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Intensive fishery scenarios on the North Patagonian coast (Río Negro, Argentina) during the Mid-Holocene

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ABSTRACT

In contrast to what was recorded in other sectors of the Atlantic coast of continental Patagonia, evidence of intensive fishing activities has been found on the northern littoral of the San Matías Gulf (Río Negro, Argentina). The archaeological evidence of this practice, that go back to around 6000 ^{14}C BP, consists mainly of fish remains (white croaker otoliths) preserved on the surface of Pleistocene marine terraces together with weights for nets and other lithic artifacts involved in the primary processing of this resource. It is proposed that under the prevailing arid conditions in Mid-Holocene times in northeastern Patagonia, the productivity and particular configuration of the coast during the marine transgression at the studied localities would have offered a very favorable framework for the early development of this practice in the area.

1. Introduction and research objectives

The relative importance and temporal depth of the exploitation of the marine resources in the Atlantic Patagonian coast was recognized just in the last few decades (for a synthesis see Orquera and Gómez Otero, 2007). For the central and southern Patagonian Atlantic coast, there exist archaeological and isotopic evidence that demonstrates a moderate to low intensity of human use of marine resources (Gómez Otero et al., 1999; Borrero and Barberena, 2006; Gómez Otero, 2007a; Borrero et al., 2009). The only exception to this panorama may be the northern coast of the Santa Cruz Province (Castro et al., 2008; Moreno, 2009), where the exploitation of marine faunas seems to have been really important, although no paleodietary data has been generated to reinforce this evidence yet.

One of the most salient results of the archaeological projects carried out since 2004 on the northern coast of the San Matías Gulf (Río Negro, Northern Patagonia) was the discovery of overwhelming evidence of marine resource exploitation, initiated during Mid-Holocene times. Such information was obtained through systematic excavations, radiocarbon dating, taphonomical studies, and archaeofaunal and paleodietary analyses (Favier Dubois and Borella, 2005; Favier Dubois et al., 2008, 2009). In this context, net fishing is particularly evident, a practice that goes back to at least 6000 years at one of the analyzed localities. This constitutes one of the earliest records of this technology in the whole littoral of continental Patagonia.

The archaeological evidence of fishing consists mainly in an enormous abundance of white croaker otoliths (inner ears of fishes made up of calcium carbonate) associated with net-weights on Pleistocene marine terraces bordering ancient coastal inlets produced by the Mid-Holocene high sea-level (Favier Dubois et al., 2009; Scartascini et al., 2009; Favier-Dubois and Kokot, in press). Palaeodietary information has been obtained (stable isotopes of C and N from human remains) that independently backs the idea of intensive exploitation of marine resources during the Mid- and first part of the Late-Holocene on that littoral. Values of δ^{13}C have been obtained that indicate predominantly marine diets from an individual dated at ca. 4800 ^{14}C BP (δ^{13}C 11.5‰), and from 11 individuals (males and females) dated between ca. 3100 and ca. 2200 ^{14}C BP (δ^{13}C mean value of −13.8 ± 1.7‰, Favier Dubois et al., 2009). In addition, values of δ^{15}N taken from the individuals of the latter group indicate that the marine species consumed were of a high trophic level (δ^{15}N mean value of 15.6 ± 1.2‰, Favier Dubois et al., 2009) (see Table 1). This agrees with a significant incorporation of fish in diets taking into account the isotopic ecology studies carried out previously in the region and neighboring areas (Gómez Otero, 2007a; Favier Dubois et al., 2009; Martínez et al., 2009).

With regard to the paleoenvironmental conditions which constituted the framework of these settlements, paleoclimatic studies carried out in dry salt lakes in northeastern Patagonia indicate arid conditions during the Mid-Holocene (ca. 7500 BP)

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Table 1
Chronology (AMS dating) and isotope values ($\delta^{13}C$ and $\delta^{15}N$) obtained on human remains from San Matías Gulf (modified from Favier Dubois et al., 2009). AA: University of Arizona AMS Laboratory; USF: University of South Florida.

Locality	Reference	Sample	^{14}C AMS age (yr BP)	Calib. range (yr BP)	Lab code (AA)	$\delta^{13}C$ AMS	$\delta^{13}C$ USF	$\delta^{15}N$ USF	Lab code (USF)
Bajo de la Quinta (BQ-S1)	BQS1-17	Tooth	3077 ± 54	3084–3334	64777	−13.8	−14.5	14.4	10067
	BQS1-290	Tooth				–	−12.7	15.2	10068
	BQ-S1 Vi	Tooth	2458 ± 50	2349–2672	75708	−15.1	−17.0	14.6	10287
Bahía de San Antonio (SAO)	SAOBA-I	Bone	2330 ± 49	2163–2347	75704	−15.5	−14.5	15.7	10291
	SAOBA-II	Bone					−15.9	13.9	10292
	SAOBA-III	Bone					−10.9	17.0	10293
	SAOPC-30	Bone	4794 ± 59	5330–5582	81726	−11.5	–	–	–
Bahía de San Antonio (Buque Sur)	BS I	Tooth	2195 ± 49	2009–2299	70720	−13.3	−13.2	17.1	10063
	BS II	Tooth					−12.8	16.6	10064
	BS III	Tooth					−13.1	15.8	10065
	BS IV	Tooth	2300 ± 49	2159–2336	70719	−13.9	−12.7	17.4	10066
Islote Lobos	IL-35	Bone	2670 ± 37	2721–2769	75713	−14.6	−14.6	14.5	10296

with high temperatures and scant rainfall (Schäbitz, 1994, 2003). Later, at ca. 5000 BP and until ca. 3000 BP, the climate changed slightly towards semi-arid conditions, with an increase in annual rainfall (240–320 mm). This transitional stage comes to an end towards the Late-Holocene ca. 3000–2500 years BP, when the present semi-arid conditions will have set in (Schäbitz, 2003).

