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White croaker (*Micropogonias furnieri*) paleodistribution in the Southwestern Atlantic Ocean. An archaeological perspective

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ABSTRACT

This paper presents strong and well dated evidence of the presence of *Micropogonias furnieri* in areas that are currently out of distribution. This evidence comes from hunter–gatherer archaeological sites along the north Patagonian coast (Argentina). Our results allow us to determine a change in the spatial distribution of *M. furnieri* during the Holocene, which are possibly linked to biogeographic changes in a set of species at regional level. Finally we discuss the potential for archaeological evidence in the service of spatial and biogeographic studies of different species.

1. Introduction and research problem

Zooarchaeological research provides us a perspective to study the biogeographic dynamics of different species over a long time scale (Grayson, 2000). It constitutes a compromise between the paleontological record (of great time depth) and current biology. We can determine changes in the behavior, dispersal and distribution patterns of a species that are not currently observable (Lyman and Cannon, 2004; Lyman, 2011). Thus, it is possible to study the distribution of any species in terms of process and not as the result of a particular or isolated event. However, we have to consider that the archaeological record only represents the selection that human groups made of past biotic communities (Daly, 1969; Lyman, 1994, 1996; Klein and Cruz-Uribe, 1984). This "cultural filter" sometimes fails to reflect the past biotic variability, yet this does not imply the rejection of archaeological faunal data in modern resource management research (See Peacock et al., 2012). This paper presents an extensive analysis of the spatial and temporal distribution of the white croaker (*Micropogonias furnieri*) during the mid and late Holocene in the northern Patagonian coast, based on archaeological assemblages. On this basis, we identify patterns of distribution that do not respond to specific local events or to individual or community behaviors (Reitz et al., 2009; Wolverton et al., 2011; Zangrando and Martinoli, 2011). We evaluate multiple factors involved in the formation processes of the archaeological record, their preservation potential, and methodological issues associated with sample recovery, identification and quantification (Behrensmeyer et al., 2000; Borrero, 2004; Lyman, 2010).

Initial results of archaeological research carried on in the San Matías Gulf Coast (Río Negro Province, Argentina) present evidence of intensive and systematic consumption of fish from the middle Holocene (*ca.* 6000 years BP) to the late Holocene (*ca.* 400 years BP) (Favier Dubois et al., 2009; Scartascini et al., 2009; Scartascini, 2010). The diversity of fish remains recovered reflects the typical species of the Patagonian coast: argentine sea bass (*Acanthistius brasilianus*), patagonian blennie (*Eleginops maclovinus*), and South American silver porgy (*Dipludus argenteus*) (Scartascini, 2010). However, archaeofaunal studies have shown a marked predominance of white croaker (*M. furnieri*—diagnosed mainly by otolith sagitta) over the other *taxa* (Favier Dubois and Scartascini, 2012; Scartascini et al., 2009; Scartascini, 2010). Despite this, *M. furnieri* is not currently present in the area. The southern limit of its current distribution is along the Buenos Aires coast (San Blas Bay 40° 33′08″ S, 62° 14’04″ W), about 200 km northwards (Fig. 1).

The aim of this work is to determine temporal changes in the distribution of *Micropogonias furnieri* based on the

