIs were determined through counting the number of apices. The faunal data of ML5, ML7, MLA3 and MLB5 sites were derived from published papers and manuscripts (Savanti, 1994; Lanata, 1995; Muñoz, 2005; Muñoz and Belardi, 2011).

The technological studies involved morpho-technical and use-wear analysis of lithic and bone assemblages. The first was addressed in order to understand the sequence of production steps that lead to the manufacture of tools, and taking into account a materialistic classification framework (Briz, 2004; Hiscock, 2007; Scheinsohn, 2010; Alvarez and Briz-Godino, 2017). Use-wear analyses involved the microscopic observation of use and technical traces as well as the post depositional alterations on tool surfaces (among others, Keeley, 1980; Alvarez, 2003). In order to do so, we employed a stereomicroscope (Numak Ltz-3 with a range of magnifications between 6x to 60x) and an incident light microscope (Olympus BHSM with a range of magnification of 50X to 500X). All technological assemblages were analyzed by the authors.

5. Subsistence strategies and technological practices

5.1 Subsistence strategies

Hunter-fisher-gatherer societies under study consumed a variety of species including marine and terrestrial mammals, seabirds, pelagic and benthopelagic fishes as well as mollusks. The frequencies of faunal remains exhibit remarkable variations among sites, probably due to differences in occupation intensity (Negre et al., 2016)

Excluding mollusks, a quantified assessment of zooarchaeological assemblages using the abundance index (Lyman, 2003) of all broad categories, show a heterogeneous distribution between sites without a temporal trend (Fig. 3). For example, guanaco (*Lama guanicoe* [Müller 1776]) specimens, a large terrestrial camelid widely distributed in Patagonia (González et al., 2006), predominate in OKXXI and TEX; seabirds are preeminent in MLB5, MLA3, ML7 and ML5 and fish in TEXI site. The evenness indices (Table 2) support this observation as most sites exhibit intermediate values. However, the richness measures indicate slight differences between sites, implying that diet diversity was stable. The linear regression carried out to explore the relationship between sample sizes and both indices indicate a negative covariation in the case of evenness (r= -0,68; r^2=46,06%) but a moderate strong correlation according to richness values (r=0,6; r^2=36,12%).

Table 2

Shannon-Weaver and evenness indexes of the faunal assemblages

	OKXXI	MLB5	MLA3	ML7	TXI	ML5	TEX
Shannon- Weaver Index	1,074	1,109	1,18	1,115	1,162	1,356	1,088
Evenness	0,732	0,758	0,542	0,610	0,533	0,647	0,594

Marine mammals consist mainly of two species of pinnipeds, namely *Arctocephalus australis* [Zimmermann 1783] and *Otaria flavescens* [Shaw 1800], both of which identified in all sampled shell middens (Table 3). Both species are available year-round in this region and they live together in rookeries along the coasts, particularly during the breeding season from October to December. According to their considerable size and frequency in excavated samples, pinnipeds would have provided most of the calories and proteins consumed by coastal groups. MNI values show ranges from 1 to 5 individuals per site. In contrast, cetacean remains are scarce in these assemblages, except for TEXI shell midden. The lack of a hunting technology to capture these animals explains their low frequency. Ethnographic evidence from the XIX and XX centuries indicate that these societies exploited cetaceans that stranded onshore which provided food (meat and blubber) as well as raw materials to make tools (Gusinde, 1982).

A variety of resident and migratory seabirds were also exploited (Table 3). The most predominant species are *Phalacrocorax* sp. [Brisson 1760] (cormorants) and *Chloephaga* sp. [Eyton 1838] (gooses), which were identified in all sequences. Colonies of different species of cormorants are accessible year-round on the Atlantic coast of Patagonia, including IGTF (Frere et al., 2005). In lower frequencies, penguins (*Spheniscus magellanicus* [Forster 1781]), kelp gulls (*Larus dominicanus* [Lichtenstein 1823]), petrels (*Macronectes giganteus* [Gmelin 1789]), Magellanic steamer ducks (*Tachyeres* sp. [Owen 1875]) and albatross (*Diomedea* sp. [Linnaeus 1758]) are also recorded, and showing a discontinuous distributions between sites. It is interesting to remark that the relative importance of *Phalacrocorax* sp. seems to diminish over time together with an increase of seabirds diversity. Terrestrial birds are represented in lower frequencies, and most of them were recovered from TEX. Cocoi herons (*Ardea cocoi* [Linnaeus 1776]), great horned owls (*Bubo virginianus* [Gmelin 1788] and variable hawks (*Geranoaetus polysoma* [Quoy and Gaimard 1824]) were identified.

Another coastal resource that was extremely important in hunter-fisher-gatherer subsistence was shellfish. Two major families of gastropods and bivalves were identified in the studied assemblages with different quantitative representation. Specimens of *Nacellidae* family [Thiele 1891] account for more than the 90% of the samples, and followed by *Mytilidae* [Rafinesque 1815]. Although their caloric contribution is low, shellfish exhibit high frequencies in some of the settlements. In Teis XI, density values for *Nacella* sp. is 48,8 NISP/dm^3 and the MNI are 3149, while in Teis X, there are 42,8 NISP/ dm^3 and the MNI is 668. In contrast, the density of *Mytilus edulis chilensis* is 0,62 NISP/dm^3 in Teis XI with MNI value of 1. Limpet shell sizes are summarized in Table 4, exhibiting a similar pattern of variation in TEXI and TEX.

Fish bone remains show a noticeable uneven distribution between sites (Fig. 2). Nearly all sites show low abundance indices, ranging broadly between 0,01 and 0,60. The only two the exceptions are ML7 and TEXI which exhibit values, respectively, between 0,19 and 0,60 and without any discernible diachronic trend. Although we have only detailed data from 3 sites of the studied samples, it is interesting to note the dominance of *Austrolycus* sp. species [Regan 1913]. Based on the bones recovered from TEXI, bird size estimates suggest specimens larger than 60 cm (Bas and Lacrouts 2017). The taxonomic list is completed with *Thyrsites atun* [Euphrasen 1791], *Patagonotothen* sp. [Balushkin 1976], *Paranotothenia magellanica* [Forster 1801], *Eleginops* *maclovinus* [Cuvier 1830], *Macruronus magellanicus* [Lönnberg 1907], *Merluccius* sp. [Rafinesque 1810], *Genypterus sp*. [Philippi 1857] and Nototheniidae [Günther 1861].

Terrestrial fauna is broadly dominated by guanaco. According to their NISP and MNI values, guanacos played a significant role in the diet of the studied hunter-gatherers throughout the excavated sequences. Together with pinnipeds, guanacos provided the vast majority of meat consumed: an individual of *A. australis* of 53 kg average offers 64000 kcal, while an individual of *L. guanicoe*, of 77kg average, yields 78315 kcal (Zangrando, 2007). The linear regression analysis between the NISP of this specie and pinnipeds show a strong correlation between them (r=0,9; r^2=64%) highlighting a similar diet contribution.

Finally, rodents remains are very scarce in the studied samples; the abundance indexes (AI= <0,01) suggest a probable natural intrusion.