The aim of this contribution is to present the main Mid-Holocene fishery scenarios corresponding to a high sea-level, as well as the archaeofaunal and technological evidence connected with this practice. In addition the conditions are evaluated whereby this littoral could have become particularly attractive for northern Patagonian human groups in terms of its supply of resources and the ecological-environmental framework prevailing at the time.

2. Study area

The northern coast of the San Matías Gulf is on the North Patagonian Atlantic littoral (Province of Río Negro, Argentina) (Fig. 1). The region is characterized by a semi-arid climate, with a mean temperature of 15 °C and annual rainfall under 300 mm. Vegetation is shrubby, corresponding to the Patagonian Monte (Cabrera and Willink, 1980). Tides are semidiurnal and have a macro tidal regime, with mean amplitudes of 6.38 m and maxima of 9.22 m at syzygies at the port of San Antonio Este, on the Bahía de San Antonio (Servicio de Hidrografía Naval, 2009).

This littoral has three localities that stand out for the richness and variety of their archaeological and bioarchaeological record from Mid- and Late-Holocene: Bahía de San Antonio, Bajo de la Quinta, and Bahía Creek (Fig. 1). These sectors belong to ancient topographical hollows inundated by the sea, which have undergone an important geomorphologic evolution since the Pleistocene, and particularly, since the Mid-Holocene transgressive maximum. The marine deposits consist mainly of beach ridges and spits. Those belonging to the Pleistocene form terraces whose height is above 10 m above sea-level (asl), whereas the Holocene ones are always below this level (Rostami et al., 2000; Schellmann and Radtke, 2010; Favier-Dubois and Kokot, in press). The principal features of each locality are described below.

Bahía de San Antonio (BSA): is a wide, deep bay, which constitutes the main coastal entrance on the Río Negro Province littoral. This bay is characterized by a broad tidal flat flanked by numerous Holocene and Pleistocene beach ridges and spits that form terraces of varying height (Angulo et al., 1978; Kokot and Favier Dubois, 2010). The bay is partially closed off by two great spits that have

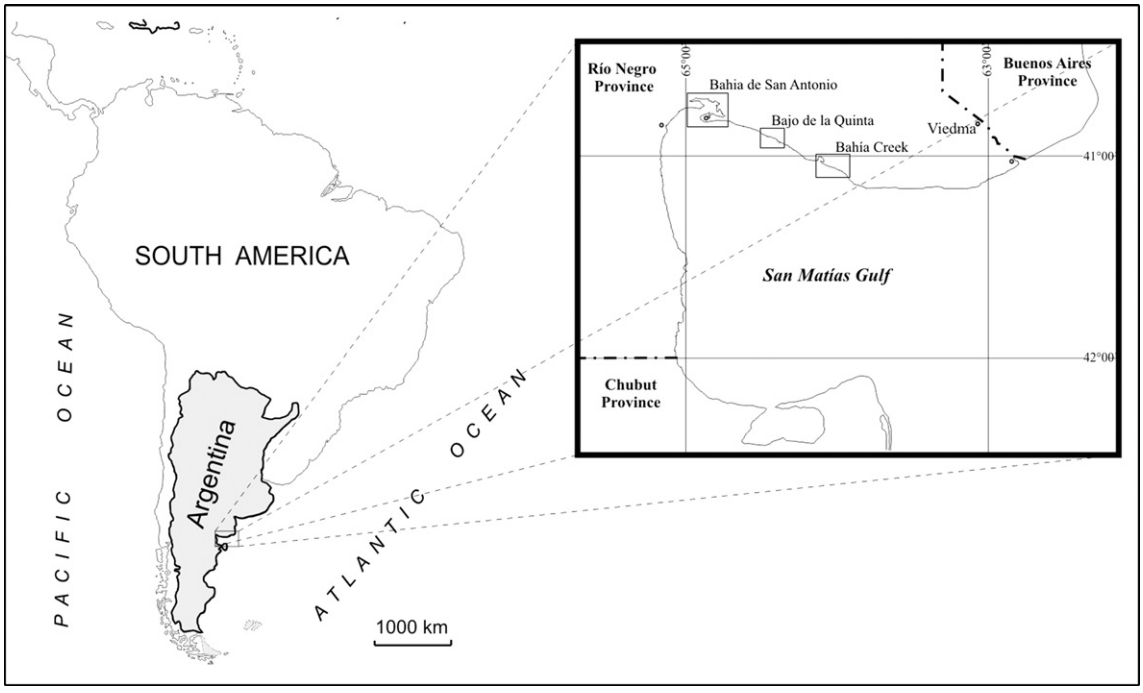

Fig. 1. Localities under study on the northern coast of the San Matías Gulf, northern Patagonian Atlantic coast, Argentina (Map: R. Kokot).

grown in opposite directions. The locality of San Antonio Oeste (SAO) occupies the western sector, and sits on a Pleistocene marine terrace (Kokot and Favier Dubois, 2010).