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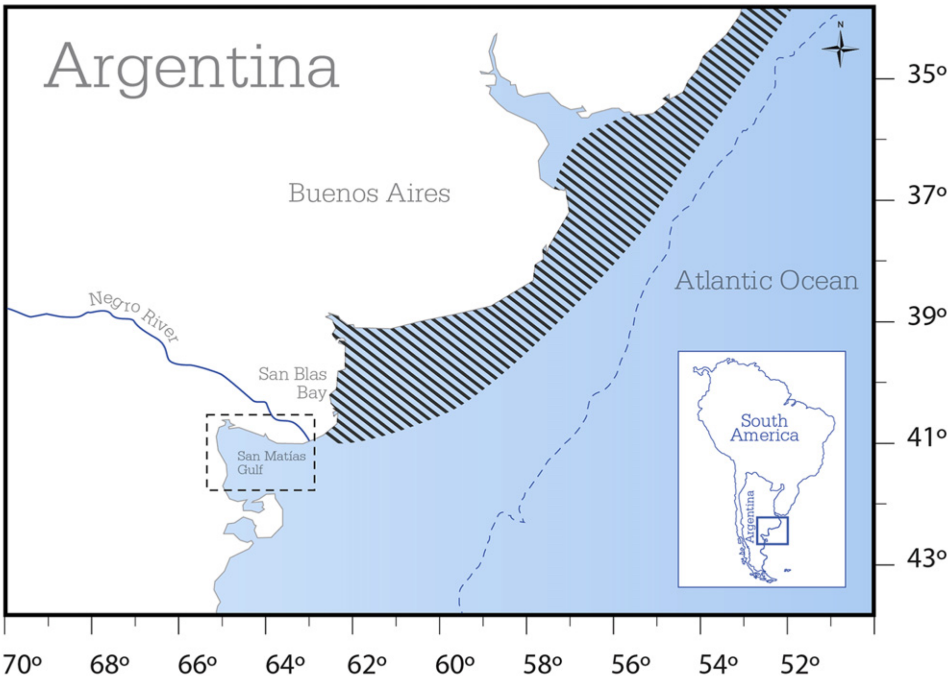

Fig. 1. *Micropogonias furnieri* distribution in the Argentinean coast (Modified from Cousseau and Perrotta, 2000). Note the study area indicated.

ichtioarchaeological record of the San Matías Gulf coast. We integrate bioecological information on the species, historical data (landings, fishery statistics, and interviews with fishermen) and archaeofaunal evidence linked to the consumption of this species over the last 6000 years. Finally, we consider possible causes of the present day absence of this resource and the place of zooarchaeology as a methodological tool in these studies.

2. Background

2.1. Study area

The San Matías Gulf is the second largest coast in Argentina covering approximately 20,000 km^2 (Fig. 1). Recent research suggests its origin may be related to ancient continental depressions of hydro-aeolian origin, with sea flooding and consequent formation of large interior lakes (Ponce et al., 2011). The gulf is a semi-enclosed area, separated from the continental shelf by a socket 80 m in depth, reaching 200 m in depth at its core, which gives it a bowl-shaped form (Servicio de Hidrografia Naval, Carta Náutica H-214, Armada Argentina). Much of the year this favors the formation of a zonally-oriented thermohaline front near 41° 50′ S, which separates the warm saline waters of the northern area from the colder and less saline waters in the southern area (Tonini, 2010). At these latitudes there is a transition zone between two biogeographic provinces: the Argentina and the Magallanica (Menni, 1983). This process creates a multi-species fishing complex, which is under the jurisdiction of the Río Negro province (Di Giácomo et al., 2005).

The climate of the region is semi-arid, with a mean annual temperature of 15 °C and annual rainfall less than 300 mm. Vegetation is shrubby and typical of the Patagonian Monte region (Cabrera and Willink, 1980). Tides are semidiurnal and have a macro tidal regime, with mean amplitudes of 6.38 m and a maximum of 9.22 m at syzygies at the port of San Antonio Este, on the San Antonio Bay (Servicio de Hidrografía Naval, 2009).

2.2. Biology of the white croaker (M. furnieri)

The white croaker is a marine species currently distributed from Veracruz, Mexico (20° 20′ N) to El Rincón, (39° 00′ S) Argentina, and it can be found very rarely in the northern coast of the San Matías Gulf (40° 00′ S) (Cousseau and Perrotta, 2000) (Fig. 1). The distribution of this species is limited primarily by salinity; it can live in coastal areas between 4 and 30 PSU (Practical salinity units) and inhabited soft bottom (sand and mud) (Jaureguizar et al., 2003; www.fishbase.org). Its diet consists mainly of bottom organisms (polychaetes, bivalves, snails, shrimp, other small crustaceans) and—to a lesser extent—small fish. It breeds along a wide strip of coastline, from spring to early summer (October to December). The average size at maturity (aged four to five years) is 34 cm in males and 36 cm in females (Isaac, 1988). Juveniles stay in shallow waters (Jaureguizar et al., 2003) and even penetrate streams and lakes that flow into the sea. It is a long-lived species, with a maximum-recorded age of 30 years.

