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So near, so distant: Human occupation and colonization trajectories on the Araucanian islands (37° 30′ S. 7000–800 cal BP [5000 cal BC–1150 cal AD])

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ABSTRACT

The initial human occupation and colonization of island areas are linked to a set of ideas and assumptions about when and how these processes occur. This paper discusses these ideas in light of archaeological evidence from the Araucanian islands (in Southern Chile) with regard to the different trajectories experienced there mostly by hunter–gatherer groups. The evidence indicates that rather than presenting a homogeneous and shared regional pattern, each island represents a particular trajectory of human history. This is represented by differing dates for the earliest human presence on each island, as well as distinct processes of abandonment and re-occupation. In addition, despite a long history of prior hunter–gatherer occupations, these islands were ultimately colonized solely by food-producer groups. This highlights the importance of considering factors such as the cultural construction of space and the constraints it places on inhabitants and their technology, as well as a population's dynamic history in terms of its relationship with the mainland and the island(s).

1. Introduction

The occupation, colonization, and abandonment of previously unknown and uninhabited territories is a topic of much interest given the different forms that these processes can take in distinct settings – a testimony to the richness and variety of human experience (Borrero, 1989–1990; Cameron and Tomka, 1996; Rockman and Steele, 2003). Islands in particular have been some of the most fruitful areas for exploring these topics, since it has been assumed that their relative isolation provides a methodological advantage in terms of segregating variables and phenomena (Mead, 1957; Evans, 1973).

This paper will discuss these issues by focusing on the Araucanian islands (Quiriquina, Santa María, and Mocha), located in the South Pacific Ocean off the coast of Chile (Fig. 1). These islands are geographically peculiar in that they are among the very few islands located today along the entire South American Pacific Coast north of Chiloé island and the archipelagic Patagonian Channels (41° 45′ S). In addition, their different human presence trajectories help to illustrate that a single overarching model to explain these processes does not fit all cases, as it is both inappropriate and fruitless. In turn, evidence from these islands highlights the importance that local and regional characteristics can have in explaining the development (its relative success, failure, and consequences, as well as its timing and signatures) of these processes.

Regarding island colonization, Takamiya (2006) has denounced the existence of a "common wisdom" or "traditional model," which states that islands that are large (10,000 km^2 or more), are close to a continent or other islands (less than 100 km roughly), or are rich in large sea mammals and other marine resources, or any combination of the these three traits, will be suitable for colonization by hunter–gatherers. Such is the case for the Aleutians Islands, the California's Channel Islands, Great Britain, or Japan. In contrast, small and distant islands are colonized by human groups that have agriculture and/or a sophisticated maritime technology. The Polynesian islands are an example of this case. As a counterexample, Takamiya proposes the case of Okinawa, a small island, far away from the mainland and other islands and deficient in marine resources. Okinawa was colonized by hunter–gatherers, who based their subsistence mostly on wild vegetal resources, complementing these with native wild boar, reptiles, and coral reef fish. Takamiya's study highlights the significance that local variables can have for explaining colonization scenarios that do not fit the traditional model.

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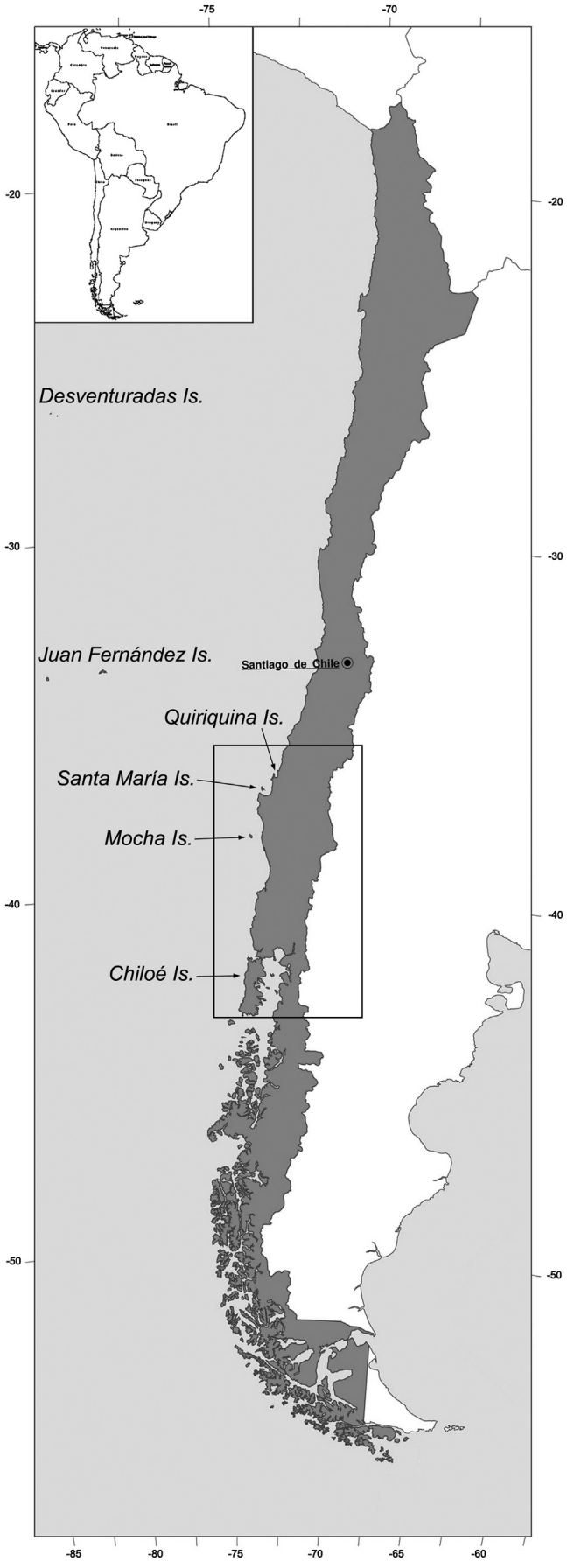

Still, there are aspects that need further refining. On the one hand is the issue of what we understand as "colonization" – as well as "discovery," "arrival," "establishment," "occupation," "abandonment," and other related concepts – in the context of island research. In other words, a set of questions is posed as follows: What are we implying when we say – and by what means can we do so – that an island has been colonized? What of an island that is permanently visited or intermittently occupied but never "colonized"? When and how it becomes necessary to colonize an island? Should we expect hunter–gatherers to colonize islands? In the case of an island that was occupied for a couple of years – or even decades – and then abandoned, was it colonized? Can an island that is close to the mainland, or even visible from it, be discovered? How far/close to the mainland does an island have to be in order to inhibit or facilitate its occupation and colonization? What are the implications, if any, of an island that remains uncolonized or unoccupied?

On the other hand, and related to the previous point, is the need for hypotheses to explain cases in which the traditional model's expectations are not fulfilled. These hypotheses are intimately related to different aspects of how the world is conceived and modified by different cultures. They include: What is "close" to one culture – given their worldview and/or technology – can be "faraway" for another; certain lifestyles are easier to replicate in a new territory, such as an island, than others; and certain organizational or subsistence patterns are more amenable to the occupation of new territories than others.