Bajo de la Quinta (BQ): this "bajo" (hollow) is fluvial in origin, and is presently covered by a field of active sand-dunes that bury Pleistocene spits and Holocene marine beach ridges. The latter have filled in the old marine inlet, making the coastline completely straight in this sector (Favier-Dubois and Kokot, in press).

Bahía Creek (BC): this sector was once a broad inlet that has progressively been filled in by Pleistocene and Holocene beach ridges, the latter in the form of a great spit (Gelós et al., 1988; Kokot et al., 2004). This spit has developed from east to west, leaving a deep, narrow open sector of a tidal domain at its western end, which is the Caleta de los Loros (Del Río and Colado, 1999). In the eastern sector, a paleocliff is noticeable, which goes inwards from the shore in a northeasterly direction, and disappears under aeolian deposits after about 3 km.

3. Methods

3.1. Geomorphologic studies and dating

Geological and geomorphologic data were obtained from on-site surveys and from the interpretation of satellite images and aerial photographs. Radiocarbon dating was also carried out on white croaker (*Micropogonias furnieri*) otoliths (Fig. 2), and on valves (*Mytilus edulis*/*Aulacomya ater*) and charcoal from anthropic shell-deposits (shell-middens). Samples were processed and measured at the Laboratorio de Tritio y Radiocarbono (LATYR, La Plata, Argentina –LP-) and the University of Arizona AMS Laboratory (–AA-). Radiocarbon ages were calibrated using CALIB REV6.0.0 (1986–2010 M. Stuiver and P. J. Reimer), at 1 sigma. The SH Atmosphere curve was selected for continental samples, and for marine samples the MARINE09 curve was used. The global $\Delta R = 0$ was used in the case of otoliths, and a $\Delta R = -134 \pm 51$ was introduced for valves according to a local reservoir effect value obtained from them (Favier Dubois, 2009). This made possible the dating of successive human occupations and the fishing activities in the different localities analyzed.

Table 2
Principal characteristics of the elevation models employed.

	ASTER GDEM (Version 1)	SRTM (Version 4)
Data source	ASTER	Space shuttle radar
Generation and distribution	NASA/METI	NASA
Launch year	2009	2003
Data acquisition period	2000 to present	11 days (in 2000)
Sampling interval	30 m	90 m
Accuracy	7–14 m	10 m

3.2. Digital modeling

The modeling was carried out by the controlled modification of digital elevation models Shuttle Radar Topography Mission (SRTM DEM) and ASTER Global Digital Elevation Model (ASTER GDEM) (Table 2). These models are the result of a numerical data structure represented by a triad of values on three axes (X, Y, Z).

The procedure consisted in mapping the terrain's landforms from the on-site survey, their positioning with GPS, and the interpretation of geo-referenced photographs. Once obtained, the data were processed with the programs SURFER 9.0 and GLOBAL MAPPER 11, in which values (X, Y, Z) were adjusted according to the data obtained on the field. Finally, different images were generated in which the sea-level was increased to different relative heights (7, 8, and 10 m) above the present level. However, only one of them was selected in each case giving its proximity to archaeological sites (Fig. 3a, b and c).

3.3. Archaeofaunal and artifact studies

The archaeofaunal sample analyzed for this study consisted of 646 otoliths, of which the majority belong to the white croaker (*M. furnieri*) ($n = 638$), and a few to the Argentine croaker (*Umbrina canosai*) ($n = 8$). Otoliths are complex polycrystalline bodies, composed mainly of calcium carbonate precipitated in the form of aragonite, and small quantities of other minerals, contained within an organic matrix in the inner ear of osseous fishes (Gauldie, 1993). The shape and structure of the otoliths are peculiar to each species (Volpedo and Echeverría, 2000), which makes it easy to determine the specimens recovered in archaeological sites.