Currently, the white croaker is one of the main fishery resources in the region. The 2009 catch in Buenos Aires was 26,601 tons, while the 2011 catch was 28,478 tons (Ministerio de Agricultura, Ganadería y Pesca, 2011 http://www.minagri.gob.ar). Analysis of fish stocks in the Argentinean coast suggests the presence of at least two populations of *M. furnieri*: one each in the southern and northern areas of the Buenos Aires province (San Blas Bay and Samborombón Bay, respectively) (Volpedo and Fernández Cirelli, 2006; Volpedo et al., 2007), but never southwards of the Negro river.

3. Materials and methods

Three main sources of data are used here: a) current biological data on the species; b) historical landing information and fishery statistics in the study area (which includes interviews with local fishermen) and c) zooarchaeological studies of otoliths recovered in the study area, providing temporal depth to the biogeographical study.

The first step was the analysis of the historical catch data of white croaker in the Patagonian and Buenos Aires coast. These statistics come from the Argentinean Ministry of Agriculture, Livestock and Fisheries (SAGPyA), bibliographic records of fishing in the area (Carozza, 2010; Llompart, 2011; Rojo and Silvosa, 1969, 1970) and informal interviews with local fishermen. The interviews were conducted during August 2011 in the town of San Antonio Oeste, Río Negro (Argentina). A total of seven fishermen were interviewed with a scheduled survey of 20 questions. Respondents were asked about the presence/absence of the species in the area, catch size, areas and the fishing technique employed. These interviews are part of a larger program that seeks to organize local fishing data established from various studies and approaches. Here, we present the basic information of respondents and the data related to *M. furnieri*. The criteria used in selecting fishermen for interviews were number of years fishing in the area and the kind of fish caught. The interviews used in this paper correspond to fishermen with more than 50 years of experience in local artisanal fisheries (Table 1).

Finally, the archaeological sample consists of 1134 white croaker *sagitta* otoliths collected in different areas of the San Matías Gulf coast. We have used sample units of 2 × 2 m in higher density areas and 4 × 4 m in lower density areas. This methodology is similar to that used to sample lithic artifacts in the San Matías Gulf coast (Borella et al., 2009). It has allowed us to assess variations in the distribution, density and composition of the zooarchaeological record. A number of otoliths were dated by conventional ^{14}C methods, yielding *taxon* dates for different coastal areas. The samples were separated into two large blocks of time: early (between 6000 and 2000 uncalibrated years BP) and late (between 2000 and 400 uncalibrated years BP).

To characterize the structure of the archaeological sample, we analyzed the morphology of otoliths using terminology proposed by Volpedo and Echeverría (1999, 2000), and we estimated croaker size by applying allometric equations proposed by Volpedo (2001). Otolith shape is species-specific (Tuset et al., 2008; Volpedo and Echeverría, 2000), because of this, thru the morphological analysis we could determine the species in all cases. Finally, we have integrated the diverse sources of data to build a map that details the past distribution of the resource—evident from the zooarchaeological analysis conducted in the study.

4. Results

4.1. Historical information

The large-scale commercial fishing in San Matías Gulf did not develop until 1970. Statistics and landings for this period not referred to *M. furnieri* among the species caught (Romero et al., 2008). Despite this, striped weakfish (*Cynoscion guatucupa)*—a species usually associated with white croaker in the area of El Condor—has been caught with bottom trawls in the gulf coast (years 2003–2007). Early reports from the 1960s (before significant fishing efforts in the gulf) never mention the white croaker in catches/landings. The first research on fishing conducted in the area yielded similar findings (Rojo and Silvosa, 1969).

There are, also, no historical records of white croaker catch by artisanal fishery in the San Matías coast. Of six sources surveyed (all available), there is no mention about *M. furnieri* as one of the species caught in the area. There is one registry of *M. furnieri* coastal fishing in the Black River mouth, but never southernmost (González, 1994). Nevertheless, there are records of argentinean silverside (*Odontesthes argentinensis*) and other coastal species during the years 1950–1960 in the area of Caleta de los Loros (See Fig. 4) (Poder Ejecutivo de la Provincia de Río Negro, 1962).