Table 3

Taxonomic identification of faunal assemblages

	OKXXI		**MLB5**		**MLA3**		**ML7**		**TEXI**		**ML5**		**TEX**	
Taxonomy	**NISP**	**MNI**	**NISP**	**MNI**	**NISP**	**MNI**	**NISP**	**MNI**	**NISP**	**MNI**	**NISP**	**MNI**	**NISP**	**MNI**
Mammals														
Otariidae	30	1	56	2	524	5	53	2	59	1	274	3	25	3
Cetacea	-	-	-	-	2	na	-	-	33	1	1	-	-	-
Lama guanicoe	64	1	124	2	839	7	47	1	299	3	305	5	70	2
Rodentia	-	-	-	-	-	-	-	-	21	1	-	-	1	1
Birds														
Phalacrocorax sp.	2	1	14	4	100	6	75	7	38	3	37	3	7	1
Chloephaga sp.	-	-	-	-	9	2	55	4	12	2	8	2	9	1
Tachyeres sp.	-	-	-	-	11	4	-	-	5	2	-	-	-	-
Larus dominicanus	-	-	-	-	-	-	-	-	4	2	7	3	1	1
Spheniscus sp.	-	-	2	2	-	-	-	-	4	1	-	-	-	-
Macronectes giganteus	-	-	-	-	-	-	-	-	2	1	-	-	-	-
Diomedea sp.	-	-	-	-	-	-	-	-	-	-	3	1	-	-
Geranoaetus polysoma	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Ardea cocoi	-	-	-	-	2	1	-	-	-	-	-	-	2	1
Bubo virginianus	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Fish														
Austrolycus sp.	1	-	-	-	28	4	35	4	305	21	47	5	1	1
Thyrsites atun	-	-	-	-	-	-	-	-	24	5	-	-	-	-
Patagonotothen sp.	-	-	-	-	-	-	-	-	6	1	-	-	-	-
Paranotothenia magellanica	-	-	-	-	-	-	-	-	4	1	-	-	-	-
Eleginops maclovinus	-	-	-	-	1	1	-	-	2	1	-	-	-	-
Macruronus magellanicus	-	-	-	-	-	-	18	1	2	1	2	1	-	-

Merluccius sp.	-	-	-	-	4	1	14	2	2	1	9	1	-	-
Genypterus sp.	-	-	-	-	-	-	9	2	-	-	7	1	-	-
Nototheniidae	-	-	-	-	1	1	-	-	-	-	-	-	-	-

NISP Number of identifiable specimens, MNI: Minimum number of individuals;

Table 4

Shell size values of TXI and TEX sites. Measures were taken from unbroken individuals

	TEXI			**TEX**		
	Large	Width	Height	Large	Width	Height
N	1271	1272	1272	136	136	136
Media	3,61	2,81	1,68	3,52	2,93	1,50
St. Desviation	1,24	0,30	0,33	0,44	1,74	0,27
Variation Coefficient	34,32%	10,55%	19,46%	12,62%	59,34%	17,76%
Minimum	0,3	0,8	0,6	2,6	2,0	0,8
Maximum	35,0	4,3	6,0	4,9	22,7	2,2

5.2 Technological strategies

The lithic assemblages are divided into three main categories of artifacts: flakes, cores and retouched artifacts. Debitage produced by tool manufacture is the most common constituent of all the assemblages with ranges from 70% and 98%. The retouched pieces exhibit a moderate diversity which comprise long-retouched edges, short retouched edges, summary retouched flakes and points (Fig.4).

The study of lithic raw material use indicate the exploitation of three types of rocks which exhibit different qualities for knapping: fine grained rocks (volcanic glasses, basalts, and fine-grained tuffs) metamorphic rhyolites and schists. All of them are available as cobbles in beach deposits and near the sites along the Atlantic coast. The distribution of these raw materials between sites exhibit significant differences; the chi-square test supports this observation (X^2=352,5; p>0,05; df=12). Figure 5 shows that rhyolites are the more exploited rocks in OKXXI, MLB5, TEXI and ML5 while fine grain rocks predominate in MLA3, ML7 and TEX; schists, the lowest-quality raw materials, also have important variations in terms of relative frequencies between settlements.

The lithic production was based on the reduction of cobbles through hard hammer direct percussion and bipolar technique on anvils. These reduction strategies have been geared towards the production of unstandardized flakes, using unidirectional removals from plain and cortical striking platforms. The sequence of production was completed by unifacial retouch which extends marginally on long and short edges. The blanks selected for secondary trimming show a variety of forms and dimensions. For instance, the average length of the retouched flakes ranges between 17 mm and 118 mm. However, if the relationship between blank size and tool design are explored, interesting distinctions can be observed. Figure 6 shows that smaller flakes were chosen for producing short retouched edges while blanks >40 mm were preferred for the manufacture of both long-retouched edges and summary retouched flakes. This reduction modality suggests a *débitage* economy (Geneste, 1991) characterized by a low degree of blank predetermination; hence, knapping activities yielded diverse support morphologies that were differentially selected for the production of tools. This strategy was continued along the Late Holocene in the studied area.

Bifacial reduction technique, using thick flakes, was also documented on the studied assemblages aimed to projectile point manufacture. Preforms and end products of diverse morphologies were identified along the sequences. Around 1000 BP larger points make an appearance in these sites, as well as two types of stemmed points, namely points with long blades and those with compressed blades with reference to the longitudinal axis. The latter points correspond, in the traditional typological classification system used in Patagonian archaeology to Bird IV type (Bird, 1993). In contrast, small stemmed and unstemmed points were identified in later human occupations dated to around 300 BP.

Use-wear analysis provided information about the resources exploited by prehistoric groups as well as the labour processes carried out at the occupied sites, as revealed by the kinematics and the worked materials. In this regard, 49,06 % (n=78) of the observed lithic artefact edges exhibit diagnostic wear-traces, 24,53% (n=39) show post-depositional modifications, such as glossy patinas and thermal alterations that prevented the recognition of micropolishes or striations, and 26,42% of the edges (n=42) were not used. Hard and soft materials were identified, but these were unevenly distributed among sites, probably because of the different activities carried out at each of these settlements (Table 5).

Table 5

Frequencies of use-wear traces identified in the studied sites

	OKXXI		MLB5		MLA3		ML7		TEXI		ML5		TEX		
	L	T	L	T	L	T	L	T	L	T	L	T	L	T	Total
Hard Materials	3	1	0	1	1	0	0	0	15	2	2	0	0	0	25
Wood	0	1	0	0	0	0	0	0	2	0	0	0	0	0	3
Bone	1	0	0	0	0	0	1	0	14	0	2	0	0	0	18
Soft Material	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
Hide	-	2	0	2	0	2	0	1	0	8	0	0	0	11	26

L: longitudinal movement; T: transversal movement

Soft materials traces include the contact with hide and fleshy tissues, which dominate in MLB5, MLA3 and TEX. Conversely, hard materials were used mainly to work bone and less so for wood-working. Soft materials were more frequently worked in OKXXI, TEXI and ML5. The most common use action was cutting (58,97%, n=46) followed by scraping (41,03%, n=32). Short-retouched edges were employed entirely for hide scraping, while long-retouched edges were used in a wide range of tasks involving the work of bone, hide, and wood, and for cutting and scraping activities. Un-retouched flakes were used almost exclusively for cutting activities (31 for cutting and 6 for scraping) and mainly to process bones (Figure 7).

Interestingly, the context of use of lithic tools seems to have influenced in raw material selection, for instance, fine-grained rocks were used for hide working while schists were employed exclusively to cut bones. These differences are not related to the process of wear formation in different raw materials (Alvarez, 2003).