In a sense, behind the lack of consideration of these aspects lies a paradigm derived from the seminal island research on the remote and dispersed Polynesian islands. On the one hand, this paradigm came close to equating "discovery" with "colonization" and "establishment," as well becoming part of a teleological way of thinking in which the territory – islands, in this case – is there to inevitably become occupied. In addition, this paradigm also led to the diffusion of the "island as lab" model, in which islands were treated as isolated units where one could more easily segregate variables to understand a variety of biological and social processes. However, using single islands is misleading because they are not the ideal spatial units for analyzing insular societies. Instead, single islands usually show indisputable connections to other areas, and studying them therefore entails consideration of those other areas as well (Broodbank, 2002; Anderson, 2004; Cherry, 2004; Curet, 2004; Mitchell, 2004; Erlandson and Fitzpatrick, 2006; Boomert and Bright, 2007; Dawson, 2011).

This paper will present the regional and specific geographical and biological setting of the Araucanian islands, and then describe the human history of mainland Araucania and how the islands became, or did not become, part of it at different moments. Later, I will discuss the data these islands have provided and what this tells us at a regional level about their human historical peculiarities, and also contribute to the refining of our conceptualizations of early human presence on islands and its later developments.

2. Regional setting

Araucania (36° 00′–39° 25′ S), in Southern Chile, is peculiar in that today it has, along some 200 km of coast, three continental islands – from north to south: Quiriquina, Santa María, and Mocha (Fig. 2). These islands are among the very few islands located along the entire South American Pacific Coast north of Chiloé island and the archipelagic Patagonian Channels.

Fig. 1. Chile. Insert indicates location of Southern Chile (see Fig. 2). Modified from GinkgoMaps http://www.ginkgomaps.com.

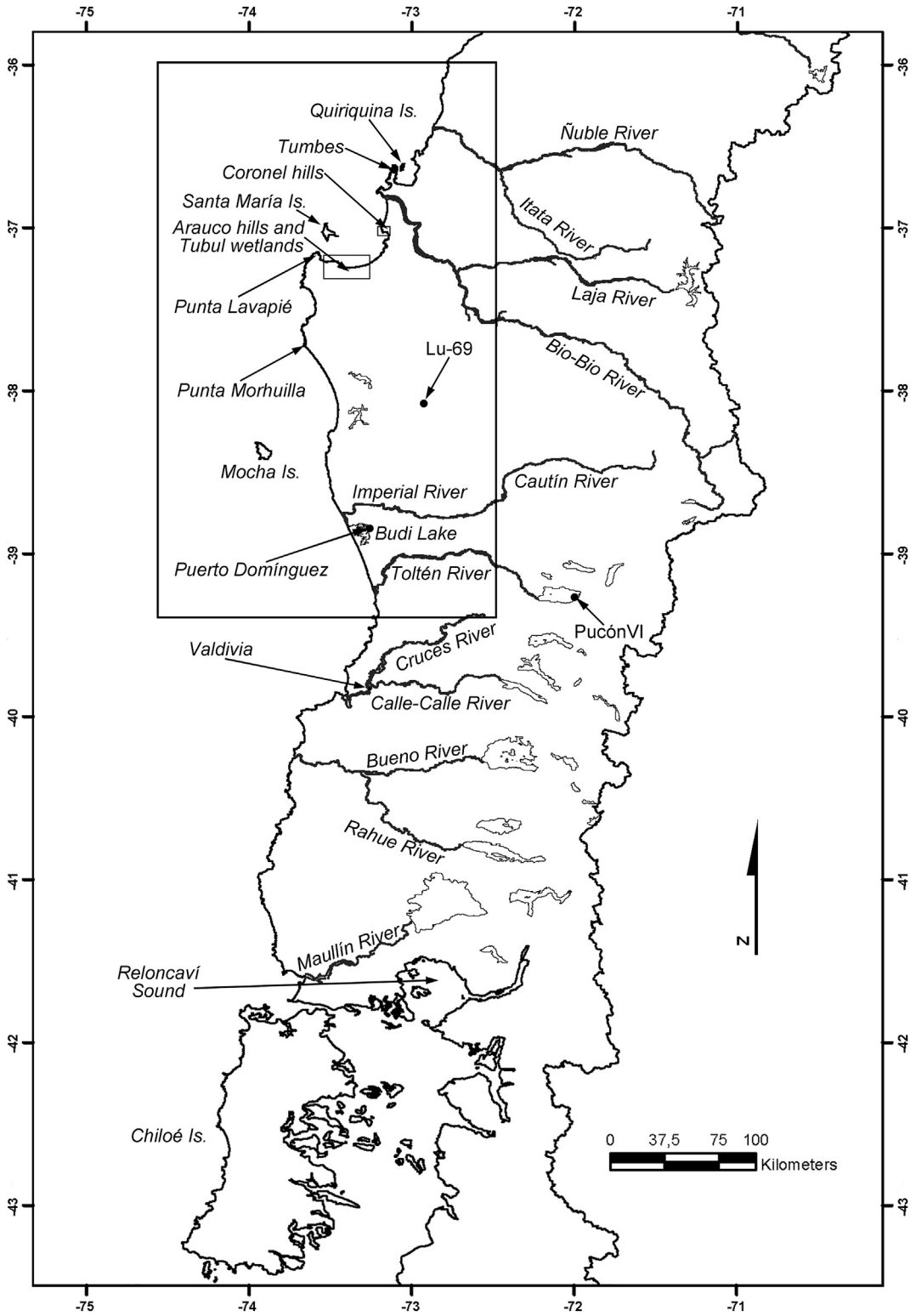

Fig. 2. Southern Chile and main archaeological sites and geographical features mentioned in the text. Insert indicates location of Araucanian coast (see Fig. 5).

Araucania can be divided from west to east into three strips: the Coast, the Intermediate Depression or Longitudinal Valley, and the Cordillera. The coast is characterized today by the coexistence of sclerophyllous and deciduous vegetation (Gajardo, 1994), precipitations between 829 mm (Tumbes) and 1580 mm (Puerto Domínguez) per year, and average year temperatures between 11.5 °C (Puerto Domínguez) and 13.3 °C (Punta Lavapie) (Hajek and Di Castri, 1975). Due to these traits, the territory is classified as a Csb climate (warm-summer Mediterranean climate) (Peel et al., 2007) and is part of the Temperate macrobioclimate unit (Luebert and Pliscoff, 2006).

In human occupation terms, the earliest evidence for the Cordillera is dated ~12,150 cal BP (~10,250 cal BC) at the site of Pucon VI (Navarro et al., 2010). For the Longitudinal Valley, the

earliest date is ~8400 cal BP (~6450 cal BC) at the site Lu-69 (Dillehay, 2007). In turn, the earliest date for the mainland coast is ~6550 cal BP (~4600 cal BC) at the site Co-3 (Quiroz et al., 2001). To explain the delayed presence of earlier sites along the coast, it has been proposed (Quiroz and Sánchez, 2004) that they are now submerged, since the current coast stabilized only after the Holocene Transgression (6000 BP), when the sea reached its highest level. However, it is also fundamental considering the coast uplifting rate, which may have saved some of these sites of being today underwater.