4.2. Local fishermen interviews

Artisanal fishing has been practiced since the beginning of this century at San Matías Gulf, both for family subsistence and commercial purposes (Lefebvre, 1977). No more than a hundred of fishermen are involved in the marine artisanal fishery in Rio Negro, most of them linked to the Patagonian squid (*Octopus tehuelchus*) fishing (González, 1994).

All respondents agree that the white croaker has not been in the area since at least the 1970's. They also comment that during that time *M. furnieri* was not commonly seen beyond the Negro river mouth (Fig. 1). In any case, the comments of all respondents showed that the white croaker was not a historically abundant resource. Their catch was an occasional and/or opportunistic event. The fishermen responded with more certainty regarding other *scianids* species, such as black sea bass (*Pogonias chromis*) and striped weakfish (*Cynosicion guatucupa*), which were more conspicuous in the past and are occasionally observed today.

4.3. Zooarchaeological evidence

The sample consists of 1134 croaker *sagitta* otoliths collected in different areas of the San Matías Gulf coast (Table 2). They correspond to a minimum of 540 individual fish. The remains were scattered on the surface of various archaeological sites, alongside other materials (specially lithic debitage and lithic net weights), and appear superficially in great concentrations on Holocene and Pleistocene marine terraces related to a higher sea level during the mid-Holocene maximum transgression (Favier Dubois and Kokot, 2011; Favier Dubois and Scartascini, 2012). In some cases the otoliths densities exceeded 22 specimens per square meter (Scartascini et al., 2009), this implies at least 11 individuals (Fig. 2).

The otoliths collected are not morphologically different from present-day examples, though some specimens were fragmented or burned and abraded due to exposure to agents of erosion. However the preservation of the sample is excelent, so the

Table 1
Highlights of the respondents.

Name	Age	Years fishing	Type of fishing	Fishing technique	Last sighting, by decade	Last area observed
Leon Baluzinski	64	51	Independent	Coastal net	1960s	Caleta de los Loros
Carlos Loremo	57	50	Independent	Coastal net	1970s	Caleta de los Loros
Armando Ullua	70	64	Independent/ deep sea	Coastal net	1950s	Caleta de los Loros
Geronimo Gonzales	75	70	Independent	Coastal net	1960–70s	Caleta de los Loros/SAE harbor
Hector Ponce	66	50	Independent	Coastal net	1960s	Caleta de los Loros
Juan Lazaro	69	50	Independent	Coastal net	1950s	Bahía Creek

Table 2
List of localities that have produced remains assigned to *Micropogonias furnieri*. (NISP: Number of Identified Specimens; MNI: Minimal number of individuals). *Uncalibrated years Before Present (BP).

Locality	Latitude (S)	Longitude (W)	NISP	MNI	^{14}C age (yr BP) and sample dated*	Reference
1-Rosas Bay	41° 08′	63° 20′	13	8	*Ca.* 3980 BP shell-midden's charcoal	Favier Dubois et al., 2008
2-Creek Bay Paleo-Cliff	41° 03′	63° 58′	176	90	*Ca.* 5110 BP white croaker otoliths	Favier Dubois and Scartascini, 2012
3-Paesani	41° 04′	63° 56′	20	10	*Ca.* 1150 BP carbon	Favier Dubois, 2011
4-Caleta de los Loros	40° 59′	64° 03′	32	22	*Ca.* 2108 BP carbon	Favier Dubois et al., 2009
5-Bajo de la Quinta	40° 56′	64° 19′	321	176	*Ca.* 6080 & 4980 BP white croaker otoliths	Scartascini et al., 2009; Favier Dubois and Kokot, 2011
6-Bajo de la Quinta Coast	40° 56′	64° 20′	159	80	*Ca.* 2197 & 1040 BP shell-midden's charcoal	Favier Dubois and Kokot, 2011
7-Final Bay	40° 51′	64° 31′	9	5	*Ca.* 800 BP human bone	Favier Dubois et al., 2009
8-Faro San Matías	40° 49′	64° 63′	119	62	*Ca.* 2210 BP shell-midden's charcoal	Favier Dubois, 2011
9-Saco Viejo	40° 48′	64° 46′	32	18	*Ca.* 1600 BP white croaker otoliths	Favier Dubois, 2011
10-San Antonio Oeste	40° 44′	64° 57′	230	108	*Ca.* 5290 BP shell-midden's charcoal *Ca.* 4560 *Ca.* 3210 *Ca.* 890 white croaker otolith	Favier Dubois and Scartascini, 2012
11-Piedras Coloradas	40° 50′	65° 7′	13	10	–	–
12-Fuerte Argentino	41° 03′	65° 10′	2	2	–	–
13-Cañadón Ortiz	41° 21′	65° 5′	5	4	–	–
14-Cañadón del Puma	41° 25′	65° 30′	3	2	–	–
Total			1134			