The studied assemblages also yielded a varied array of well-preserved formal bone artefacts, but in noticeable lower quantities than lithic tools. Bones of guanacos, cetaceans, and birds were used to manufacture beveled pieces, flat points, bipoints, blunted points, beads, pounders and harpoons (Table 6). The identification of debris from their manufacture suggests that production activities took place in the very settlements.

According to the model proposed by Scheinsohn (Scheinsohn, 2010), the selection of raw materials relied on the structural properties of bones. Thus, the hollow bones of birds were used to make beads since they can be cut easily but exhibit greater resistance when as small pieces. Beads were obtained by polishing the surface and both extremes of cut pieces of bird bones. In contrast, guanaco bones were mainly chosen for making different kinds of long tools that had a great resistance against losing their original shape, while cetacean specimens were suitable for absorbing energy. Use-wear traces show that both of these bone artefacts were used for applying pressure and percussion.

Table 6

Bone technology

Bone artifacts	MLB5	MLA3	ML7	TEXI	ML5	TEX
Camelid bone blunted point (retouchers)	5	5	1	2	2	-
Camelid/cetacean bone beveled piece	-	1	-	2	1	1
Camelid bone flat points	-	-	-	2	-	1
Camelid pounders			2	1	-	-
Cetacean bone bipoints	-	-	-	1	-	-
Harpoon	-	1	-	-	-	-
Awls	-	-	-	-	1	-
Bird beads	-	-	-	1	-	1
Artefact fragment	-	-	-	1	-	-
Manufacture debris				3	-	-
Flakes				3	-	-

6. Discussion

The last 1500 years witnessed several palaeoclimatic and palaeoenvironmental shifts in the southernmost tip of South America. Cycles of expansion-retraction of forested habitats are well documented and indicate periods of cooler/wetter conditions followed by warmer/drier regimes. These fluctuations were related to the latitudinal position and strength of the SWW. Thus, approximately between 1000 and 500 cal yrs, warmer and drier conditions were present at different locations as a result of the MCA, followed by a decrease in temperature and the intensification of rainfalls ca. 400 yr cal BP with the onset of LIA.

While late Holocene palaeoenvironmental changes are reasonably clear, the relationship between these climatic shifts and marine productivity or between these and the availability of faunal resources exploited by HFG groups is less clear in the study region for the lack of specific data. The palaeoenvironmental records obtained for the Magellan Strait and the Beagle Channel do not reveal a synchronous pattern, probably due to their particular topographic settings and ecological conditions (e.g. freshwater supply, input of organic matter). Nevertheless, and interestingly, both records showed in common an increase in marine productivity during LIA perturbation.

Within this scenario of climatic and environmental fluctuations, we had proposed that HFG societies of southern part of the Atlantic Coast of IGTF, instead of developing technological innovations and/or significant changes in diet breath, they would have carried out flexible strategies in terms of their settlement patterns, subsistence and technology practices as a way of coping with environmental uncertainty. Although the information is still incomplete and relies on the data drawn from some archaeological assemblages, the aforementioned results support these expectations.

The clustered site distribution along coastlines and nearby close bays suggests a settlement strategy focused on the most productive coastal habitats, in terms of edible resources, and as a result were preferentially occupied. These habitats, not only would have provided access to sea mammals and seabirds, but also predictable and low-cost procurement resources such as sessile marine invertebrates or fish trapped in rock pools during low tides. At the same time, potential lithic sources for tool manufacture are also found in these same places in form of cobbles of variable sizes.

As a result of this dynamic strategy in settlement, archaeological sites were used as residential camps where domestic activities such as food processing and tool manufacture were carried out. However, previous studies have shown that while some sites experienced short-term occupation and small accumulation of deposit, others exhibit more intense episodes of occupation that led to large and substantial buildup of occupational debris (Negre et al., 2016). There is currently not enough evidence for determining the factors behind these patterns, but they do not seem to be related to a particular trend in time. Further studies addressing seasonal variations in settlement patterns could well shed light on these marked differences.

Regarding subsistence strategies, the zooarchaeological assemblages show that HFG societies took advantage of the broad spectrum of faunal species available in the studied region with a significant emphasis on sea and terrestrial mammals, seabirds, fish and rocky shore shellfish. The subsistence practices were centered on the exploitation of a diverse range of resources that involved different labor investments (with regards to the procurement and processing activities), a range of food values (in terms of calories) and also prey size. Undoubtedly, pinnipeds and guanacos were caught with different hunting techniques and were major contributors to the diet of HFG societies.

Although the caloric contribution of seabirds is lower in relation to both pinnipeds and guanacos, the data presented here indicate that they were nonetheless very important in HFG diet. A wide variety of seabird taxa were exploited, with *Phalacrocorax* sp. and *Cholephaga* sp. being dominant in most sites. Interestingly, an increase in species diversity is apparent in later times. The high frequencies of these taxa along the local sequence suggest that bird hunting may have promoted economic stability among the inhabitants of the south-eastern coast of IGTF by providing and abundant and reliable resource which would have implied a relative low procurement cost as most of them form large breeding colonies.

Like coastal societies worldwide, shellfish was a staple in HFG subsistence. The large amounts of limpets and mussels present at these shell middens can be explained by the economic advantages they provided to past societies. They were continuously available and easily accessible without the need for specialized skills or technologies. On the other hand, the role of fish in the diet of studied societies is unclear for two reasons. Firstly, they register very variable frequencies in the studied assemblages; and secondly, material evidence of fishing technology is lacking from sites so far excavated. It is thus likely that fish would have been used as a complement to the main diet. According to ethnographic sources, two fishing methods were employed by Atlantic coast populations: using nets on river mouths and catching fish within rock pools during low tides through the use of spears, harpoons or simply using their bare hands (Gusinde, 1982; Chapman, 1989; Coiazzi, 1997; Gallardo, 1998)

In sum, the overall distribution of these taxa between sites suggests that subsistence strategies extended along the studied sequence beyond the variation in the frequency of certain faunal classes. These variations are the result, in part, of the intensity of settlement occupations; however, evenness index showed that these alternative dietary options remain constant. The faunal assemblages dated respectively during the MCA and LIA events do not exhibit remarkable differences.

In the case of the technology present at these sites, this preliminary study suggests the existence of a long-term trend toward the continuity of production and consumption practices independently of the palaeoclimatic changes. The analysis of lithic assemblages indicate that knapping activities were oriented to the manufacture of tools with low production-values and scarce morphological diversity. This means that labour invested in production techniques was low because the steps involved in tool manufacture are very few (Alvarez 2003; Perrault et al., 2013). Lithic raw materials were procured from beach deposits near the sites and blanks were obtained by direct percussion and bipolar technique, and showed little investment in predetermination during core reduction. Hence, blanks with variable morphologies were chosen to manufacture processing tools according to a débitage economy. The retouch applied resembles the form of the flake, while the differences between artifacts lay mainly on the extension of retouch and blank size in order to get the intended performance characteristics. Our studies also show that the lithic processing tools maintain their designs along the studied sequence.

Moreover, use-wear analyses show that these tools were consumed in domestic activities by using them directly (e.g., scraping or cutting) on several materials, such as bone, hide or wood. Long-retouched edges and natural flakes were versatile tools as revealed by their use in a wide variety of tasks while maintaining generalized designs. In contrast short-retouched edges had a specific use context. The selection of specific raw materials related to the performance of particular activities strongly suggest that HFG societies took advantages of the structural properties of available resources.