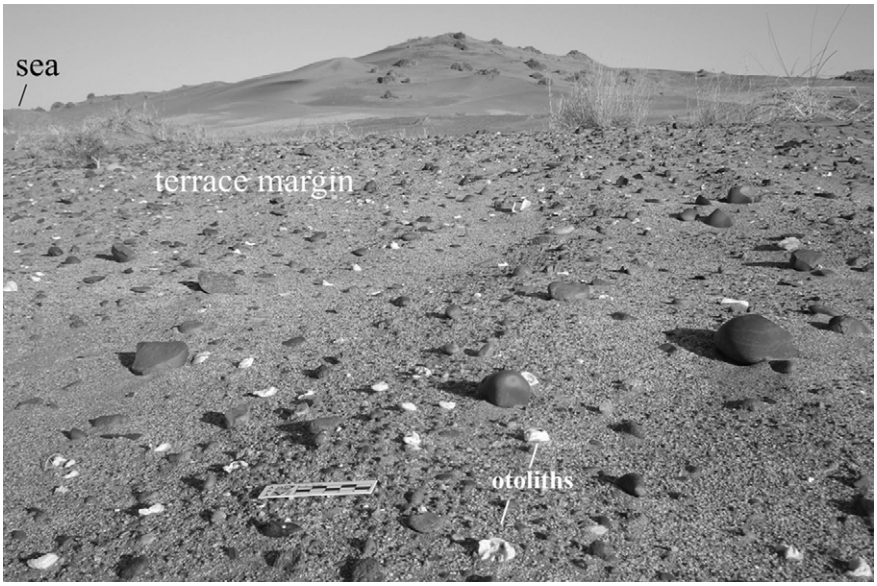

Fig. 2. View of white croaker otoliths on the surface of a Pleistocene spit. They are placed near the margin of an ancient coastal inlet (locality BQ).

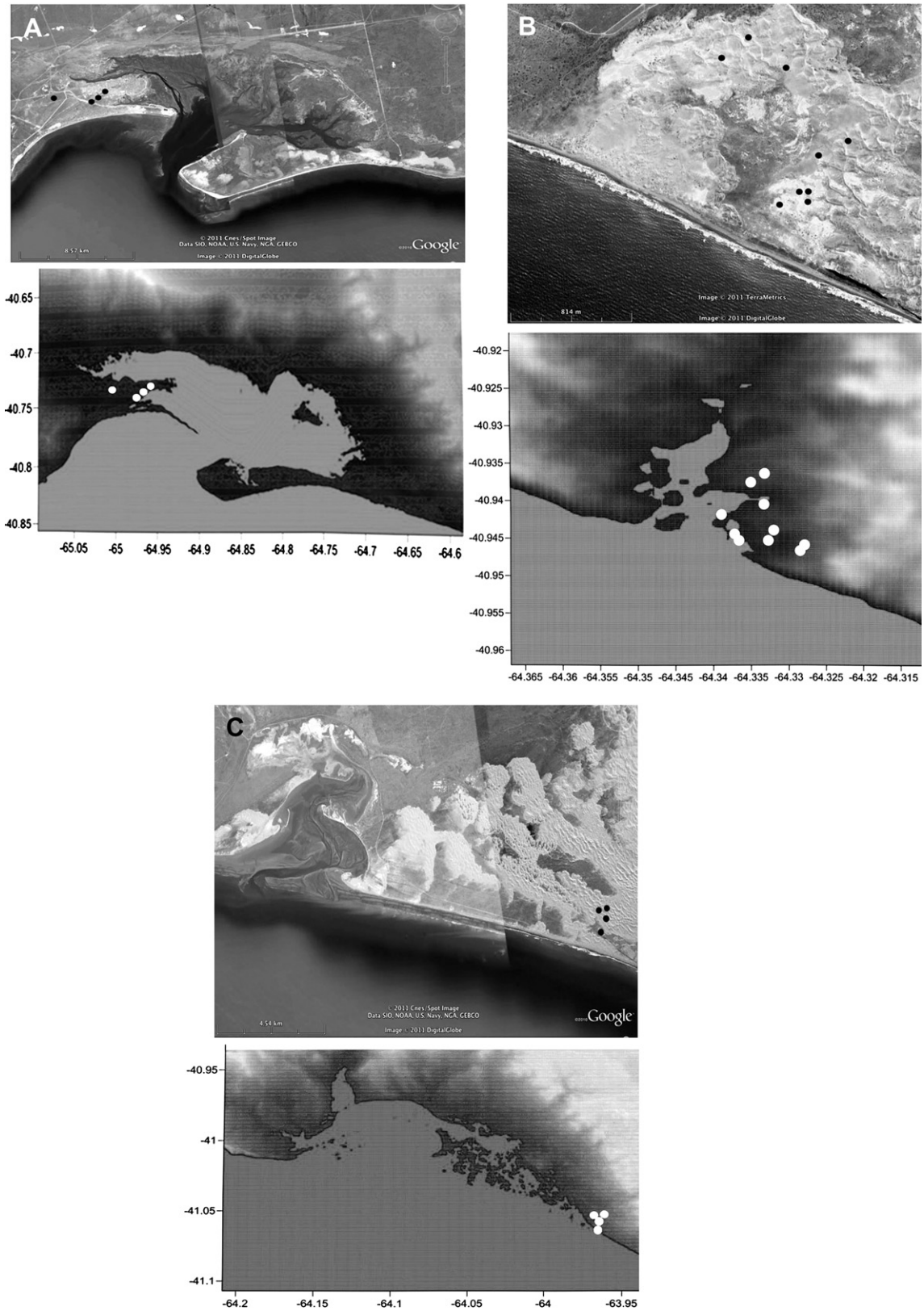

Fig. 3. Present view and simulated scenarios generated by an increase in sea-level at the three localities under study. The simulations approximate the shoreline to the fishing sites dated between ca. 6000 and ca. 4000 ^{14}C BP. This approximation is better in BSA (3a, 8 m asl) than other localities as BQ (3b, 7 m asl) or BC (3c, 10 m asl) due to the presence of high dunes that introduce topographic modifications in the last two.