morphological identification and subsequent specific identification, was very easy (Fig. 3).

The mean length of otoliths is 35.09 mm with a minimum value of 13.19 mm and a 65.83 mm maximum. Size estimation displays a wide range of sizes from large juveniles to adults, with the latter group predominating significantly (Fig. 4a). Otolith chronology can be grouped around two main time spans. One time span occurs around 5000 years BP and another around the last 1000 years BP (see Table 2). Are notable the differences observed between these two blocks, both in estimated sizes and in the total frequency of specimens. Analyses show a decrease in the frequency of otoliths in sites post-2000 years BP (N early: 730 *vs.* N late: 281). The sizes in the early span (between 6000 and 2000 yr BP) is on average lower than that observed in the later span (X Early = 447.7 mm *vs.* X Late = 498 mm) (Fig. 4b). Significant differences were observed in the variance of these sets. Because of this we used the *Mann–Whitney* test for unequal variances, which resulted in significant differences between both samples ($U = 0{,}0008$, $p < 0.0001$). Same results shows *Monte Carlo* test ($p < 0.0001$).

5. Discussion

The preservation of zooarchaeological remains is conditioned by the passage of time and by numerous geomorphic and taphonomic factors that threaten their preservation (Behrensmeyer et al., 2000; Lyman, 2003). Nevertheless, the record of white croaker consumption is significant, in relation to their frequency (more than 11 individuals per square meter in some sites) and their spatial and temporal distribution in the north Patagonian coast. Remains of white croaker appear, with variations in frequency, from the mouth of the Negro river to Lobos islet (190 km of coastline approximately) (Fig. 5), and from the middle (*ca.* 6000 yr BP) to the end of the late Holocene (*ca.* 800 yr BP). Consistent over time and in location, this pattern involves the systematic prehistoric exploitation of an abundant and known resource by human populations. Total sample fish size analysis suggests a population structure dominated by adults and a small proportion of large juveniles (sizes between 240 and 360 mm). Though the otolith sample presents variations over the time, it was observed that otolith frequency

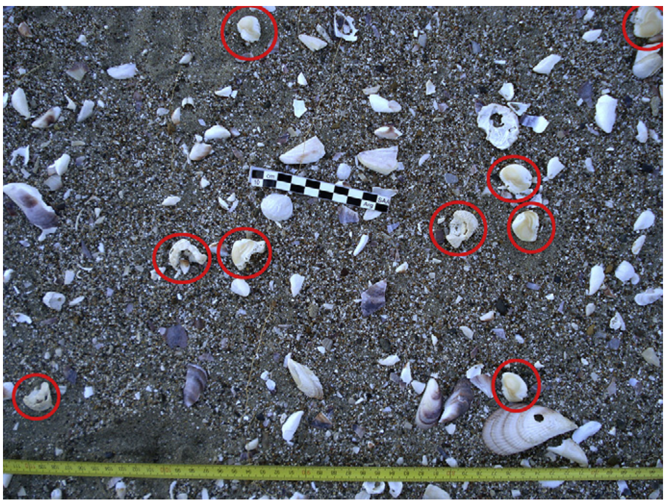

Fig. 2. *Micropogonias furnieri* otoliths *in situ*. Note the frequency and the density in Faro San Matías locality.