Consequently, with low production values and raw material economy, HFG societies obtained high consumption values while attaining high productivity levels. Only lithic weapons seem to experience changes in their designs in the studied assemblages. These results may be linked merely to sample size or to the reorganization of hunting activities. It is hoped that future studies would allow us to resolve this problem.

7. Conclusion

Currently it is widely accepted that human-ecosystems interaction is neither linear nor deterministic. Conversely, it is a complex relationship where human beings not only have a key role in the reshaping of global biodiversity (Boivin et al., 2016) but also in the design of creative responses for human sustainability. The present contribution intended to give insight into this problem unveiling the strategies developed by HFG societies who inhabited the southern part of the Atlantic Coast during the last part of Late Holocene when two small-scale climatic events took place. These fluctuations would potentially have been challenging for HFG groups who had to deal with changes in the temporal and spatial distribution of resources.

Although archaeological and palaeoclimatic data are incomplete, it is clear that flexible strategies were undertaken during 1500 yrs which entailed big and small game exploitation, a versatile technology and a landscape organization that were partially driven by the distribution of the most abundant and predictable resources. These strategies may have enhanced social resilience through centuries.

According to the ideas proposed by different authors (Rosen and Rivera-Collazo, 2012; Roberts et al., 2017) we argue that social memory, cumulative knowledge about environmental changes (including climatic fluctuations or seasonal variations) and material conditions were important resources for shaping hunter-gatherer decision-making. The ongoing research on the studied area will allow us to increase archaeological and environmental information to support this perspective.

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References

Acha, E.M., Mianzan, H.W., Guerrero, R.A., Favero, M., Bava, J., 2004. Marine fronts at the continental shelves of austral South America: Physical and ecological processes. Journal of Marine Systems 44, 83–105. doi:https://doi.org/10.1016/j.jmarsys.2003.09.005

Alvarez, M., 2003. Organización tecnológica en el canal Beagle. El caso de Túnel I (Tierra del Fuego, Argentina). Universidad de Buenos Aires.

Alvarez, M., Briz-Godino, I., 2017. Production and Consumption: Theory, Methodology, and Lithic Analysis. In: Rosenswig, R., Cunningham, J. (Ed.), Modes of Production and Archaeology. Gainesville: University Press of Florida, pp. 99–122.

Aracena, C., Kilian, R., Lange, C.B., Bertrand, S., Lamy, F., Arz, H.W., Pol-Holz, R. De, Baeza, O., Pantoja, S., Kissel, C., 2015. Holocene variations in productivity associated with changes in glacier activity and freshwater flux in the central basin of the Strait of Magellan. Palaeogeography, Palaeoclimatology, Palaeoecology 436, 112–122. doi:https://doi.org/10.1016/j.palaeo.2015.06.023

Bamforth, D., Bleed, P., 1997. Technology, flake stone technology, and risk. In: Barton, C.M., Clark, G.A. (Eds.), Rediscovering Darwin: Evolutionary Theory in Archaeology. Anthropological Association, 7, Washington, pp. 109–140.

Barberena, R., 2004. Arqueología e isótopos estables en Tierra del Fuego, En Temas de Arqueología. In: Borrero, L., Barberena, R. (Ed.), Arqueología Del Norte de La Isla Grande de Tierra Del Fuego. pp. 135–169.

Bas, M., Lacrouts, A., 2017. El aprovechamiento de recursos faunísticos en la costa atlántica de

Tierra del Fuego. Arqueología 23, 197–218.
Binford, L., 1980. Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. American Antiquity 45, 4–20.
Bird, J., 1993. Viajes y arqueología en Chile austral, Punta Aren. ed. Ediciones de la Universidad de Magallanes.
Boivin, N.L., Zeder, M.A., Fuller, D.Q., Crowther, A., Larson, G., Erlandson, J.M., Denham, T., Petraglia, M.D., 2016. Ecological consequences of human niche construction: Examining long-term anthropogenic shaping of global species distributions. Proceedings of the National Academy of Sciences of the United States of America 113, 6388–96. doi:10.1073/pnas.1525200113
Borrero, L., 1986. La economía prehistórica de los habitantes del norte de la Isla Grande de Tierra del Fuego. Facultad de Filosofía y Letras, Universidad de Buenos Aires.
Borrero, L., 2011. Los cazadores Orientales de Tierra del Fuego. In: Zangrando, A.F., Vásquez, M., Tessone, A. (Ed.), Los Cazadores Recolectores Del Extremo Oriental Fueguino. Arqueología de La Península Mitre E Isla De Los Estados. Sociedad Argentina de Antropología, Buenos Aires, pp. 287–298.
Borrero, L., Barberena, R., 2004. Temas de Arqueología. Arqueología del Norte del Isla Grande de Tierra del Fuego. Dunken, Buenos Aires.
Borromei, A.M., Coronato, A., Franzén, L.G., Ponce, J.F., Sáez, J.A.L., Maidana, N., Rabassa, J., Candel, M.S., 2010. Multiproxy record of Holocene paleoenvironmental change, Tierra del Fuego, Argentina. Palaeogeography, Palaeoclimatology, Palaeoecology 286, 1–16. doi:10.1016/j.palaeo.2009.11.033
Briz, I., 2004. Dinámiques económiques de producció-consum en el registre lític cagador recol·lector de l´extrem sud americá. La societat Yámana. Publicación electrónica del Servei de Publicacions de la Universitat Autónoma de Barcelona.
Briz, I., Estévez, J., Vila, A., 2009. Analizando la variabilidad del registro arqueológico en sociedades cazadoras-recolectoras desde la etnoarqueología. Arqueología Iberoamericana 1, 5–16.
Bujalesky, G., 2007. Coastal geomorphology and evolution of Tierra del Fuego (Southern Argentina). Geologica Acta 5, 337–362.
Bujalesky, G.G., González Bonorino, G., Abascal, L., 2014. Holocene coastal environments and processes in subantarctic/temperate cold Tierra del Fuego, Argentina-Chile. Geological Society, London, Special Publications 388, 281–303. doi:10.1144/SP388.10
Chapman, A., 1989. El fin de un mundo. Los Selk´nam de Tierra del Fuego. Vásquez Manzini Editores., Buenos Aires.
Coiazzi, A., 1997. Los indios del archipiélago fueguino. Editorial Ateli, Punta Arenas.
Costall, A., 1997. The meaning of things. Social Analysis 41, 76–85.
Dobres, M.A., Robb, J., 2000. Agency in Archaeology. Routledge.
Favier Dubois, C.M., Borrero, L.A., 2005. Playas de acreción: cronología y procesos de formación del registro arqueológico en la costa central de la Bahía San Sebastián, Tierra del Fuego (Argentina). Magallania 33, 83–89.
Fitzhugh, B., 2012. Hazards, Impacts, and Resilience among Hunter-Gatherers of the Kuril Islands. In: Cooper, J., Sheets, P. (Eds.), Surviving Sudden Environmental Change: Answers from Archaeology. pp. 19–42.
Furlong, C., 1917. Tribal distribution and settlements of the fueguians, comprising nomenclature, etymology, philology and populations. The Geographical Review III, 170–187.
Gallardo, C., 1998. Tierra del Fuego. Los Onas. Cabaut y Cia, Buenos Aires.
Geneste, J.M., 1991. Systèmes techniques de production lithique Variations techno-économiques dans les processus de réalisation des outillages paléolithiques. Techniques et Culture 17–18, 1–35.
González, B., Palma, E., Zapata, B., Marín, J., 2006. Taxonomic and biogeographical status of guanaco Lama guanicoe (Artiodactyla, Camelidae). Mammal Review 36, 157–178. doi:10.1111/j.1365-2907.2006.00084.x
Grayson, D.K., 1984. Quantitative zooarchaeology: topics in the analysis of archaeological faunas. Academic Press, Orlando, Florida.

