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MARINE RESERVOIR EFFECT VALUES FROM SHELL-MIDDENS OF SAN MATÍAS GULF, NORTHERN PATAGONIA (ARGENTINA): A 5000-YR RECORD

Cristián M Favier Dubois[1*] • A J Timothy Jull[2,3]

[1]INCUAPA–CONICET–UNICEN, Departamento de Arqueología, Facultad de Ciencias Sociales, Avda. del Valle 5737, B7400JWI Olavarría, Prov. de Buenos Aires, Argentina.
[2]Department of Geosciences and AMS Laboratory, University of Arizona, Tucson, Arizona 85721 USA.
[3]Isotope Climatology Research Centre, Institute of Nuclear Research, 4026 Debrecen, Hungary.

ABSTRACT. Ten marine reservoir effect (R) values were obtained from archaeological shell-middens along the San Matías Gulf, North Patagonian Atlantic coast, Argentina. They were determined by accelerator mass spectrometry (AMS) measurements on marine shell (Mytilidae) and charcoal samples (burned, short-lived plants) derived from a common stratigraphic unit. The R values fluctuate between 205 ± 48 and 358 ± 56 ^{14}C yr BP from ca. 5300 to ca. 700 ^{14}C yr BP with no obvious temporal trend. Calculated ΔR values fluctuate between +30 ± 66 and –162 ± 48 yr during the same time span. Local factors such as restricted connection with the open sea or presence of aged carbonates do not appear to have had an influence on this effect along the gulf coastline. The mean R value obtained (266 ± 51 yr) constitutes a useful value for correcting ages in shells from abundant archaeological deposits recorded in the area since Middle Holocene times.

KEYWORDS: marine reservoir effect, Mid-Late Holocene, Mytilidae, northern Patagonia.

RESEARCH BACKGROUND AND SETTING

Archaeological work carried out since 2004 at the San Matías Gulf (northern Patagonia, Argentina) uncovered plentiful evidence of exploitation of marine resources since Mid-Holocene times by hunter-gatherer groups. The most conspicuous archaeological deposits are shell-middens, which contain faunal remains, lithic artifacts, and numerous charcoal fragments. These shell-middens are discrete accumulations of valves related to events that record the consumption of mussels (*Mytilus edulis* and *Aulacomya ater*). According to ethnographic references and archaeological studies, mussels were dropped into small fires for opening the valves and consumed immediately, discarding the shells in the same fire context (Caviglia and Borrero 1978; Orquera 1999). This practice enables us to compare ages of valves and charcoal to establish reservoir age estimates, also evidenced by other studies (Favier Dubois et al. 2015). The high temporal resolution of these anthropic accumulations enables them to be a good choice for evaluating age offsets due to the marine reservoir effect (MRE). Stuiver et al. (1986) define R as the difference between marine and atmospheric radiocarbon (^{14}C) ages of material that sampled each reservoir at the same time. Stuiver and Braziunas (1993) developed the first model relating calibrated terrestrial ages and coexisting marine material, with this age difference defined as ΔR. The dataset obtained from this study was initially published in a regional magazine (Favier Dubois 2009) but in order to make these results available to an international audience they are presented in this report, with calculated ΔR values.

The San Matías Gulf is located in the northern Patagonian Atlantic coast, comprised mainly by the Río Negro province, Argentina (Figure 1). The area has a semiarid climate with a mean annual temperature of 15ºC and a mean annual precipitation of 300 mm. Strong winds blow from the southwest, dominating littoral currents and coastal dune morphology. Tides are semidiurnal and have a macro tidal regime, with mean amplitudes of 6.71 m and maxima of 9.43 m at syzygies at the port of San Antonio Este, on the Bahía de San Antonio (Servicio de Hidrografía Naval 2016). Vegetation is shrubby, corresponding to the Patagonian Monte, where *Larrea* spp. predominates (Cabrera and Willink 1980).

*Corresponding author. Email: cfavier3@gmail.com.