Along the paper the symbol "~" is used to refer to the date Median Probability value (Telford et al., 2004) produced by taking its calibration and rounding this value to the nearest 50 year. Also, the use of a BC/AD scale along with BP is justified by the use of thermoluminescence (TL) dates, which are only reported in that scale, and the need to put both radiocarbon (14C) and TL in an equivalent frame. The ^{14}C dates were calibrated using the Calib 7.0 software (Stuiver et al., 2014), the ShCal13 (Hogg et al., 2013) calibration curve for terrestrial samples (charcoal and bone), and the Marine13 (Reimer et al., 2013) calibration curve for marine samples (shells) with a factor of 190 ± 40 as indicated by Stuiver and Braziunas (1993) for the South American South Pacific. Still, these last samples dates have to be taken with caution, given the absence of a true local estimation of the reservoir effect and the difficulties to estimate it also (Kennett et al., 2002; Ortlieb et al., 2011).

2.1. The islands

An outline of the geomorphological and ecological characteristics of the Araucanian islands and coast are fundamental to comprehend the human trajectories that occurred in these territories. This section will deal with that, starting by the islands.

Quiriquina and the Bio-Bio river mouth paleo-archipelago (Ilabaca, 1979, 1989; Valdovinos, 2011; Isla et al., 2012) (Fig. 3). It was during the Late Pliocene and Early Pleistocene (3.6–0.8 Ma) that a set of islands appeared in the area of the Bay of Concepción and the Bio-Bio river mouth. Later (25,000–10,000 BP), however, during the Last Glacial Maximum (LGM) and until the end of the Pleistocene, these islands appear to have been part of the mainland. Nonetheless, as a part of the Holocene Transgression (6000 BP) an archipelagic system emerged again at the Bio-Bio river mouth. This archipelago comprised the islands Tumbes (35 km^2), Hualpén (17 km^2), Quiriquina (5 km^2), Andalién (3 km^2), and La U-Macera (3 km^2), besides other minor islands and islets. The naming of these islands is derived from today's correspondent island (Quiriquina), peninsula (Tumbes and Hualpén), two adjoining hills (La U and Macera), and city neighborhood (Andalién). Their approximate surface areas are measured from a base point of 20 masl. Since the Holocene Transgression, river sedimentation started to create a plain that ended up connecting these islands to the mainland, turning them into peninsulas or hills within the plain. The exception was Quiriquina, which was left as the sole island in this area up

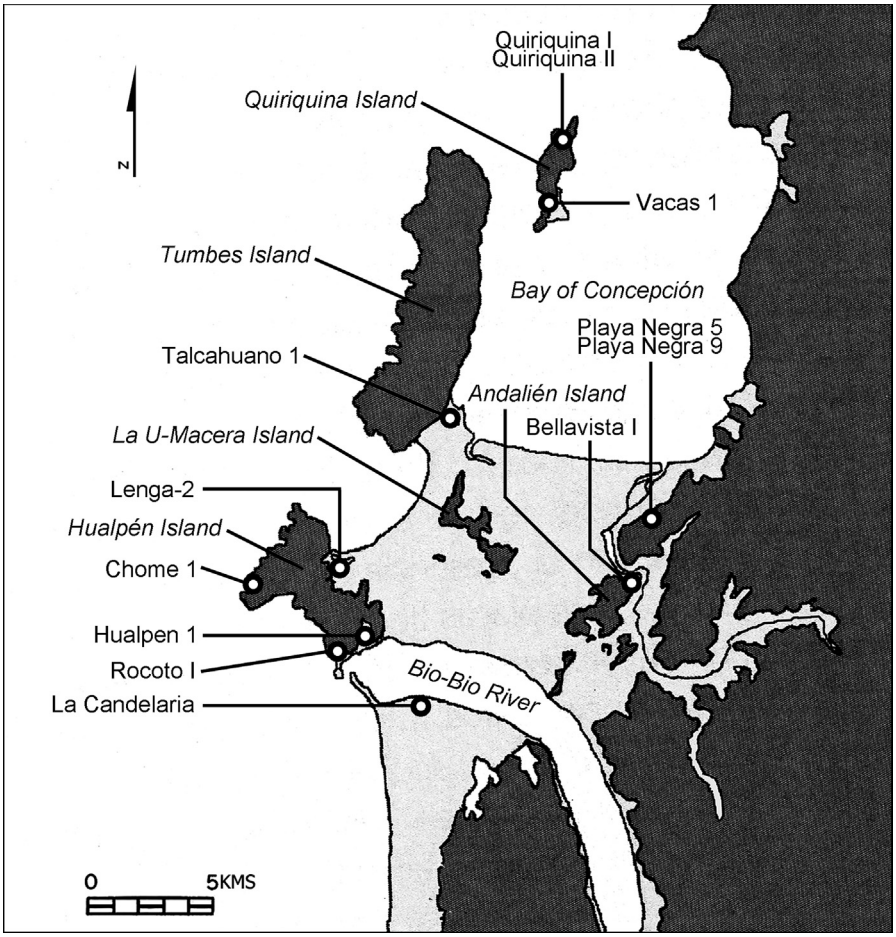

Fig. 3. Bio-Bio river mouth paleo-archipelago area and archaeological sites and geographical features mentioned in the text. Light gray corresponds to Holocene fluvial-marine sedimentation. (Adapted from Ilabaca, 1989; Falcón et al., 2010; Sánchez et al., 2011).

to the present. The lack of more in-depth studies makes it difficult to estimate the exact moment at which each island lost its insular condition, or to measure the seagoing distance between the different islands and the mainland at different times. Today, Quiriquina island is 5 km^2 and is located 2 km off the nearby mainland coast.

Santa María (Kaizuka et al., 1973; Ilabaca, 1989; Contreras et al., 2003; Melnick et al., 2006). It is estimated that this island emerged above sea level after the Pliocene (>2.6 Ma). Since then, it has experienced different uplifting processes, and it is probable that during the LGM and until the end of the Pleistocene it came to be connected to the mainland. However, since at least the Holocene Transgression (but quite probably much earlier than that) it has kept its insular condition. Today, Santa Maria is 30 km^2 and is located 10 km off the nearby mainland coast.

Mocha (Kaizuka et al., 1973; Nelson and Manley, 1992; Prieto, 1997). It is estimated that this island emerged above sea level during the Pleistocene (2.6 Ma–10,000 BP). Since then, it has experienced a constant uplifting process through aseismic and coseismic phenomena. It was not connected to the mainland during the LGM. Today, Mocha is 50 km^2 and is located 30 km off the nearby mainland coast.