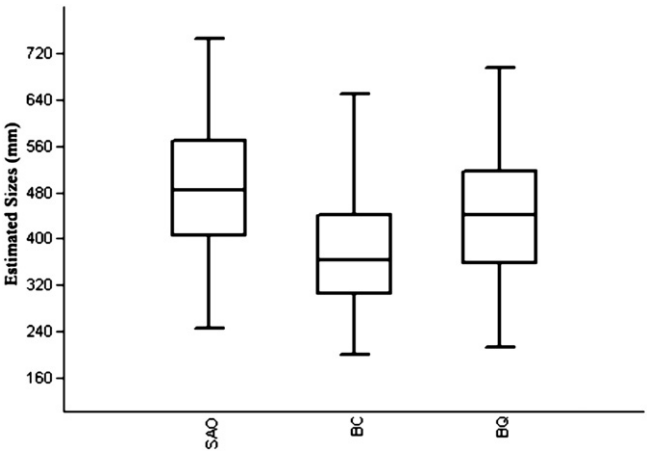

Fig. 4. Box Plot of white croaker sizes at each locality (mm). Notice the overlap in the distribution of the same.

In areas with a great density of surface remains (Fig. 2), the collection of these structures consisted in setting up grid-squares (e.g. 2 m × 2 m), whereas in places with a lower density the collection was time-based. This methodology was similar to that set up for the sampling of lithic artifacts in the area under study, which has made it possible to evaluate the archaeological record's distribution, density and composition in the different sectors (Favier Dubois et al., 2008).

The sizes of the white croakers were estimated by means of the allometric equations proposed by Volpedo (2001), based on the size of the otolith. The methodology used was similar to that of previous works (Scartascini et al., 2009). First, the maximum length of the otoliths (OL) was measured in mm with a digital caliper with an error under 0.01, and it was compared with allometric data known at the present time (Volpedo, 2001). From this the functional relationships between the total length of the fish (TL) and the otolith length (TL *vs.* OL) were calculated, according to the descriptions of Volpedo and Echeverría (2000). The application of these equations allowed an accurate estimation of the size of the white croaker consumed by human groups in the past (Fig. 4, Table 4).

Close to the fish remains a great number of pebbles of a flat section and oval or sub-oval contours, with side-notches, were recovered (Fig. 5). These artifacts recovered in coastal settings were interpreted by various authors as stone weights (Gusinde, 1982; Massone and Torres, 2004; Gómez Otero, 2007b; Mansur, 2007; Torres et al., 2007; Scartascini and Cardillo, 2009). In the area under study these weights are found on the surface of Pleistocene marine terraces. It is common to find these artifacts somewhat spread out, for which reason it was decided to use grid-squares of variable size once they were identified in the field. In these squares, abundant lithic debris, rock cores and numerous denticulate tools that can be associated with the first stages of fish processing were recovered.

Table 4
Descriptive statistics of estimated sizes (mm) for white croaker in the three localities.

	SAO	BC	BQ
N	178	154	306
Min	243	197.55	209.88
Max	745.4	648.8	693
Mean	484.49	376.07	441.31
Variance	12185.3	9790.41	11831.5
Stand. dev	110.38	98.94	108.77
Median	481.5	361.01	439.1

The variables that were taken into account to describe the stone weights were technological and metrical: type of raw material, type of modification (abrasion, percussion, etc.), modification axis, length/breadth/thickness (mm), weight (g). However, for the purposes of this work, only the weight of the artifacts is evaluated, and the remaining variables are mentioned without an in-depth analysis (for a complete report see Scartascini, 2010).

4. Results

In the three research localities, human occupations are recorded as from the Mid-Holocene, and at those times the archaeological evidence is very similar in the three cases. This is so not only as regards the type of record (white croaker otoliths, stone weights, as well as lithic debris, rock cores and denticulate tools) but also their location context: elevated Pleistocene spits (between 15 and 25 masl) up to 2 km inland from the present shore, which border ancient coastlines actives during the Mid-Holocene (Favier Dubois et al., 2009) (Figs. 2 and 3a, b and c). The formation of these spits in the Pleistocene, their evolution and utility as fishing sites during the Holocene transgressive maximum has been specially studied in the case of BQ locality (see Favier-Dubois and Kokot, in press).

Radiocarbon dates obtained from the otoliths in the northern coast of the San Matías Gulf place fishing activities between ca. 6000 and ca. 5000 ^{14}C BP at BQ and BC, and with greater continuity, between ca. 5300 and ca. 890 ^{14}C BP in the BSA (Table 3). The calibration of radiocarbon ages and ΔR correction of marine samples does not modify significantly this panorama: however, it moves the older ages further back and brings forward the more recent.

The coastal scenarios in which the ancient hunter-gatherers carried out their fishing practices were very different from those that can be seen nowadays in those localities. The high sea-level recorded for this littoral between ca. 6000 and 4000 ^{14}C BP inundated spaces between elevated Pleistocene spits and fluvial canyons, giving rise to the formation of small inlets and canals in

Table 3
Chronology and context of archaeological evidence related to fishing in the three analyzed localities.