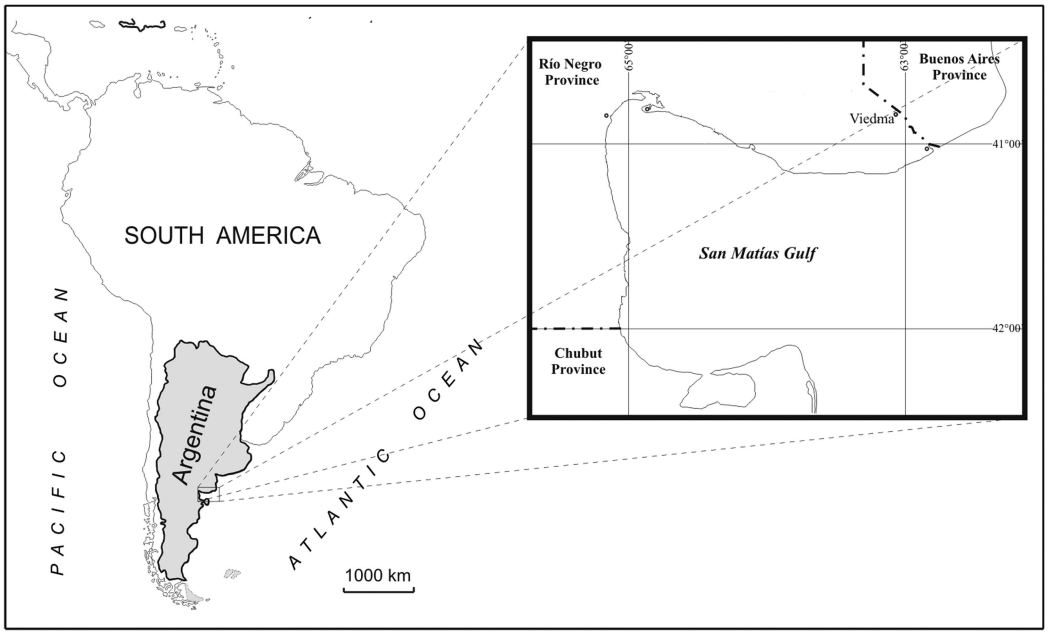

Figure 1 Location of the San Matías Gulf.

MATERIALS AND METHODS

For local MRE evaluation, shell and charcoal pairs were selected from archaeological shell-middens dated between ca. 5300 and ca. 700 ^{14}C yr BP. In each pair, one sample is in equilibrium with the atmospheric reservoir (charcoal) and the other with the marine reservoir (mollusk). Marine samples correspond to meso and infra-littoral bivalves belonging to the Mytilidae family: *Mytilus edulis* (blue mussel) and *Aulacomya ater* (ribbed mussel). They live attached on the rocky littoral platform (i.e. Tertiary siltstones and Quaternary conglomerates) that runs along this coast. Terrestrial samples (charcoal) correspond to burned shrub species that are common in the area, as *Larrea* spp. (Jarilla), *Prosopis* sp. (Alpataco), and *Schinus* sp. (Molle). They are still used today as a source of firewood. Each shell-charcoal pair comes from a single stratigraphic unit (artificial level of 5 cm). Pairs were taken from 10 shell-middens corresponding to six different archaeological localities along the San Matías Gulf (Figure 2).

Samples were chosen following two criteria: (1) specimens from the most ancient to most recent archaeological localities to evaluate possible changes in MRE through time; and (2) specimens corresponding to localities placed in different geographical/geological settings along the northern coast of the San Matias gulf (Table 1), to check local factors. All samples were dated by accelerator mass spectrometry (AMS) at the NSF Arizona AMS Facility laboratories, according to established procedures.

RESULTS

The dating of the archaeological pairs provided 20 AMS ages and 10 age offsets between ca. 5300 to ca. 700 ^{14}C yr BP (Table 2). The age offsets are considered primarily due to changes in the MRE, which we refer to as R (Stuiver et al. 1986). These values do not show noticeable temporal tendencies, fluctuating between 205 and 358 yr (Table 2 and Figure 3). We have also

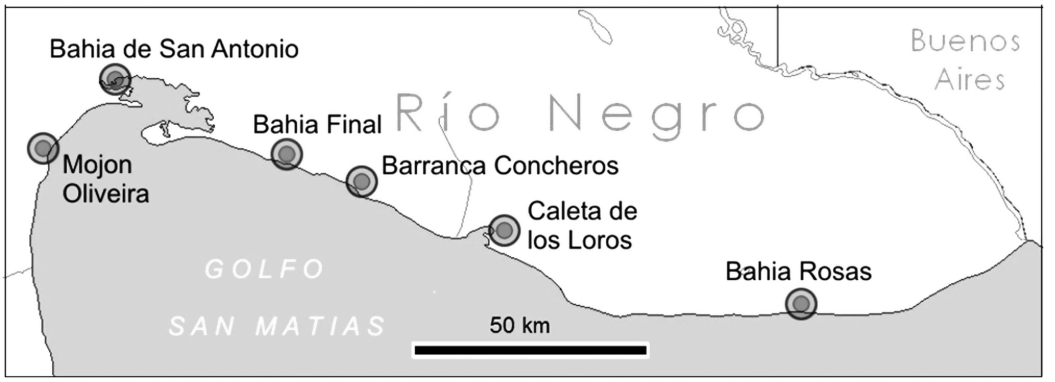

Figure 2 Archaeological localities sampled for MRE studies in northern San Matias Gulf.