Fig. 3. Current and archaeological otoliths of *M. furnieri*. Note the morphological similarities and the good preservation of archaeological specimen.

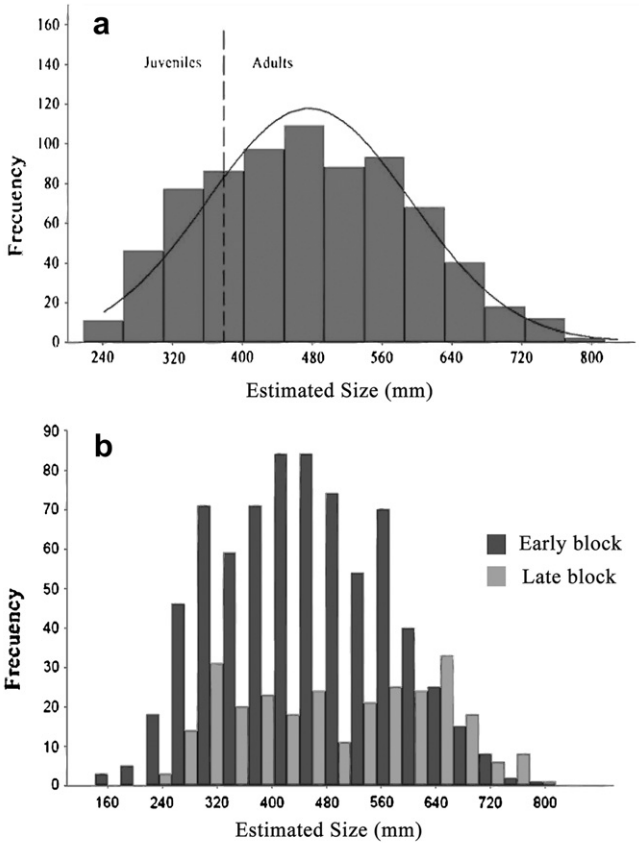

Fig. 4. a) Histogram of estimated size frequencies of *Micropogonias furnieri* total sample. Adults are observed to predominate in the structure of the population. b) Samples divided by chronological blocks. Note the differences in the frequency and the estimated size. Note also that the late block distribution (gray) has a bi modal structure.

drops significantly in the late Holocene (after 2000 yr BP). This pattern is contrary to what would be expected in taphonomically biased contexts, where the earliest record are potentially poorly preserved. If we assume that the estimated sizes are a sensitive indicator of the exploited population's structure, we are able to make behavioral and ecological inferences from the data of similar present-day populations. Significant variations in fish sizes caught over time are also noted. Smaller size and increased variability were observed during the old sets. However, this aspect may be strongly linked with the human fishing techniques used in the past. Previous papers (Scartascini et al., 2009; Scartascini, 2010) noted differences in fishing gear over time. We proposed a mass-harvesting fishing technique (nets) for much of the Middle Holocene, and a more selective one (lines) for the last 2000 years. 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 and mixed-continental signal during the last 2000 years (Favier Dubois et al., 2009).

In 2009–2010, in the San Blas Bay area, maximum sizes in catches of croaker ranged from 420 to 696 mm, with an average of 561 mm (Llompart, 2011). About 5% of the archaeological population is larger than the individuals caught today (>696 mm); mean values are in the range of what is currently found in the northernmost record of the species. We can conclude that the archaeological population was very similar to the current population but with a wider distribution in the San Matías Gulf.

The current absence of white croaker in the San Matías Gulf contrasts with the frequency and continuity of the species record during the middle and late Holocene. This allows us to pose several questions. What changes occurred to the environment to make it unable to sustain the species?; Was the human activity a factor?; When did this happen?; Does this phenomenon have paleoenvironmental implications?; What are they? How can we study them?; What can zooarchaeology add to this discussion?