Sector	Archaeological evidence	^{14}C age (yr BP) and sample dated	Calib. range (yr BP)	Geomorphologic context
Bahía de San Antonio (10 + *loci*)	Otoliths, lithic weights, fish bones in shell-middens	5290 ± 39 (AA77304) shell-midden's charcoal	5922–6170	Pleistocene terrace (spit margins)
		4560 ± 80 (LP1900) white croaker otoliths	4638–4850	
		3210 ± 70 (LP1964) white croaker otoliths	2922–3131	
		890 ± 80 (LP 2235) white croaker otoliths	437–591	Holocene terrace (beach ridges)
Bajo de la Quinta (20 + *loci*)	Otoliths, lithic weights	6080 ± 80 (LP1904) white croaker otoliths	6412–6602	Pleistocene terrace (spits & canyons)
		4980 ± 90 (LP2312) white croaker otoliths	5224–5459	
		4800 ± 70 (LP2456) white croaker otoliths	4947–5208	
Bahía Creek (8 + *loci*)	Otoliths, lithic weights, shell-middens	5310 ± 60 (LP2317) shell-midden's valves	5725–5901	Pleistocene terrace (spits & paleocliff)
		5110 ± 80 (LP2321) white croaker otoliths	5363–5571	

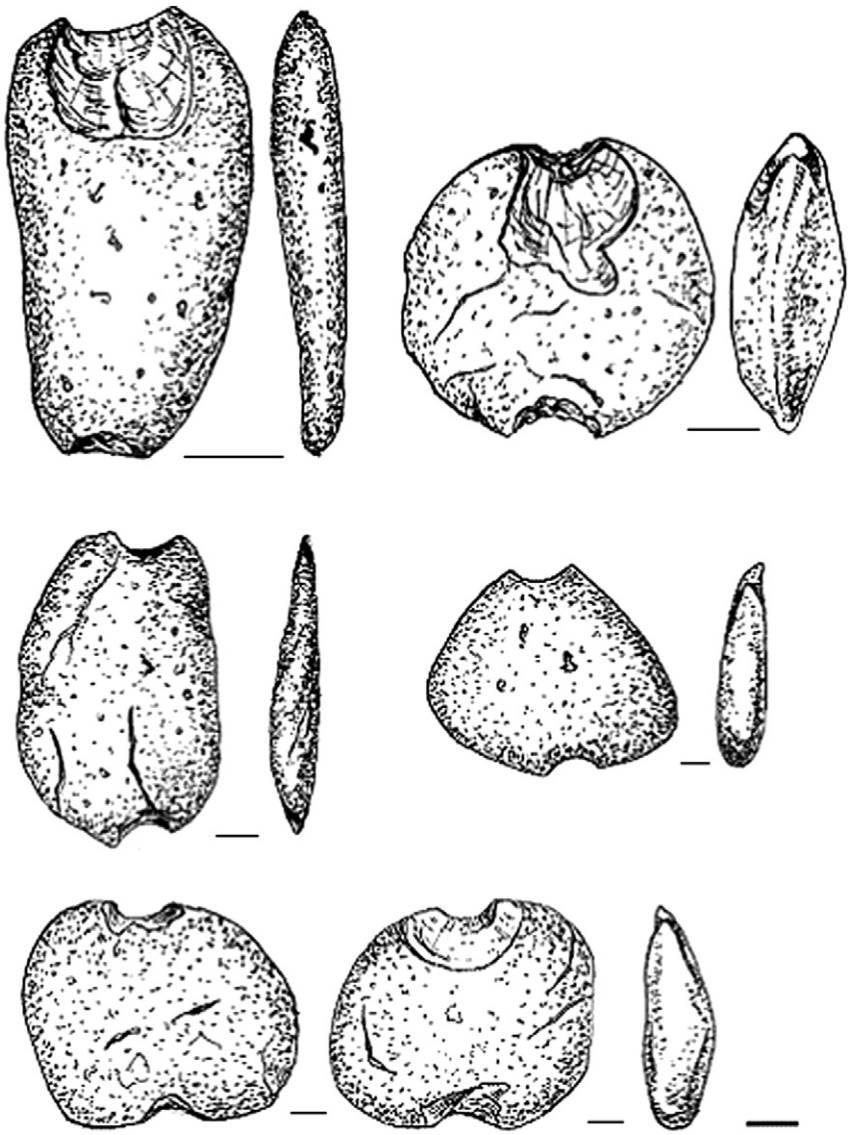

Fig. 5. View of the stone weights recovered in the study area. Horizontal bar is 1 cm. (Drawing: M. Cardillo).

what was then a very irregular coastline (Fig. 3 a, b, c). In this context the use of nets will have provided an abundant catch, for instance by setting them in a transversal direction to that of the canals dominated by the tides. Added to this is the macro tidal regimen of this seaboard (up to 9 m in the Bahía de San Antonio), favorable both for the use of nets as for other possible techniques of mass capture (e.g. trapping, enclosing) (Von Brandt, 1984; Torres, unpublished).

Those coastal scenarios differ considerably from the ones existing today, the product of geomorphologic evolution after the marine transgression, which has tended to fill in and straighten the coastline, particularly at BQ and BC. In the BSA, the fishing scenario enjoyed greater continuity. This is indicated by dating of otoliths recovered from a Holocene terrace close to the present shore, which provided an age of 890 ± 80 ^{14}C BP (calibrated range 437–591 BP, Table 3). However, the analysis of these materials is not included in this work.