Table 1 Position and contextual information of sampled localities.

Location	Lat./long.	Shell-midden context	Local relevant variables
a. Bahía Rosas (BR)	41°09′S 63°22′W	Dunes on marine terrace	Small open bay
b. Caleta de los Loros (CL)	41°01′S 64°07′W	Dunes on marine terrace	Narrow inlet. Restricted connection with open sea
c. Barranca de los Concheros (BCH)	40°55′S 64° 23′W	Colluvial deposits (paleocliff talus)	Open coast. Presence of fossil carbonates on littoral platform
d. Bahía Final (BF)	40°52′S 64°30′W	Dunes on marine terrace	Open coast. Presence of fossil carbonates on littoral platform
e. Bahía de San Antonio (BSA)	40°44′S 64°57′W	Dunes on marine terrace	Almost closed bay. Restricted connection with open sea
f. Mojón Oliveira (MO)	41°09′S 63°22′W	Dunes on active cliff	Open coast

calculated values of ΔR (Stuiver and Braziunas 1993; Reimer and Reimer 2001) using the online interface at calib.org/deltar (Reimer and Reimer 2016). The results do not suggest either a marked influence of local effects as restricted connection with open sea or the presence of fossil carbonates. Our results can be compared to Gomez et al. (2008), who measured ΔR values of –40 ± 46 to +143 ± 46 yr in the Bahia Blanca estuary, to the north of our sampling location.

FINAL REMARKS

The continental Patagonian coast, which is more than 3000 km long, shows a significant variability in ΔR values. This was highlighted by 20 modern shell-plant pairs collected from northern Patagonia to Tierra del Fuego showing ^{14}C age offsets from 80 to 1100 yr (Cordero et al. 2003). We also note that Gomez et al. (2008) measured large values of ΔR from the Quequén River estuary, as well as on the coast of Mar del Plata and Punta Mogotes in Buenos Aires Province. Both these studies demonstrate a marked influence of local factors in some locations along the Argentine coast. In southern Tierra del Fuego (Beagle Channel, Argentina)

Table 2 MRE values from ca. 700 yr BP to ca. 5300 ^{14}C yr BP in northern San Matías Gulf.

Sites (E to W)	Sampled pairs	AMS date (^{14}C yr BP)	δ^{13}C	Lab nr (AA-)	R (^{14}C yr)	ΔR (yr)
1. BR2	Charcoal	3985 ± 41	–25.4	77298	265 ± 57	–38 ± 72
	Shell (*Mytilus*)	4250 ± 41	3.1	77297		
2. CL3	Charcoal	2108 ± 35	–23.6	77300	238 ± 49	–64 ± 58
	Shell (*Mytilus*)	2346 ± 35	2.1	77299		
3. BCH 1	Charcoal	2839 ± 42	–10.4	64774	303 ± 67	+16± 70
	Shell (*Aulacomya*)	3142 ± 53	3.1	74744		
4. BCH 4	Charcoal	2984 ± 50	–22.7	74746	246 ± 72	–42 ± 80
	Shell (*Mytilus*)	3230 ± 52	2.2	74745		
5. BCH 10	Charcoal	2482 ± 49	–15.4	74748	226 ± 78	–98 ± 94
	Shell (*Aulacomya*)	2708 ± 61	1.5	74747		
6. BCH 16	Charcoal	1772 ± 36	–10	64775	334 ± 65	+30± 66
	Shell (*Mytilus*)	2106 ± 54	1.7	74749		
7. BF6 coast	Charcoal	740 ± 40	–24.3	64772	269 ± 71	–90 ± 70
	Shell (*Mytilus*)	1009 ± 59	1.3	74750		
8. BF6 paleocliff	Charcoal	3430 ± 43	–21.7	64773	213 ± 70	–78 ± 66
	Shell (*Aulacomya*)	3643 ± 56	2.9	74751		
9. BSA (SAO-PC)	Charcoal	5290 ± 39	–11.2	77304	358 ± 56	+13± 73
	Shell (*Mytilus*)	5648 ± 40	1.7	77303		
10. MO1	Charcoal	715 ± 33	–24.2	77306	205 ± 48	–162 ± 48
	Shell (*Aulacomya*)	920 ± 35	3.1	77305		
Average age offset and standard deviation			**266 ± 51**			**–65 ± 22** (ΔR mean value)