One possibility is that the significant past presence of *Micropogonias furnieri* is linked to changes in coastal environments, especially when they involve changes in the coastline in some areas of the Gulf (Favier Dubois and Kokot, 2011; Favier Dubois et al., 2009). Geomorphological studies conducted in the northern area of the Gulf showed that what today appears as a relatively straight coastline, in the past, more specifically during the mid-Holocene maximum marine transgression was an area characterized by protected environments, such as bays cuts, where the sea penetrated the continent. If this was the case, these protected areas with soft bottoms may have functioned as ideal environments for the breeding and spawning of many fish species including the croaker

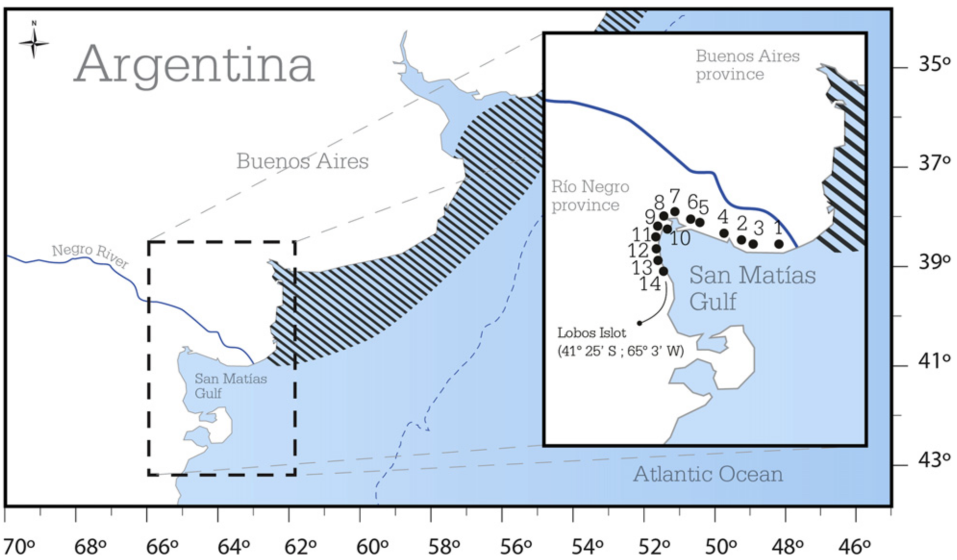

Fig. 5. Paleodistribution of *Micropogonias furnieri* from beginning of archeofaunistic record (See localities names in Table 2).

(Deegan, 1990; Wright, 1988). Different works in nearby areas showed that *M. furnieri* uses this type of environment to breed and spawn (Lasta, 1995; Jaureguizar et al., 2003). With this in mind, it is possible that in the past the croaker used certain areas of the San Matías Gulf coast as nursery environments. Similarly, hunter–gatherer groups could have had access without major obstacles to a large number of juvenile and adult fish. Over time, when these environments no longer existed due to growing coastal accretion during the late Holocene, some species of fish, including the croaker, may have experienced changes in their biogeographic patterns. Today, the San Blas Bay Area and Anegada Bay in southern Buenos Aires province are the environments that support the southern fishing stock of the white croaker (Volpedo and Fernández Cirelli, 2006; Volpedo et al., 2007).

However, this hypothesis has two major problems. First, although spatially restricted, the San Matías Gulf coast currently has environments similar to those that existed in the past, i.e., marine protected environments and vegetation starters. Second, the current coastal configuration was established about 3000 years BP, and yet there are many archaeological remains of white croaker after that time. In any case, we should assess changes in the coastline in the context of major changes, including changes in seawater temperature, salinity and bio-marine productivity. This issue is well-addressed in a recent paper by Favier Dubois et al. (2009). Those authors found isotopic trends (^{18}O) marking a decrease in temperature and bio-productivity (^{13}C) to current levels, in a period from 4000 years BP to the present, in the northern coast of the San Matías Gulf. This process was accompanied by increasingly arid conditions in continental areas adjacent to the coast, resulting in the formation of large dune fields. In some cases, this buried river drainages (freshwater) to the sea, and therefore could have favored the increase in relative salinity of the seawater.