In addition to these recognized islands and paleoislands, several others islands should have existed on the Araucanian coast in the past, along a different seashore. This is inferred from the current geomorphology, since there are hills, some of them peninsulas, that lie on or close to the current seashore. On the other hand, some coastal sectors are comprised of extensive Holocene age coastal plains, which in turn surround some of the above inferred islands. Examples of these paleoislands might be the complex formed by the hills Arenas Blancas, Millabú, La Colonia, and Obligado around Coronel; the dispersed and small hills around Arauco and also associated with the nearby Tubul wetlands; and Punta Morhuilla south of Lebu. Punta Morhuilla is locally also known as "La Isla" ("The Island" in Spanish), while in the Tubul wetlands another hill has that name as well. Still, none of these inferred islands would be larger and farther away from the mainland than Quiriquina is today. Also, the morphology of the river mouths (such as the Imperial and Toltén rivers) and coastal lakes (such as Budi) in the past must have been different from the present conditions (Abarzúa, 2009). It is clear then that the Araucanian coastal setting has changed significantly during the time we could expect a human presence there, and requires the implementation of much more in-depth geological and biological studies.

Returning to the recognized islands and paleoislands, it is crucial to note two aspects in relation to early human presence on them. On the one hand, they exhibit differences in terms of the timeframes available for occupation. In this sense, it is plausible that Quiriquina and its adjacent islands were populated during the Late Pleistocene, considering that during this period humans first arrived in Chile. It is not clear if that scenario was also possible for Santa María, and it was not the case for Mocha. After this, and peaking during the Holocene Transgression, these islands obtained (Santa Maria?, Bio-Bio river mouth archipelago) and retained (Santa Maria?, Mocha) up to the present their insular condition. This condition was lost only by the Bio-Bio river mouth archipelago (except for Quiriquina). This implies that since the Holocene Transgression almost any human presence at the presently existing islands entails the use of some kind of navigation technology. Such technology is certainly necessary for reaching Santa María and Mocha, while it might be unnecessary for reaching Quiriquina. The earliest human presence at the Araucanian mainland coast has been dated at just ~6550 cal BP (~4600 cal BC). If one considers this factor, even though site preservation problems may hinder the discovery of earlier evidence, it implies that the groups who first arrived at the Araucanian islands may have possessed the required navigation technology.

On the other hand, these islands are today clearly visible from the mainland, maintaining a constant inter-visibility. While this has been the case with Quiriquina and the Bio-Bio river mouth paleoislands since the beginning of their insular condition, it is not clear if the same is true for Santa María and Mocha. For the latter two cases, what is needed is an accurate estimation of their uplifting processes, which perhaps made them visible – or more visible – through the years. If one does not consider this factor, it is worth mentioning that the concept of "discovery" – so common to island research – loses its meaning because the island turns out to have always been there. The real issue is then how to reach it, and once there, how to return to the mainland.

In environmental terms, both the mainland coast and the Araucanian islands are part of an area extremely rich in marine, coastal, and inland resources. For starters, they are located along the Humboldt Current, which supports one of the most productive fishery areas in the world; the Araucanian coast today is Chile's main fishery area. This also includes a rich and varied trophic chain from seaweed and shellfish to large fish and sea mammals. This area contains several sea lion (*Otaria flavescens*) colonies on the former Tumbes and Hualpén islands – now peninsulas – as well on Santa María and Mocha islands, among other locations (Sepúlveda et al., 2007, 2011).

On the mainland, the various rivers and streams that drain into the ocean also provide an excellent environment for a diverse range of fauna, such as terrestrial and sea mammals, birds, and amphibians. In particular, in terms of mammals, Mocha – and very probably Santa María as well – is notable for the fact that its endemic fauna is comprised of small rodents, reptiles, and amphibians only (Pefaur and Yáñez, 1980). This implies that the presence of large terrestrial animals is strictly related to human transportation or translocation phenomena. Mocha is also home to a sizeable population of permanent and migratory birds – more than 100 species – to the point that Chilean historian Vicuña Mackenna (in Reiche, 1903:47) nicknamed it the "isla gallinero" ("henhouse island").

The Araucanian coast, as is located in a temperate Mediterranean area, presents an endemic rich variety of botanical wild resources for gathering. They are constituted by trees, shrubs, herbs, creepers, epiphytes, fungii, and algae with edible parts (Campbell, 2011:279–297), in addition to their several techno-economic uses (as medicine, firewood, raw material, etc). Among the most characteristic can be mentioned maqui (*Aristotelia chilensis*), peumo (*Cryptocarya alba*), strawberry (*Fragaria chiloensis*), Chilean hazel (*Gevuina avellana*), nalca (*Gunnera tinctoria*), quilo (*Muehlenbeckia hastulata*), berries (*Rubus geoides* and *Rubus radicans*), totora (*Typha angustifolia*), and murtilla (*Ugni molinae*). In relation to the islands, and lacking more in-depth studies, it is difficult to indicate which of those many taxa were available there at the different moments of human occupation as well which of them – and when and how – were introduced by humans in the past. The latter was certainly the case for the native crops (pre-1550 AD) as quinoa (*Chenopodium quinoa*), squashes (*Cucurbita* sp.), beans (*Phaseolus vulgaris*), potatoes (*Solanum tuberosum*), and maize (*Zea mays*).

At this point, and in consideration of the above described aspects, we can return to the discussion of the traditional island colonization model. According to this model, the Araucanian islands ought to be considered as small (the largest is Mocha at 50 km^2), are considerably close to the continent (up to 30 km away), and are quite rich in marine and coastal resources. These islands were therefore suitable for hunter–gatherer colonization as they possess a combination of two (proximity and resources) of the three traits stipulated by the traditional model.

To evaluate this proposition and contribute to the refinement of our ideas about the concepts, requisites, and characteristics of island colonization, this paper will present the archaeological data for the human occupation trajectories represented on each island – their similarities, differences, and peculiarities – providing as background the larger scenario of coastal Araucania.

3. Materials and methods

An evaluation of the human occupation trajectories on the Araucanian islands requires a review of the available archaeological evidence for the islands themselves, as well for the adjacent mainland coast. Archaeological research on Araucania's coast and islands dates back to the 1930s (Quiroz, 2011), although most of the sites identified and excavated in those years were poorly reported and lack numerical chronological control.

In the 1960s due to the efforts of the Instituto de Antropología at the Universidad de Concepción, several key sites were excavated and the first ^{14}C dates were obtained. However, because of the 1973 coup d'etat that research was suspended and much of the information, although it circulated informally, remained unpublished until the late 1990s (Seguel, 1969, 1970, 1998, 2003a; Seguel and Campana, 2003). During the 1970s and 1980s, there was an almost complete halt in the research; notable exceptions are Sánchez (1979) and Bustos (1985). It is only after 1990 that research resumes, leading to a much better understanding of the past human processes that occurred in the area, a more accurate chronological control, and an assessment – by contextual similarity – of most of the sites and materials previously recovered (Quiroz, 2001; Quiroz and Sánchez, 2004; Massone et al., 2011). This helped to produce a basic chronological scheme for prehistoric times, comprising an Early Archaic period (11,500–8000 cal BP [9500–6000 cal BC]), a Middle Archaic period (8000–3950 cal BP [6000–2000 cal BC]), a Late Archaic period (3950–1550 cal BP [2000 cal BC–400 cal AD]), an Early Ceramic period (1550–950 cal BP [400–1000 cal AD]), and a Late Ceramic period (950–400 cal BP [1000–1550 cal AD]) (Fig. 4).