Gusinde, M., 1982. Los indios de Tierra del Fuego. CAEA, Buenos Aires.
Heusser, C. y R.J., 1995. Late Holocene forest-steppe interaction at Cabo San Pablo, Isla Grande de Tierra del Fuego, Argentina. Quaternary of South America and Antarctic Peninsula 9, 173–182.
Hewlett, B.S., Fouts, H.N., Boyette, A.H., Hewlett, B.L., 2011. Social learning among Congo Basin hunter–gatherers. Philosophical Transactions of the Royal Society B: Biological Sciences 366, 1168–1178. doi:10.1098/rstb.2010.0373
Hiscock, P., 2007. Looking the Other Way: A Materialist/Technological Approach to Classifying Tools and Implements, Cores and Retouched Flakes. In: McPherron, S.P. (Ed.), Tools versus Cores: Alternative Approaches to Stone Tool Analysis. Cambridge Scholars Publishing, pp. 198–222.
Hogg, A., Hua, Q., Blackwell, P., Niu, M., Buck, C., Guilderson, T., Heaton, T., Palmer, J., Reimer, P., Reimer, R., Turney, C., Zimmerman, S., 2013. SHCal13 Southern Hemisphere Calibration, 0–50,000 Years cal BP. Radiocarbon 55, 1889–1903.
Ingold, T., 1981. The hunter and his spear: notes on the cultural mediation of social and ecological systems. In: Sheridan, A., Bailey, G. (Eds.), Economic Archaeology. Oxford, pp. 119–130.
Keeley, L., 1980. Experimental Determination of Stone Tool Uses: A Microwear Analysis. University of Chicago Press.
Kilian, R., Lamy, F., 2012. A review of Glacial and Holocene paleoclimate records from southernmost Patagonia (49-55??S). Quaternary Science Reviews 53, 1–23. doi:10.1016/j.quascirev.2012.07.017
Koch, J., Kilian, R., 2005. “Little Ice Age” glacier fluctuations, Gran Campo Nevado, southernmost Chile. Holocene 15, 20–28. doi:10.1191/0959683605hl780rp
Lanata, J.L., 1995. Paisajes Arqueológicos y Propiedades del Registro en el Sudeste Fueguino. Facultad de Filosofía y Letras, Universidad de Buenos Aires.
Lanata, J.L., 1996a. La diversidad instrumental en el norte de Península Mitre, Tierra del Fuego. Arqueología 6, 159–197.
Lanata, J.L., 1996b. The Haush puzzle: piecing together subsistence and settlement at the fueguian southeast. Revista do Museu de Arqueologia e Etnologia 11–32.
Lyman, R., 1994. Vetebrate Taphonomy. Cambridge University Press.
Lyman, R., 2008. Quantitative Paleozoology. Cambridge University Press.
Lyman, R.L., 2003. The influence of time averaging and space averaging on the application of foraging theory in zooarchaeology. Journal of Archaeological Science 30, 595–610. doi:https://doi.org/10.1016/S0305-4403(02)00236-4
Mauquoy, D., Blaauw, M., Geel, B. van, Borromei, A., Quattrocchio, M., Chambers, F.M., Possnert, G., 2004. Late Holocene climatic changes in Tierra del Fuego based on multiproxy analyses of peat deposits. Quaternary Research 61, 148–158. doi:10.1016/j.yqres.2003.10.001
Mesoudi, A., 2013. Studying cultural transmission with in an interdisciplinary cultural evolutionary framework. In: Understanding Cultural Transmission in Anthropology, A Critical Synthesis. Berghahn Books, pp. 131–147.
Miloslavich, P., Klein, E., Díaz, J.M., Hernández, C.E., Bigatti, G., Campos, L., Artigas, F., Castillo, J., Penchaszadeh, P.E., Neill, P.E., Carranza, A., Retana, M. V., Díaz de Astarloa, J.M., Lewis, M., Yorio, P., Piriz, M.L., Rodríguez, D., Yoneshigue-Valentin, Y., Gamboa, L., Martín, A., 2011. Marine Biodiversity in the Atlantic and Pacific Coasts of South America: Knowledge and Gaps. PLoS ONE 6, e14631. doi:10.1371/journal.pone.0014631
Morello, F., Borrero, L., Torres, J., Massone, M., Arroyo-Kalin, M., Mcculloch, R., Calas, E., Lucero, M., Martínez, I., Bahamonde, G., 2009. Evaluando el registro arqueologico de Tierra del Fuego durante el Holoceno temprano y medio. In: M. Salemme, F. Santiago, M. Alvarez, E. Piana, M.V.& M.E.M. (Ed.), Arqueología de Patagonia: Una Mirada Desde El Ultimo Conf Ín: pp. 1075–1092.
Morello, F., Borrero, L., Massone, M., Stern, C., García-Herbst, A., McCulloch, R., Arroyo-Kalin, M., Calás, E., Torres, J., Prieto, A., Martinez, I., Bahamonde, G., Cárdenas, P., 2012. Hunter-gatherers, biogeographic barriers and the development of human settlement in Tierra del Fuego. Antiquity 86, 71–87. doi:10.1017/S0003598X00062463
Muñoz, A.S., 2005. Zooarqueología del sector atlántico de la isla grande de Tierra del Fuego. La