The Mid-Holocene coastal scenarios show a high density of otoliths at three localities, of which Bajo de la Quinta is the one that shows the highest frequency of finds. In general terms, fishery played a fundamental role in all. Altogether, the sample obtained from sites dated between ca. 6000 and 3200 ^{14}C BP (Middle Holocene) contains 320 individuals.

The metric analyses showed that the three localities have specimens of similar size. However, it was found that those of SAO are larger on average than those of BQ and BC, and the differences are significant ($F = 44.81$ $p < 0.01$). The data show that all three samples are dominated by medium to large specimens; the majority of them adults, taking into account that white croakers reach their sexual maturity with lengths above 340 mm in males and 360 mm in females (Cousseau and Perrota, 2000). A great dispersion of the estimated sizes is found in the three localities (Fig. 4 and Table 4), which would show a mass-capture-strategy (i.e. the use of nets) rather than a selective one (i.e. use of fishing-lines).

With regard to fishing artifacts, the total sample analyzed in this work consists of 269 pieces from the three localities under study. Stone weights are artifacts traditionally related to fishing activities, and are characterized by presenting a simple or little standardized form (Scartascini and Cardillo, 2009). On the coast under study they show a marked homogeneity in their shape and section (discoid), which agrees with the natural shape of beach pebbles. Anthropic modification is represented by lateral notches produced by

Table 5
Descriptive statistics for the weight (gr.) of stone weights in the three localities.

	SAO	BQ	BC
N	79	46	12
Min	21.9	30	43.9
Max	249	303	263
Mean	108.03	123.94	152.09
Variance	3300.21	4017.24	4115.63
Stand. dev	57.44	63.38	64.15
Median	109.6	124.55	146.75

percussion, with their edges abraded so as to eliminate sharpness. Such notches are found on the longitudinal or transversal axes of the piece (Scartascini and Cardillo, 2009) (Fig. 5).

The comparison of technological variables showed that the weights collected in the three localities are similar and present the mentioned characteristics (Scartascini, 2010). Notwithstanding, some differences were observed as to sizes. Analyses showed that the weights from BQ and BC are on average heavier and therefore larger than those of SAO (Table 5), as the raw materials with which they are fashioned (volcanic rocks for the most part) have similar densities.

The results of the technological analyses developed for the weights gathered at SAO, BQ, and BC would indicate similar capture techniques in the different sectors. The analyses suggest that in the three localities implements of the same type were used, which varied in size and weight perhaps owing to each of the environments having somewhat different characteristics as regards the geometry of each sector, depth, substrate and strength of the marine currents, among other variables. In the case of SAO, where the smaller (less heavy) weights were found, this could be connected with an adaptation (technological performance) to a more sheltered, half-closed milieu, as the Bahía de San Antonio is.

5. Discussion

The northern shore of the San Matías Gulf shows plentiful ichthyoarchaeological evidence with a clear evidence of fishery technology, which is a unique example in the region. During the Mid-Holocene, fish was a systematically exploited resource on this seaboard. The evidence suggests that the occupation of the area took place in close connection with this kind of resource. Fishery has the advantage of being a predictable resource, safe and easy to capture by the use of suitable technologies. As Erlandson (2001) points out, fish obtained in abundance can furnish large quantities of proteins and calories, occasionally greater than those provided by land species. The exploitation of the regional ichthyofauna took shape according to planned strategies that allowed the colonization of the coastal environments of the Mid-Holocene according to the evidence encountered.

This work has shown that those ancient scenarios, with a higher sea-level than the present, favored the mass-capture of fish, as many species have gregarious habits and reach the coastal shallow waters in groups (Cousseau and Perrota, 2000). The most common record is that of the white croaker, but a more varied ichthyofauna must have been caught, which cannot be archaeologically detected, among other reasons, because of the differential surface preservation of fishbone elements. White croaker otoliths are comparatively much larger than those of other species, denser and very robust, with a spherical morphology, aspects that undoubtedly favored their preservation and archaeological visibility (see Falabella et al., 1994).

Large-scale fishing is indicated, besides, by an independent line of evidence, the technological, which shows the existence of fishing implements and associated artifacts, with similar characteristics in the three areas. As a result of previous studies (Scartascini and Cardillo, 2009; Scartascini, 2010), it has been proposed that these stone weights are artifacts connected with fish-nets. The main reasons to support this statement are: 1. The limited variability in morphology, size and weights observed, though it must be borne in mind that the distribution and sizes of the weights can show a slight variation according to the environment and the way in which the net was used (Torres, unpublished and b; Scartascini and Cardillo, 2009); 2. The discovery of these pieces concentrated in limited spaces, which agrees with what was observed in other sets of net-weights from other regions (Greenspan, 1998; Torres, unpublished, 2007b); 3. The recovery contexts are exclusively elevated sectors on the edges of ancient coastal inlets with a very suitable morphology for the use of nets: and 4. The profiles of fish-sizes corresponding to specimens caught by the use of fishing-nets (Greenspan, 1998) agree with the distribution of sizes obtained in the localities analyzed here.