While Early Archaic sites are absent from the Araucanian coast and islands, as mentioned above, the Middle Archaic and Late Archaic are characterized solely by hunter–gatherer groups. However, it is during the Late Archaic that the earliest evidence of ceramics in the area is dated. The importance of ceramics is due to a certain presumption – not always confirmed – in Chilean archaeology of an association between ceramics, food production and/or a more sedentary life. In this context, little is known of the economic practices and social organization of Early Ceramic period groups, precluding the assessment of the abovementioned association. In addition, Central Chile (Cornejo and Sanhueza, 2003), Pampa (Berón and Baffi, 2003), and Patagonia (Schuster, 2014) have provided examples of hunter–gatherer groups that did not abandon this economy even though they started to produce ceramics and/or to obtain it from ceramic-producing groups.

The ceramic tradition (and mostly the decorated ceramics) of these Early Ceramic period groups has been merged within the so-called Pitrén Complex (Menghin, 1959–1960; Aldunate, 1989; Dillehay, 1990; Adán and Mera, 1997, 2011), although other still poorly described traditions or complexes (such as the Lenga or Temprano Complex [Quiroz, 2010; Quiroz and Sánchez, 2010]) seem to have existed contemporarily. Finally, in the Late Ceramic period, an economic system that combines hunter–gather practices and prominent food production (crop cultivation and tamed camelids) becomes evident, and which must have antecedents in the previous period. This period, and the above features, in turn, are accompanied by a different ceramic tradition, constituting the so-called El Vergel Complex (Menghin, 1959–1960; Bullock, 1970; Aldunate, 1989, 2005; Dillehay, 2007).

The current knowledge of this area indicates that the earliest-dated occupation on the mainland coast falls in the Middle Archaic, dated ~6550 cal BP (4600 cal BC) at the site Co-3 in the Coronel locality (Quiroz et al., 2001) (Fig. 5). This occupation

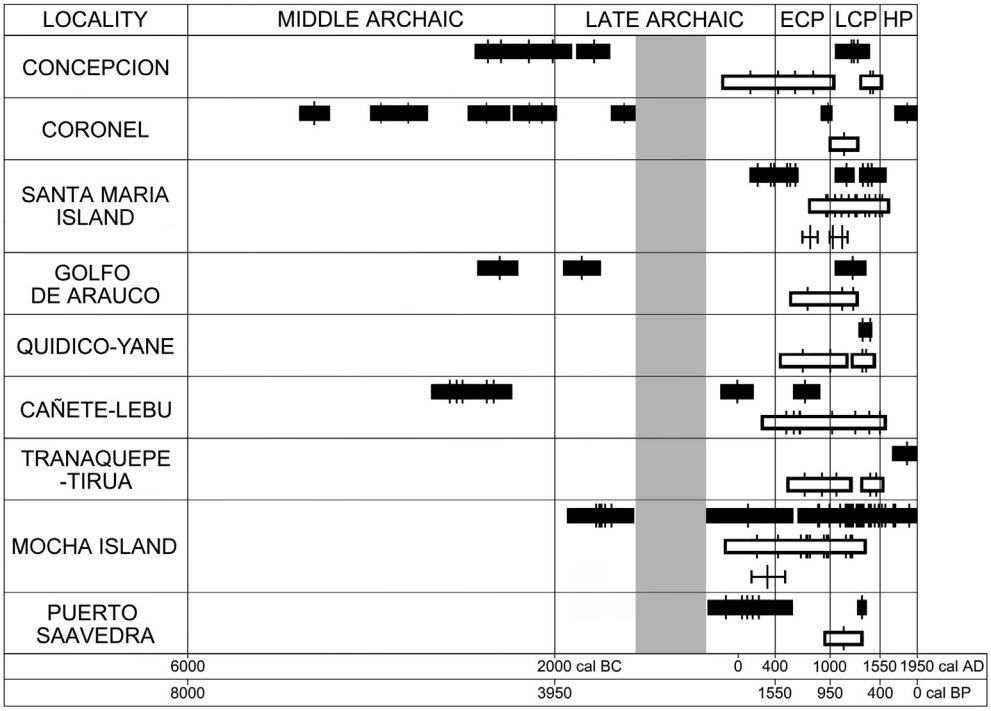

Fig. 4. Numerical dates for Araucanian coast mainland and island localities. Solid bars correspond to ^{14}C dates, unfilled bars correspond to TL dates, lines correspond to dated burning (likely human-induced) events at Santa María and Mocha islands (all of them ^{14}C dates). In gray, minimum time-span for the proposed Late Archaic coastal hiatus. All dates are represented with two error ranges (95% confidence level). (ECP = Early Ceramic Period, LCP = Late Ceramic Period, HP = Historic Period).

already exhibits evidence of the exploitation of shellfish, fish, and birds, and the presence of stemmed triangular projectile points and notched flat cobbles interpreted as net-sinkers. It is followed at the same site and at the nearby Co-2 site by similar context occupations dated between ~5850 cal BP (3900 cal BC) and 4100 cal BP (2150 cal BC) (Quiroz et al., 2001; Bahamondes et al., 2014). Also, since ~5100 cal BP (~3150 cal BC), other localities start showing signs of occupation; such is the case with Cañete-Lebu, Golfo de Arauco, and Concepción (where the Bio-Bio archipelagic system was located). In addition to these occupations, the Quidico-Yane locality – with undated sites – also contains sites that conform to Middle Archaic patterns. The various sites at these localities present certain similarities and differences in their artifactual assemblages, which has helped researchers to propose cultural affinities among them and to overcome the lack of numerical dates for some (Tables 1 and 2). Of these artifacts, it is worth noting the notched flat cobbles, the ornamental bone or lithic plaques, and the Talcahuanense projectile points – a type of triangular double-notched stemmed point, interpreted as being used for hunting sea mammals.

Table 1
Middle Archaic to Late Ceramic Araucanian coast mainland and island archaeological sites' chronological data. (The Late Ceramic period sites included are those with dates up to a calibrated Median Probability of ~800 BP [~1150 AD]. For the Early Ceramic and Late Ceramic periods, only sites in the Concepción, Santa María island and Mocha island localities are included.)