utilización de camélidos y pinnípedos por los cazadores-recolectores fueguinos. Relaciones de la Sociedad Argentina de Antropologia XXX, 59–77.
Muñoz, A.S., Belardi, J., 2011. Nueva información sobre viejos datos: arqueología del norte de la península Mitre. En: Los cazadores-recolectores del extremo oriental fueguino. In: Zangrando, A.F. Vázquez, M.. Tessone, A. (Ed.), Arqueología de Península Mitre E Isla de Los Estados. Sociedad Argentina de Antropología, pp. 171–202.
Musotto, L., Borromei, A., Bianchinotti, M., Coronato, A., 2016a. Late Quaternary palaeoenvironmental reconstruction of central Tierra del Fuego (Argentina) based on pollen and fungi, Quaternary International. doi:10.1016/j.quaint.2016.01.071
Musotto, L.L., Borromei, A.M., Coronato, A., Menounos, B., Osborn, G., Marr, R., 2016b. Late Pleistocene and Holocene palaeoenvironmental changes in central Tierra del Fuego (~54°S) inferred from pollen analysis. Vegetation History and Archaeobotany 25, 117–130. doi:10.1007/s00334-015-0537-8
Negre, J., Álvarez, M., Pal, N., Bas, M., Briz, I., Lacrouts, A., Lasa, A., 2016. Variabilidad espacial e intensidad de ocupación en sitios cazadores-recolectores de la costa atlántica de Tierra del Fuego (Argentina). Arqueología Iberoamericana 32, 37–51.
Negre, J., Briz i Godino, I., Pal, N., Alvarez, M., 2018. Estrategias de asentamiento y movilidad en sociedades cazadoras-recolectoras-pescadoras del sector meridional de la costa atlántica fueguina. Arqueología 24, In press.
Nelson, M., 1991. The Study of Technological Organization 3, 57–100.
Orquera, L., Piana, E., 2000. Composición de conchales de la costa del canal Beagle (Tierra del Fuego, República Argentina) - primera parte -. Relaciones de la Sociedad Argentina de Antropología 25, 249–274.
Orquera, L.A., Legoupil, D., Piana, E.L., 2011. Littoral adaptation at the southern end of South America. Quaternary International 239, 61–69. doi:https://doi.org/10.1016/j.quaint.2011.02.032
Pal, N., Álvarez, M., Briz, I., Negre, J., Lasa, A., 2016. Ocupaciones humanas en la costa Atlántica de Tierra del Fuego durante el Holoceno tardío. Revista de Arqueología Americana 34.
Pereda, M., Zurro, D., Santos, J.I., Briz i Godino, I., Álvarez, M., Caro, J., Galán, J.M., 2017. Emergence and Evolution of Cooperation Under Resource Pressure. Scientific Reports 7, 45574. doi:10.1038/srep45574
Rabassa, J., Coronato, A., Bujalesky, G., Salemme, M., Roig, C., Meglioli, A., Heusser, C., Gordillo, S., Roig, F., Borromei, A., Quattrocchio, M., 2000. Quaternary of Tierra del Fuego, Southernmost South America: an updated review. Quaternary International 68–71, 217–240. doi:10.1016/S1040-6182(00)00046-X
Roberts, N., Woodbridge, J., Bevan, A., Palmisano, A., Shennan, S., Asouti, E., 2017. Human responses and non-responses to climatic variations during the last Glacial-Interglacial transition in the eastern Mediterranean. Quaternary Science Reviews. doi:https://doi.org/10.1016/j.quascirev.2017.09.011
Rosen, A.M., Rivera-Collazo, I., 2012. Climate change, adaptive cycles, and the persistence of foraging economies during the late Pleistocene/Holocene transition in the Levant. Proceedings of the National Academy of Sciences 109, 3640–3645. doi:10.1073/pnas.1113931109
Salemme, M., Santiago, F., Oría, J., 2014. La Arcillosa 2: la ocupación humana durante el Holoceno medio, Tierra del Fuego, Argentina. Revista Chilena de Antropología 29, 19–25.
San Román, M., Reyes, M., Morello, F., Torres, J., 2016. Archaeology of Maritime Hunter-gatherers from Southernmost Patagonia, South America: Discussing Timing, Changes and Cultural Traditions during the Holocene. In: Bjerck, H. B., Breivik, H.M., Fretheim, S.E., Piana, E.L., Skar, B., Tivoli, A.M., Zangrando, A.. (Ed.), Marine Ventures - Archaeological Perspectives on Human-Sea Relations. pp. 157–174.
Saporiti, F., Bala, L.O., Crespo, E.A., Gómez Otero, J., Zangrando, A.F.J., Aguilar, A., Cardona, L., 2013. Changing patterns of marine resource exploitation by hunter-gatherers throughout the late Holocene of Argentina are uncorrelated to sea surface temperature. Quaternary International 299, 108–115. doi:https://doi.org/10.1016/j.quaint.2013.03.026
Saporiti, F., Bala, L.O., Otero, J.G., Crespo, E.A., Piana, E.L., Aguilar, A., Cardona, L., 2014. Paleoindian pinniped exploitation in South America was driven by oceanic productivity. Quaternary International 352, 85–91. doi:https://doi.org/10.1016/j.quaint.2014.05.015

Sauer, J.J., 2015. The Archaeology and Ethnohistory of Araucanian Resilience 21–46. doi:10.1007/978-3-319-09201-0
Savanti, F., 1994. Las aves en las dietas de los cazadores-recolectores terrestres de la costa fueguina, Consejo Na. ed.
Scheinsohn, V., 2010. Hearts and Bones: Bone Raw Material Exploitation in Tierra del Fuego. BAR International Series 2094.
Shennan, S., 2000. Population, Culture History, and the Dynamics of Culture Change. Current Anthropology 41, 811–835. doi:10.1086/317403
Stuiver, M., Reimer, P.J., 1993. Extended 14C data base and revised CALIB 3.0 14C age calibration program. Radiocarbon 35, 215–230.
Stuiver, M., Reimer, P.J., Reimer, R.W., n.d. 1986-2016. CALIB 7.1 [WWW program].
Torrence, R., 1989. Retooling: toward a behavioral theory of stone tools. In: Time, Energy, and Stone Tools. Cambridge University Press, Cambridge, pp. 57–66.
Tuhkanen, S., 1992. The climate of Tierra del Fuego from a vegetation geographical point of view and its eco-climatic counterparts elsewhere. Acta Botanica Fennica 145, 1–64.
Vázquez, M., Elkin, D., Oría, J., 2017. Patrimonio a orillas del Mar. Arqueología del Litoral Atlántico de Tierra del Fuego. Editora Cultural de Tierra del Fuego.
Waldmann, N., Ariztegui, D., Anselmetti, F.S., Austin, J.A., Moy, C.M., Stern, C., Recasens, C., Dunbar, R.B., 2010. Holocene climatic fluctuations and positioning of the Southern Hemisphere westerlies in Tierra del Fuego (54° S), Patagonia. Journal of Quaternary Science 25, 1063–1075. doi:10.1002/jqs.1263
Whallon, R., 2006. Social networks and information: Non-“utilitarian” mobility among hunter-gatherers. Journal of Anthropological Archaeology 25, 259–270.
Yesner, D., Figuerero Torres, M.J., Guichón, R.A., Borrero, L.A., 1991. Análisis de isótopos estables en esqueletos humanos: confirmación de patrones de subsistencia etnográficos para Tierra del Fuego. Shincal 3, 182–191.
Yesner, D., Figuerero Torres, M.J., Guichón, R.A., Borrero, L.A., 2003. Stable isotope analysis of human bone and ethnohistoric subsistence patterns in Tierra del Fuego. Journal of Anthropological Archaeology 22, 279–291.
Zangrando, A.F., 2007. Historia evolutiva, tempos y subsistencia humana en la región del Canal de Beagle : una aproximación zooarqueológica. Universidad de Buenos Aires.
Zangrando, F., Tessone, A., Vázquez, M., 2009. El uso de espacios marginales en el archipiélago fueguino: implicancias de la evidencia arqueológica en Bahía San Valentín. In: Salemme, M., Santiago, F., Alvarez,M., Piana,E., Vázquez, M., Mansur, E. (Ed.), Arqueología de La Patagonia. Una Mirada Desde El Último Confín. Utopías, Ushuaia, pp. 47–62.

Figure captions

Fig.1. Intertidal zone of Atlantic coast of Tierra del Fuego (54°28'51.53"S; 66°25'22.37"W) during low tide.

Fig.2. Map of Isla Grande de Tierra del Fuego showing the studied area and the archaeological sites from which data discussed in this paper was drawn. On the right: a detailed image with the location of archaeological sites.

Fig.3. Abundance index of faunal categories in the studied assemblages.