With regard to the environmental framework in which fishing activities developed, the paleoclimatic Mid-Holocene scenario corresponds to the more arid conditions recorded for the Holocene in the northeastern region of Patagonia (Schäbitz, 1994, 2003). The consequent impoverishment of the terrestrial ecosystems at that time would be favorable for the colonization of spaces with sustained productivity, such as the maritime littoral (Bailey and Milner, 2002). Therefore, the northern coast of the San Matías Gulf possesses a high marine productivity and biodiversity, due both to its situation in the transition zone between the Argentine and Magellan biogeographic regions and the variety of coastal environments that exist (Capítoli, unpublished). In addition, this region possesses a relatively temperate and humid climate compared with other sectors of the Patagonian coast and has numerous freshwater sources in the dune-fields that develop in the coastal entrances (Olivares and Sisul, 2005; Favier Dubois and Borella, in press). These particular conditions were able to favor the colonization of this littoral and the intensive exploitation of its resources from early on, as the record of fishing activities in 6000 ^{14}C BP suggests. As Borrero and Barberena (2006) have posited, in semi-arid regions marine resources can represent the only way to intensification.

Finally, the use of digital elevation models as a complement to geomorphologic studies turned out to be a tool of great value, which allowed the graphic visualization of changes in the evolution of the coastline on a regional scale. This tool, however, offers certain difficulties in its manipulation, among them its low resolution, which prevents the complete and precise modeling of the landforms (stable or mobile) and the need for debugging and correcting errors and missing data. However, this computer tool presents the possibility of obtaining spatial consistency on a regional level, offers general topographical information (though limited due to the source data and present relief), allows it to be manipulated with computer programs (S.I.G.) and is free. It can be considered that, regardless of its shortcomings, it is a very valuable resource for those studies that seek to understand landscape changes on a medium scale, as was the intention of this work.

6. Conclusions

For the Mid-Holocene there is evidence of intensive fishery at very favorable coastal scenarios, which show similarities in the three localities that were studied. The abundant Pleistocene spits and small canyons inundated by seawater gave shape to an irregular coastline with numerous inlets, today indistinct due to its gradual infilling (see Favier-Dubois and Kokot, in press, for the case of BQ). It was possible to evaluate these Mid-Holocene scenarios by means of geomorphologic studies and digital modeling.

As these are all surface sites, the evidence of fishing activities has been biased by the taphonomic history of the assemblages, consisting mainly of the presence of white croaker otoliths and stone weights on the surface. Despite their distribution and density, they are sufficient to stress the importance and intensity these practices had during the Mid-Holocene, resting at the same time on paleodietary values obtained from human remains at this time (Table 1).

The strong and significant ichthyoarchaeological signal present ca. 6000 ^{14}C BP (calibrated range 6412–6602 BP, Table 3) implies a clear knowledge of the environments, the resources, technologies, and fishing gear that point to previous settlements in the area, undetected at present. The practice of intensive fishery on the north shore of the San Matías Gulf is unprecedented on the Atlantic coast of Patagonia, and currently represents a unique case along the whole of its length. Archaeological sites on the Patagonian Atlantic littoral reveal the presence of mollusc, sea-lion, and sea-bird remains, but a very small number of fish remains (Mansur, 2007; Gómez Otero, 2007b; Arrigoni et al., 2008; Borrero et al., 2008; Castro et al., 2008; Moreno, 2009). This shows a great contrast with the emphasis fishing seems to have enjoyed in the area under study, indicated not only by surface otholiths, but also by the abundant amount of fish remains recovered from shell-middens in the different localities (Scartascini, 2010; Borella et al., in press).

On the southern coast of Buenos Aires province, north of the San Matías Gulf, there is a clear sign of fish consumption (Martínez et al., 2005; Aldazabal et al., 2007; Stoessel, 2010). However, in many of these contexts fresh-water species predominate over the marine, and the fishing practices would be one of several intensification strategies developed during late-Holocene times in the area (Martínez et al., 2005, 2009; Martínez and Gutierrez, 2004; Stoessel, 2010).

A sector where a heavy dependence on fishing activities was observed is the Pacific northern Patagonian coast of Concepción (Bío-Bío region, Chile). At the Playa Negra site, archaeofaunal studies showed an intensification of resources developed on the basis of fish as early as the Mid-Holocene settlements and, as on the northern shore of the San Matías Gulf, the presence of stone weights was documented, as well as fishing lines (Torres, 2007b).

In the case study area, the arid conditions that prevailed during the Mid-Holocene in northeastern Patagonia must have represented a favorable framework for the resettlement of populations in the region by encouraging the colonization of coastal areas and perhaps generating “archaeological silences” or gaps in the human occupation of some interior places, remaining to evaluate. This might help explain the early development of these practices on the shore of the San Matías Gulf, favored additionally by its particular configuration at the time of the marine transgression, as has been shown by geomorphologic studies (Favier-Dubois and Kokot, in press) and the sea-level simulations presented here. In sum, the studies carried out indicate that fishing practices were intense during the Mid-Holocene in the north of the San Matías Gulf for at least two millennia, reflecting an early coastal adaptation which at the moment seems to have been unique along the whole Atlantic coast of continental Patagonia.

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