Period	Site	Locality	Laboratory code	Material	14C age	Age or date sigma	Cal. BC/AD Median Probability or BC/AD date	Cal. BP Median Probability	References
	La Posada 3	Coronel							Sánchez, 2005
	El Arenal 5	Quidico							Contreras and Quiroz, 2011
	Co-1	Coronel							Quiroz, 2001; Quiroz et al., 2001
	Playa Negra 5	Concepción (Mainland)							Sánchez, 2005
	SM-28	Santa María island							Massone et al., 2002
	SM-29	Santa María island							Massone et al., 2002
	SM-39	Santa María island							Massone et al., 2012a
	Quiriquina I	Concepción (Quiriquina island)							Seguel, 1970; Quiroz and Sánchez, 2000; Seguel, 2003b; Sánchez et al., 2011
Middle Archaic-like contexts									
	Quiriquina II	Concepción (Quiriquina island)							Seguel, 1970
	Rocoto I	Concepción (Hualpén island)							Quiroz et al., 2000b; Quiroz, 2001; Seguel, 2003b; Seguel and Campana, 2003
	Vacas 1	Concepción (Quiriquina island)							Bustos, 1985; Bustos et al., 1998; Sánchez et al., 2011
	Co-4	Coronel							Quiroz, 2001; Quiroz et al., 2001
	Piures 4	Quidico							Contreras and Quiroz, 2011
Middle Archaic	Co-3	Coronel	Beta 143907	Shell	6330	60	−4622	6572	Quiroz et al., 2001; Quiroz and Sánchez, 2004; Sánchez et al., 2011; Bahamondes et al., 2014
			Beta 360434	Shell	5660	30	−3895	5844	
			Beta 143906	Shell	5380	70	−3598	5547	
			Beta 143908	Shell	4700	80	−2745	4694	
			Beta 359693	Shell	4250	30	−2143	4092	
	Le-2	Cañete-Lebu	Beta 123576	Shell	5000	80	−3145	5094	Quiroz, 2002; Quiroz and Sánchez, 2004; Quiroz et al., 1998, 2000a; Contreras and Quiroz 2011
			Beta 123578	Shell	4940	80	−3068	5017	
			Beta 110335	Shell	4900	60	−3007	4956	
			Beta 110334	Shell	4690	50	−2742	4691	
			Beta 123577	Shell	4630	70	−2669	4618	
	Playa Negra 9	Concepción (Mainland)	Beta 193345	Charcoal	4180	40	−2730	4663	Torres et al., 2007; Sánchez et al., 2011
	La Trila	Golfo de Arauco	Beta 129253	Shell	4580	70	−2602	4552	Bustos and Vergara, 2001, 2004
	Chome 1	Concepción (Hualpén island)	Beta 129681	Shell	4570	70	−2588	4538	Bustos and Vergara, 2000; Quiroz and Sánchez, 2000
	Talcahuano 1	Concepción (Tumbes island)	Beta 117178	Shell	4350	80	−2284	4233	Bustos and Vergara, 1998; Quiroz, 2001; Quiroz and Sánchez, 2000; Quiroz et al., 2001
			Beta 117179	Shell	4160	60	−2022	3971	
	Co-2	Coronel	Beta 362855	Charcoal	3870	30	−2279	4228	Bahamondes et al., 2014
	Bellavista I	Concepción (Andalién island)	IVIC 844	Charcoal	3870	80	−2283	4213	Seguel, 1969, 1998, 2003b; Tamers 1973
Late Archaic	El Visal	Golfo de Arauco	Beta 117180	Shell	3920	70	−1709	3658	Bustos and Vergara, 2001; Bustos et al., 1998
	Bellavista I	Concepción (Andalién island)	IVIC 845	Charcoal	3330	80	−1572	3510	Seguel, 1969, 1998, 2003b; Tamers 1973
	P30-1	Mocha island	Gd 4885	Charcoal	3310	90	−1553	3490	Quiroz and Sánchez, 1993; Quiroz et al., 2000c; Vásquez, 1997
			Beta 57810/ CAMS 5348	Charcoal	3280	60	−1517	3450	
			Gd 4884	Charcoal	3270	120	−1506	3443	
	P27-1	Mocha island	Beta 110336	Shell	3740	50	−1493	3442	Quiroz and Vásquez, 1996; Quiroz et al., 2000b, 2000c; Vásquez, 1997
			Beta 71647/ CAMS 13062	Charcoal	3220	50	−1453	3391	
			Beta 110337	Shell	3650	70	−1384	3338	

(*continued on next page*)

Table 1 (*continued*)

Period	Site	Locality	Laboratory code	Material	14C age	Age or date sigma	Cal. BC/AD Median Probability or BC/AD date	Cal. BP Median Probability	References
	Co-2	Coronel	Beta 362483	Bone (human)	3050	30	−1247	3196	Bahamondes et al., 2014; Espinoza y Lobos, 2014
	Monkul-1	Puerto Saavedra	GrN 16325	Shell	2630	60	−137	2086	Van Meurs and Gordon, 1989
			GrN 16322	Charcoal	2000	80	38	1894	Van Meurs and Gordon, 1989, 1993
			GrN 16324	Shell	2440	60	94	1856	Van Meurs and Gordon, 1989
			GrN 16323	Charcoal	1900	70	155	1776	Van Meurs and Gordon, 1989, 1993
			GrN 16321	Charcoal	1840	160	222	1710	Van Meurs and Gordon, 1989
	Le-4	Cañete-Lebu	Beta 121446	Shell	2530	60	−14	1963	Quiroz, 2001; Quiroz and Sánchez, 1999, 2000
	P25-1	Mocha island	Gd 9197	Charcoal	1940	180	103	1827	Sánchez, 1997
			Gd 10007	Charcoal	1760	130	314	1620	
	Talcahuano 1	Concepción (Mainland)	UCTL 1051	Ceramics		160	130		Bustos and Vergara, 1998, 2001; Quiroz, 2010
	P21-1	Mocha island	UCTL 531	Ceramics		180	200		Campbell and Quiroz, 2015
	SM-39	Santa María island	Beta 269490	Bone (human)	1850	40	209	1724	Massone et al., 2009, 2012a
			Beta 310945	Bone (human)	1850	30	209	1725	
			Beta 269489	Charcoal	1730	40	351	1583	
			Beta 269491	Bone (human)	1700	40	388	1562	
	Laguna Huairavos[a]	Mocha island	Beta 62523	Charcoal	1760	80	316	1617	Le-Quesne et al., 1999
Early Ceramic Period	Lenga-2	Concepción (Mainland)	UCTL 1630	Ceramics		160	430		Contreras, 2008; Quiroz, 2010; Quiroz and Sánchez, 2010
	P10-1[b]	Mocha island	UCTL 537	Ceramics		150	430		Vásquez and Sánchez, 1994; Constantinescu, 1997; Sánchez, 1997; Quiroz, 2010
	SM-39	Santa María island	Beta 310948	Bone (human)	1580	30	528	1407	Massone et al., 2012a
			Beta 310947	Bone (human)	1550	30	563	1376	
			Beta 310949	Bone (human)	1480	30	618	1326	
	La Candelaria[c]	Concepción (Mainland)	UCTL 1743	Ceramics		140	615		Bahamondes et al., 2006; Quiroz, 2010
	P25-1	Mocha island	UCTL 536	Ceramics		130	680		Vásquez, 1994; Sánchez, 1997;
			UCTL 535	Ceramics		130	750		Quiroz, 2010
	P22-1	Mocha island	UCTL 543	Ceramics		100	740		Sánchez, 1997
			UCTL 542	Ceramics		130	780		
			Beta 71646	Charcoal	1200	140	879	1069	
	Pajonal de la Dolores[a]	Santa María island		Charcoal	1290	30	779	1171	Haberle et al., 2009; Massone et al., 2012b
	Hualpén 1	Concepción (Mainland)	UCTL 1628	Ceramics		120	815		Quiroz, 2010
	P5-1	Mocha island	Beta 73675	Charcoal	1210	110	866	1081	Rojas and Cardemil, 1995; Sánchez et al., 2004
	P21-1	Mocha island	UCTL 541	Ceramics		100	930		Constantinescu, 1997; Sánchez,
			UCTL 540	Ceramics		110	960		1997; Quiroz and Sánchez,
			UCTL 539	Ceramics		100	970		2005; Goicovich and Quiroz,
			UCTL 530	Ceramics		100	980		2008; Quiroz, 2010
	SM-6	Santa María island	UCTL 1745	Ceramics		100	955		Massone et al., 2002; Contreras,
			UCTL 1421	Ceramics		100	970		2008; Massone et al., 2008; Quiroz, 2010; Silva, 2010
	P29-1	Mocha island	AA89420	Charcoal	1105	36	988	960	Campbell, 2011
	Montículo Norte	Mocha island	AA 89415	Charcoal	1096	37	994	956	Campbell, 2011
Late Ceramic Period	Puerto Sur[a]	Santa María island		Charcoal	1050	30	1029	921	Haberle et al., 2009; Massone et al., 2012b
	SM-25	Santa María island	UCTL 1424	Ceramics		100	1050		Massone et al., 2002
	P29-1	Mocha island	AA 89419	Charcoal	964	36	1108	842	Campbell, 2011
	SM-26	Santa María island	UCTL 1427	Ceramics		90	1120		Massone et al., 2002; Contreras, 2008
	Pajonal de la Dolores[a]	Santa María island		Charcoal	950	30	1129	821	Haberle et al., 2009; Massone et al., 2012b