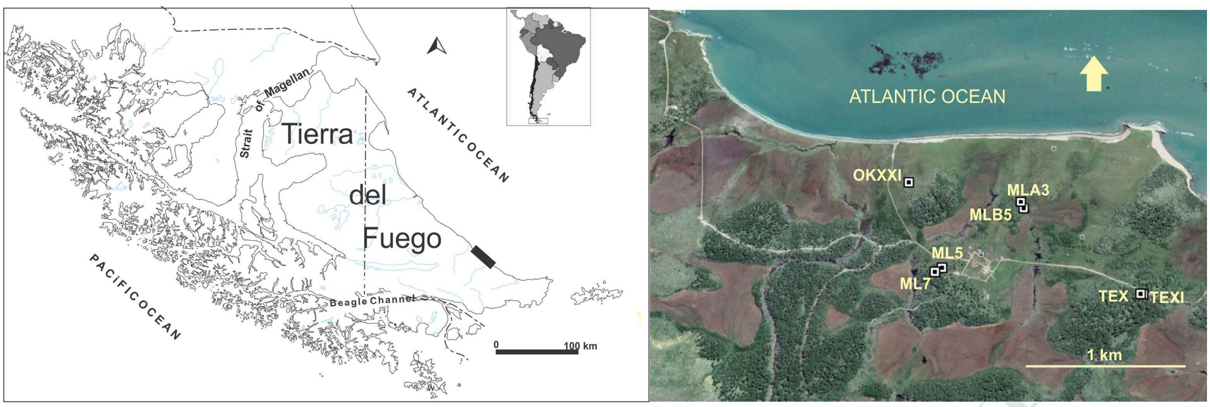
Fig.4. Lithic tools from the studied sites. A, B, E,F: short-retouched edges; C: flake with summary retouch; D, I, J: long-retouched edges: G, H, K, L, M: points

Fig.5. Lithic raw material distribution between sites. RHY: rhyolites; FGR: fine-grained rocks; SCH: schists.

Fig. 6. Relative frequencies of blank size distribution according to tool designs. LRE: long-retouched edges; SRED: short retouched edges; FSR: flakes with summary retouch; FNA: flakes with natural edges.

Fig. 7. Use-wear traces of lithic tools. A, B: Bone working traces; C,D: Hide working bones; E, F: Wood working traces. Magnification: 200X.

Fig 8. Bone tecnology. A, D, E, K: manufacture debris; B: cetacean artifact; C: cetacean bone beveled piece, F, G: bird beads; H: camelid pounder; I, M: camelid bone flat points; J: camelid bone beveled piece; L: camelid bipoints, N: camelid bone blunted point; O, P, Q: bone flakes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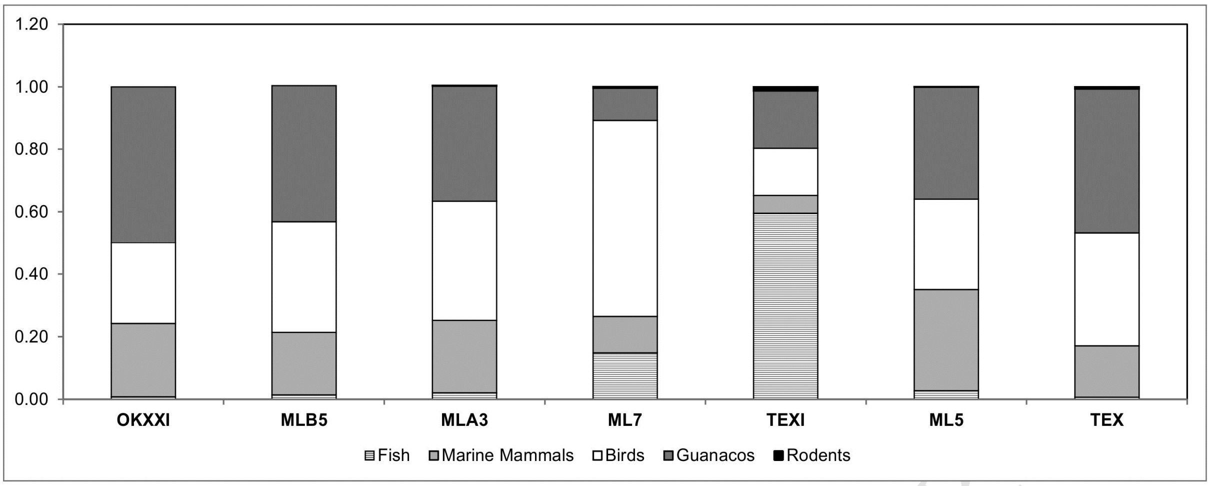
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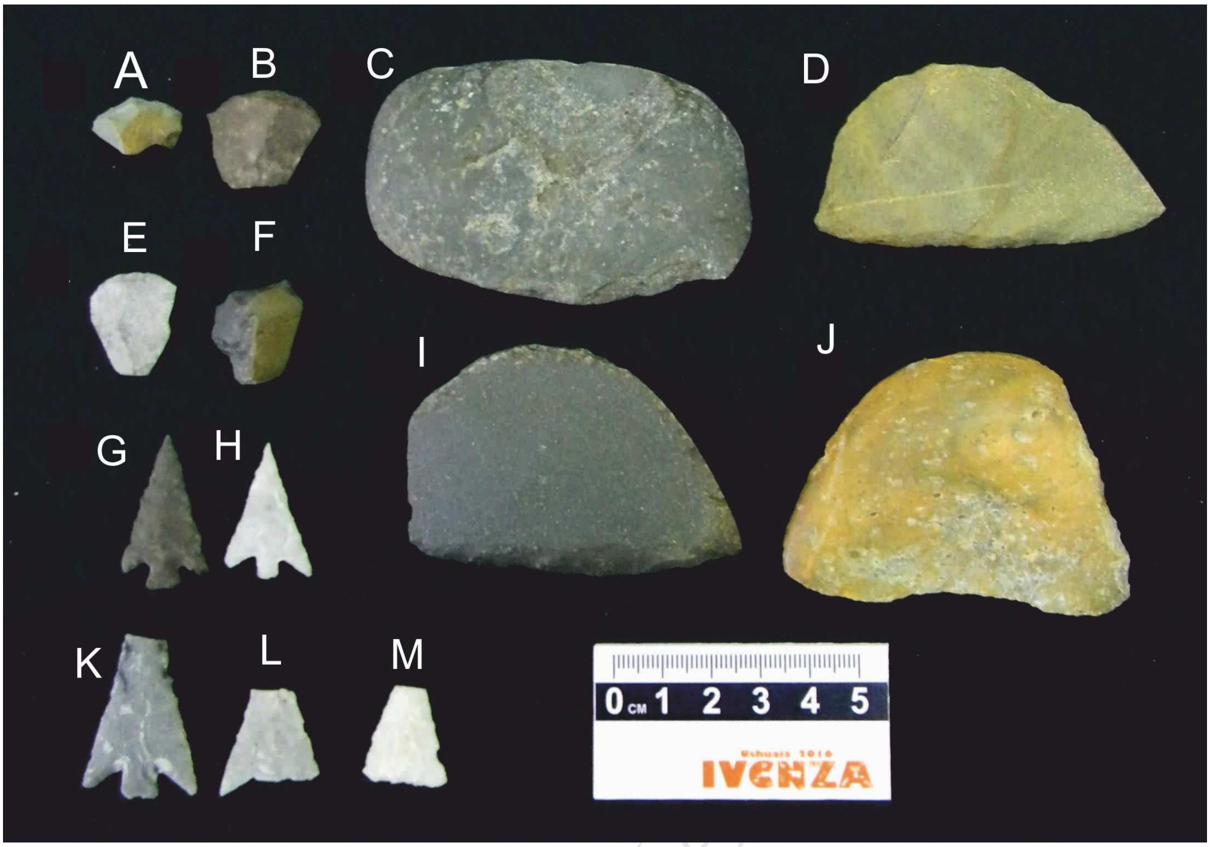
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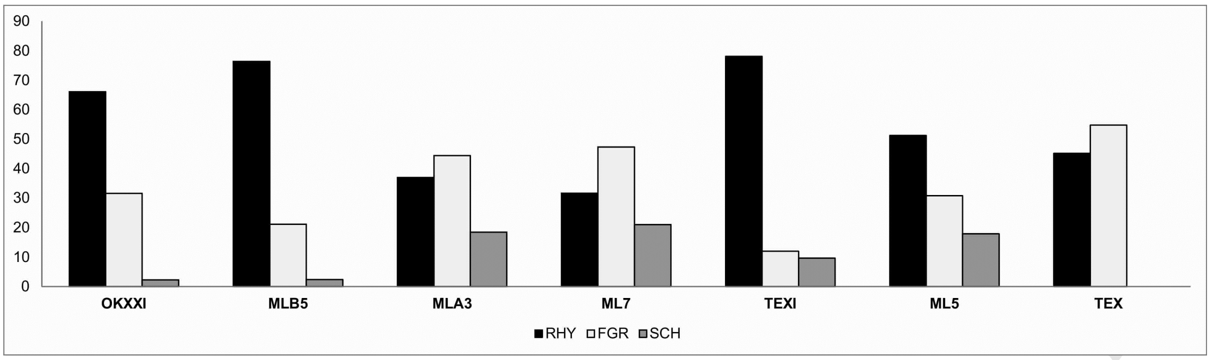
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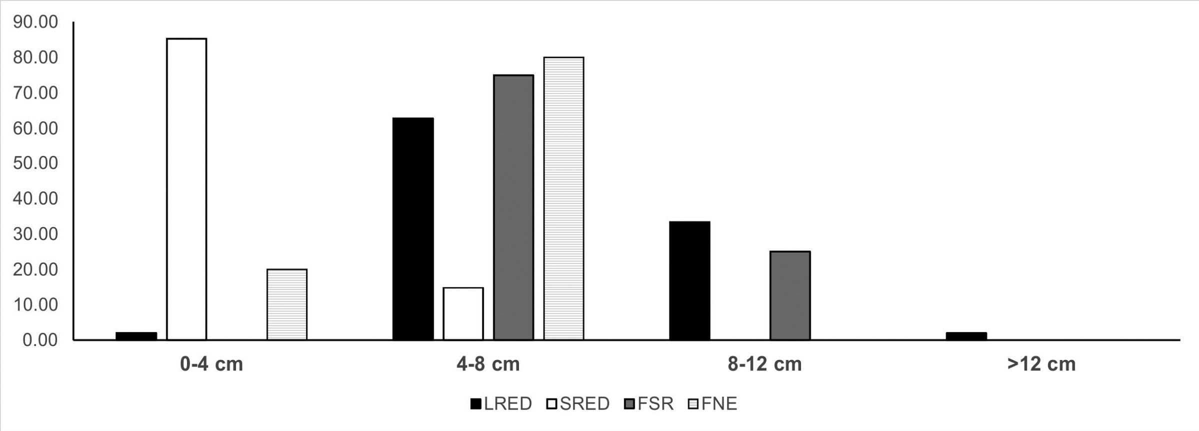