a MRE archaeological evaluation was carried out on *Mytilus* sp. from prehispanic shell-middens, obtaining a mean value of 551 ±61 ^{14}C yr BP (Albero et al. 1987). This value would reflect the latitudinal variation in the MRE between Mytilidae specimens from northern Patagonia (40º/41º lat. S, this contribution) and southern Tierra del Fuego (54º lat. S). However, it is also possible that the relative low R values obtained at the San Matías Gulf might be explained in part by the high tidal range of the region, which traduces in extensive intertidal areas, and the frequent occurrence of strong winds. The conjunction of these situations would result in a more effective mixture of atmospheric CO_2 with seawater resulting in a lower R values than in deeper open waters.

These studies highlight the increasing importance of MRE estimations for obtaining local representative values. Our results provide a mean value useful for correcting dates on shells from Mid-Late Holocene sites in northern Patagonia, where differences in centuries may be important for interpreting the timing and correlations of cultural events.

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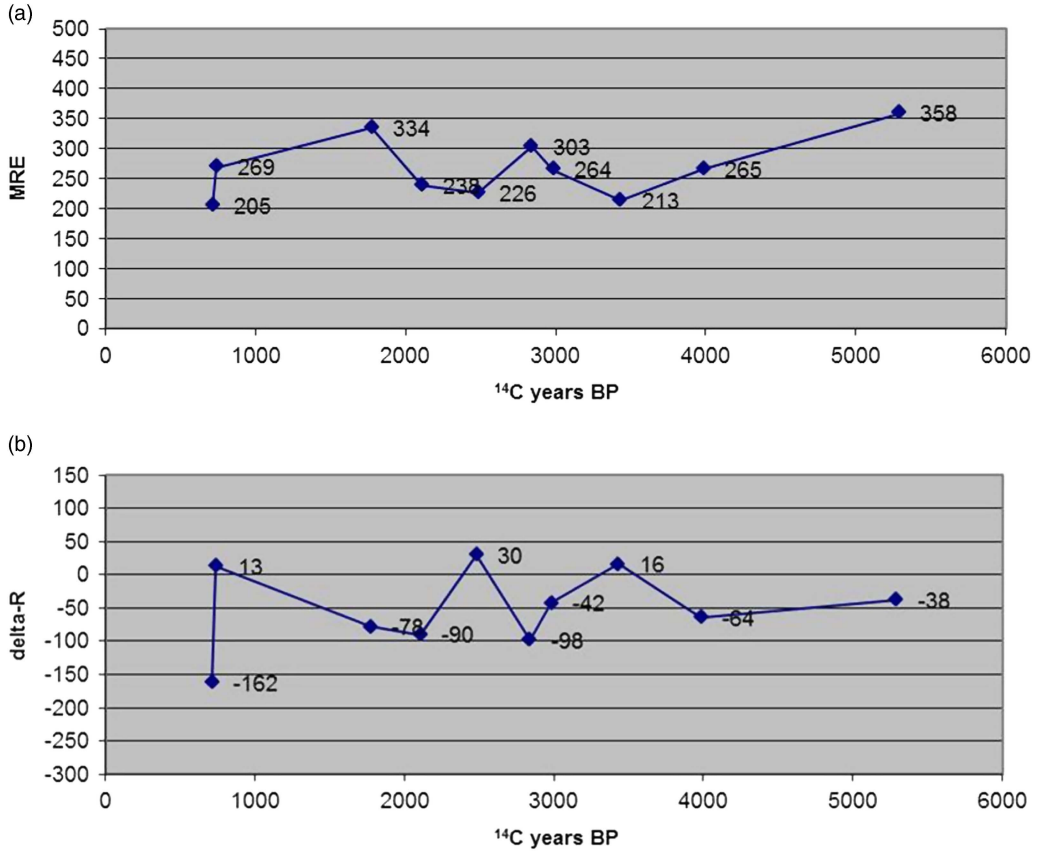

Figure 3 Variation in (a) MRE and (b) ΔR values from ca. 700 yr BP to ca. 5300 ^{14}C yr BP.

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