[a] It is an environmental column, not an archaeological excavation.
[b] It is a looted and disturbed context.
[c] It is a looted context, it has a more appropriate Late Ceramic date.

Table 2
Middle Archaic to Late Ceramic Araucanian coast mainland and island archaeological sites' artifactual data. (The Late Ceramic period sites included are those with dates up to a calibrated Median Probability of ~800 BP [~1150 AD]. For the Early Ceramic and Late Ceramic periods, only sites in the Concepción, Santa María island and Mocha island localities are included.)

Period	Site	Net-sinkers[a]	Projectile points	Fishhook	Burials	Ornamental plaques	Sandstone mortar, bowl, and/or anvil	Bone needles and/or awls	Bone and/or shell beads and/or pendants	Ceramics
	La Posada 3	Present								
	El Arenal 5				Flexed				Present	
	Co-1	NFC								
	Playa Negra 5	Present								
	SM-28		Talcahuanense on surface							
	SM-29		Talcahuanense on surface							
	SM-39					On Late Ceramic context				
Middle Archaic-like Contexts	Quiriquina I	NFC and EGC	Lanceolate. Talcahuanense	Possible composite on bone		On stone		Present	Present	
	Quiriquina II	Present	Present			Present?				
	Rocoto I	NFC	Lanceolate							
	Vacas 1	NFC	Lanceolate. Talcahuanense				Present?			
	Co-4	NFC	Present			Present?	Present			
	Piures 4		Talcahuanense							
Middle Archaic	Co-3	NFC	Stemmed and Non-stemmed denticulate. Stemmed triangular. Talcahuanense	Possible on shell		On stone	Present on surface	Present		
	Le-2		Lanceolate. Stemmed. Talcahuanense							
	Playa Negra 9	NFC	Stemmed and Non-stemmed denticulate lanceolate. Talcahuanense	Possible on bone	Flexed and extended	On stone			Present	
	La Trila	Present								
	Chome 1	NFC and EGC	Lanceolate. Talcahuanense		Flexed	On stone				
	Talcahuano 1	NFC	Denticulate. Lanceolate. Talcahuanense				Present		Present	
	Co-2	NFC	Present		Flexed and extended		Present			
	Bellavista I	NFC and EGC	Lanceolate denticulate and non-denticulate. Side-notched denticulate. Stemmed		Flexed	On bone and stone	Present	Present	Present	
Late Archaic	El Visal	NFC and EGC			Flexed		Present?		Present	
	Bellavista I	NFC and EGC	Lanceolate denticulate and non-denticulate. Side-notched denticulate. Stemmed.		Flexed	On bone and stone	Present	Present	Present	
	P30-1			Composite on shell				Present		
	P27-1			Composite on bone			Present	Present	Present	
	Co-2	NFC	Present		Flexed	On stone	Present			
	Monkul-1									
	Le-4	EGC on surface					Present on surface			
	P25-1	Present		On bone	Present?			Present?		Pitrén?
	Talcahuano 1	NFC	Present		Flexed					Temprano? Lenga?

(*continued on next page*)

Table 2 (*continued*)

Period	Site	Net-sinkers[a]	Projectile points	Fishhook	Burials	Ornamental plaques	Sandstone mortar, bowl, and/or anvil	Bone needles and/or awls	Bone and/or shell beads and/or pendants	Ceramics
	P21-1									Present
	SM-39				Flexed	Present				Temprano? Lenga?
	Laguna Huairavos[a]									
Early Ceramic Period	Lenga-2		Denticulate Middle Archaic-like							Temprano or Lenga
	P10-1[b]				Disturbed					Pitrén
	SM-39				Non-articulated					Temprano? Lenga?
	La Candelaria	NFC	Triangular Auriculate		Extended				Present	El Vergel
	P25-1	Present			Present?			Present?		Pitrén
	P22-1							Present	Present	Pitrén
	Pajonal de la Dolores[a]									
	Hualpén 1									El Vergel
	P5-1									Present
	P21-1				Flexed			Present?		Pitrén
	SM-6	Present	Talcahuanense on Late Ceramic context							El Vergel
	P29-1									Present
	Montículo Norte	EGC								Present
Late Ceramic Period	Puerto Sur[a]									
	SM-25									Present
	P29-1									Present
	SM-26	Present		Present				Present		El Vergel
	Pajonal de la Dolores[a]									

[a] NFC = Notched flat cobble, EGC = Equatorial grooved cobble.
[b] It is an environmental column, not an archaeological excavation.

The Middle Archaic sites for which there is sufficient information (artifact description and/or numerical dates) in the Bio-Bio archipelagic system are: Playa Negra 5 and Playa Negra 9 on the mainland; Chome 1 and Rocoto I on paleo-island Hualpén; Talcahuano 1 on paleo-island Tumbes; Quiriquina I, Quiriquina II, and Vacas 1 on Quiriquina island; and Bellavista I on paleo-island Andalién. It is clear that those sites, along with those at the Coronel locality (Co-1, Co-2, Co-3, and Co-4), all share the presence of notched flat cobbles. On the other hand, the ornamental plaques appear at several of those sites, as well as Co-3. Finally, the Talcahuanense projectile points are not the only projectile points in use during that period, as they are contemporary with several other types. Still, it is important to note that the Talcahuanense projectile points tend to appear in areas close to sea lion colonies. This factor helps to explain their virtual absence at both the Coronel and Golfo de Arauco localities; their southern distribution seems to reach the Valdivia area (Menghin, 1959–1960).

In this context, the site Le-2 (in the Cañete-Lebu locality) is an emblematic one, since it has yielded more than a hundred of these projectile points and has allowed for their first chronological framing. In addition, the significant presence of penguin (*Spheniscus* sp.) remains has been attributed to a no longer existent penguin colony, proof of the changing coastal geomorphology (Quiroz et al., 1998, 2000a; Quiroz, 2002, 2005). As a whole, the most emblematic Middle Archaic artifact assemblages – Talcahuanense projectile points, notched flat cobbles, and ornamental plaques - can be placed between ~5100 cal BP and ~4000 cal BP (~3150 cal BC and ~1950 cal BC).