Another scenario addresses the genesis process of the San Matías Gulf and implications on the population dynamics of marine life. A recent studies by Ponce et al. (2011) points to the feasibility of a San Matías Gulf genesis around 12,000 years BP as part of a process of gradual increases in sea level that could have flooded old low-saline coast after the last glacial maximum (approximately 24,000 calibrated years BP). Because of the Gulf's connection to the continental shelf, it is possible that during its formation some faunal species of the Argentina province (including the white croaker) could have extended its distribution to this new environment as part of meta-populations (see other coastal scienids metapopulations examples in: Gold et al., 2001; Kritzer and Sale, 2004). This seems to be the case observed for other temperate species (*Diplodus argenteus, Pagrus pagrus and Pseudopercis Numidian*, among others) that have extended their home range to the coast of Puerto Madryn (43° S, over 200 km of distribution known) (Galván et al., 2005; Irigoyen et al., 2005; Venerus et al., 2007). For example, the *Epinephelus marginatus* represents a relict population of a serranids, currently distributed in the warm temperate waters of the Argentina province, which could imply that some of these species were present in the San Matías Gulf. Similarly, there is an endemic seahorse species in the San Antonio Bay and San Matías Gulf (*Hippocampus patagonicus*) that would have arisen from other species that lived further north (*Hippocampus erectus*, distributed from the coast of Uruguay to the Caribbean Sea) following a "few" thousand years of disruptive selection. This suggests that once upon a time *H. erectus* (now restricted to lower latitudes) would have been common in the waters of the San Matías Gulf (González et al., 2012).

In summary, then, different elements suggest a complex and changing scenario throughout the Holocene (habitat fragmentation and breeding isolation, among others). This could partly explain the observed changes in faunal communities present today. *M. furnieri* case may be reflects metapopulation level changes over time that are not archaeologically visible. This subpopulation would be the most austral group of *M. furnieri*, which disappeared in the last 1000 years.

Finally, we consider that the disappearance of white croacker in the area is not linked to systematically fisheries since the mid-Holocene, which was intense but responds to a small-scale exploitation by small groups of highly mobility hunter–gatherers (Favier Dubois et al., 2009). Meanwhile the commercial (and large scale) exploitation of this resource began around early to mid twentieth century (that is after the disappearance of the croaker in the San Matías Gulf Coast). In sum, we propose that the human factor would not have had a prominent role in the range reduction of *M. furnier*i. The response to this process may be linked to environmental factors and to ecological and biogeographic aspects of the species. Future studies should conduct specific analysis from other proxies and help us to complete a complex and changing paleoenvironmental picture so we can determine paleodistribution trends of the white croaker with greater certainty.

6. Final words

This study finds that the distribution of white croaker reached southern waters in the past, with a tentative limit near the Lobos islet (41° 25′38 .20″ S 65° 3′55 .20″ O), about 150 km south of San Blas Bay (current limit). We also note a marked decrease in otolith frequency after 3000 years BP. This may be strongly linked to the observed changes in coastal geomorphology and the modification in fishing strategy. Our study presents a data set well-defined and dated that triggers a new set of questions and lines of evidence to study the biogeographic changes of fish communities in south Atlantic. Despite this, there is still much work to be done. A proper paleoenvironmental reconstruction is the product of approaches that link and integrate as many indicators as possible (Grosjean et al., 2003). We need to integrate information from other proxies, shellfish and pollen profiles (currently underway) (See-Marcos and Mancini, 2012). Obviously, all these data must be processed and dealt with individually so taphonomic aspects can be integrated and interpreted. Many papers showed that the archaeological faunal data is a valuable resource to generate discussion about past environments and resource management today (Campbell and Butler, 2010; Grayson, 2000, 2001, 2005; Lyman, 2006, 2011; Wolverton, 2005; Wolverton et al., 2011). From our perspective, it can function as an indicator of information in a meso-scale from a remote paleontological past to ecological studies involving current species (see Wolverton et al., 2011).

This paper then, presents a case study in which archaeological data is used to raise hypotheses and new questions about current biological issues. During this study, we observed strong evidence that implies the conspicuous presence of the white croaker for much of the Holocene on the coast of the Rio Negro province, and the total absence of the species from the historical to present-days. We have outlined some assumptions as arguments; testing these hypotheses is beyond the scope of this paper and should be evaluated in the future with new interdisciplinary work.

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