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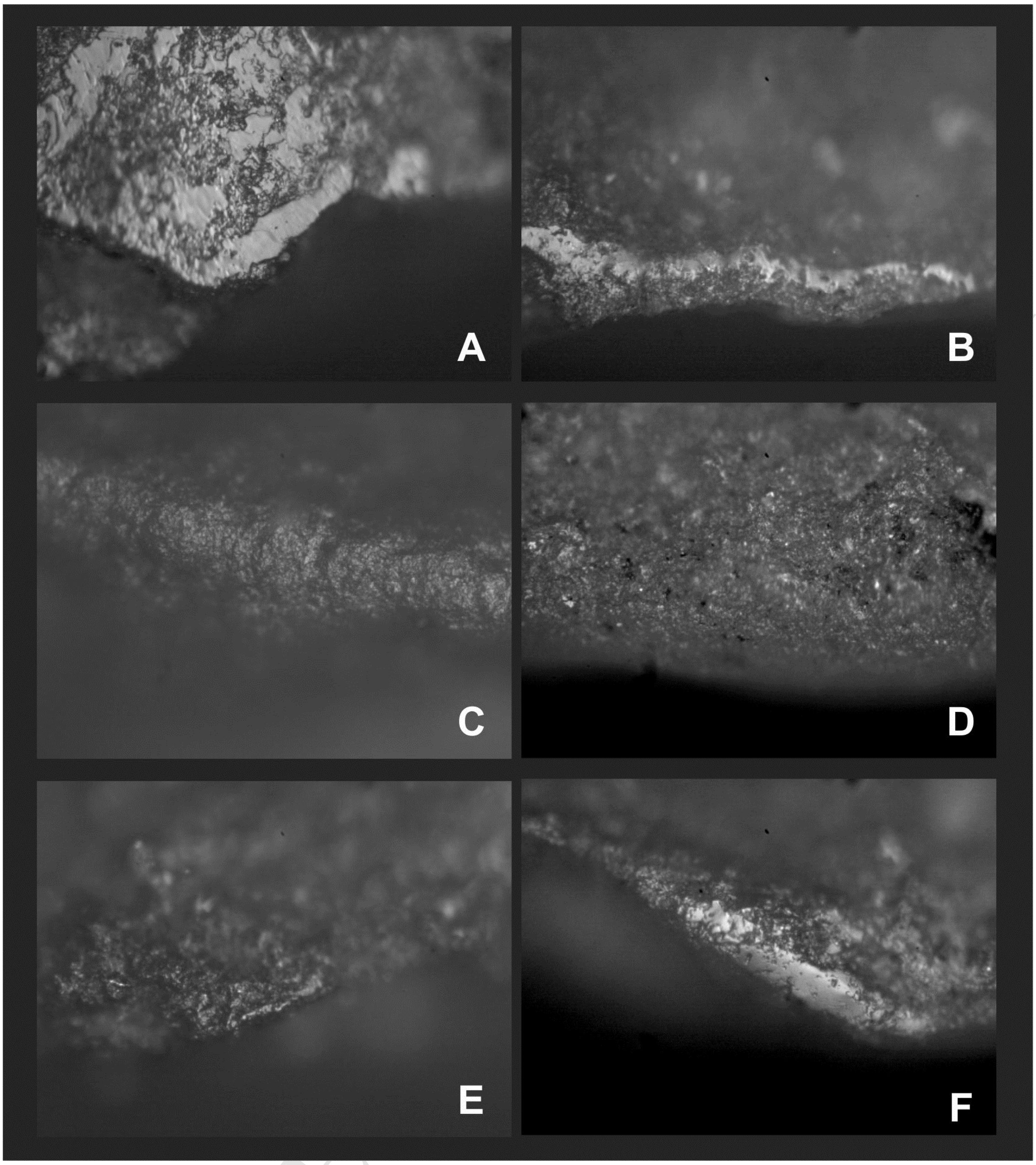
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