From this information it is clear that the Bio-Bio archipelagic system - and Quiriquina as part of it - was occupied by hunter–gatherer groups, thereby meeting the criteria of being close to continent and/or other islands and rich in marine resources. Despite the proximity of these islands among them and to the mainland, it cannot be ruled out the existence of some navigation technology, although it is not at all mandatory. Finally, there is evidence of a sophisticated toolkit composed of, at least, net-sinkers, and probably fishhooks, for fishing, and projectile points for hunting sea mammals.

In turn, both Santa María and Mocha islands do not have occupations dated to this period, or artifacts stratigraphically conformable to the Middle Archaic. Only on the former island have Talcahuanense projectile points been recovered at sites SM-28 and SM-29 (both on surface) and SM-6 (from a Late Ceramic stratum), while an ornamental plaque from a Late Ceramic stratum has been found at site SM-39 (Massone et al., 2002, 2012a; Contreras, 2008). However, archaeological excavations at these sites and others have been unable to provide evidence to support a proposed Middle Archaic hunter–gatherer occupation on this island or on Mocha. While these artifacts may indicate an initial "occupational pulse" (*sensu* Contreras, 2008) for Santa María during the Middle Archaic, it is also true that some Ceramic period sites exhibit Middle Archaic artifacts (such as projectile points and ornamental plaques) among their recovered artifacts, a tendency that can be interpreted as a kind of ancient native antiquarism (Quiroz pers. comm.).

This set of data indicates that by the end of the Middle Archaic period – and we do not yet know with what antiquity – mainland coastal populations of hunter–gatherers may have developed sufficient maritime technology so as to navigate to and around the islands closest to the continent, but not those much farther away. An alternative is that they had reached all of the islands but had not

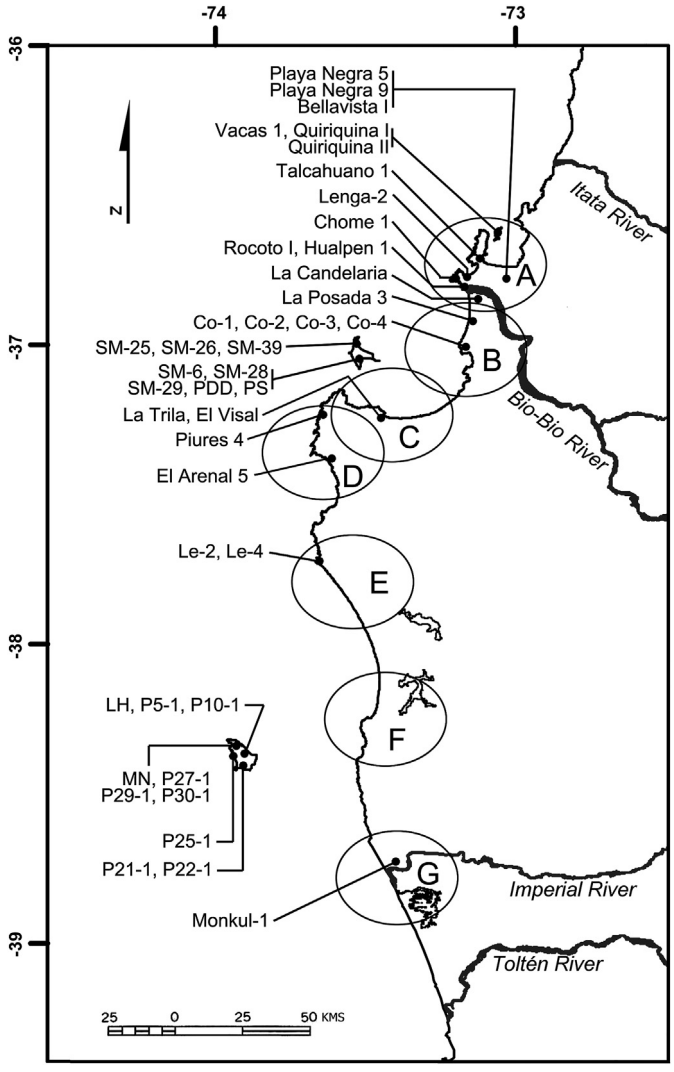

Fig. 5. Research area and archaeological sites and environmental columns mentioned in the text and in Tables 1, 2 and 3 (PDD = Pajonal de la Dolores, PS = Puerto Sur, LH = Laguna Huairavos, MN = Montículo Norte). Ellipses correspond to archaeological localities (A = Concepción, B = Coronel, C = Golfo de Arauco, D = Quidico-Yane, E = Cañete-Lebu, F = Tranaquepe-Tirúa, G = Puerto Saavedra).

settled them or left a clear and solid trace of this at them, although this alternative might be less tenable given the abundant resources available there for marine and coastal subsistence.

The ~3950 cal BP (~2000 cal BC) threshold is important because it marks the almost complete disappearance of the most characteristic Middle Archaic artifactual assemblages, and with it the end of the Middle Archaic period. This phenomenon is also accompanied – or is possibly part of a single process, still poorly understood – by the virtual absence of sites, dates, and contexts for the next 1000 to 1500 years on the Araucanian mainland coast. This has led researchers to propose that during those years there was an occupational hiatus in the coast (Quiroz, 2001; Contreras and Quiroz, 2011; Campbell and Quiroz, 2015).

In this sense, the Late Archaic period remains a riddle. Its earlier section, or "Late Archaic I" (*sensu* Quiroz, 2001), is represented by two phenomena. On the one hand, occupations represented only at the sites Bellavista I, El Visal, and Co-2, that could be taken as a continuation of Middle Archaic patterns; and, on the other hand, by evidence of human occupation for the first time on Mocha island. Then, the period's middle section is marked by the end of the mainland's and Mocha's occupation, along with the 1000-–1500-year regional population hiatus on the coast and islands. Finally, the late section, or "Late Archaic II", sees a reoccupation of the coast – including, for the first time, the three Araucanian islands – and the earliest presence of ceramics. It is very significant that at sites such as Bellavista I, Talcahuano 1, Co-2, and Co-3, ceramics are present above the strata dated to the Middle Archaic, with nothing in between (Seguel, 1969; Bustos and Vergara, 1998; Quiroz et al., 2001; Bahamondes et al., 2014; Espinoza y Lobos, 2014).

The constrained, isolated, and peculiar occupation of Mocha – the largest and farthest away of the Araucanian islands – is represented by sites P30-1 and P27-1 (Quiroz and Sánchez, 1993; Quiroz and Vásquez, 1996; Vásquez, 1997; Quiroz et al., 2000b, 2000c), with dates tightly aligned at ~3400 cal BP (~1450 cal BC). The artifacts present at these sites do not resemble the mainland Middle Archaic ones or the few early Late Archaic ones. Among these mainland Late Archaic artifacts is the appearance of a new morphology of net-sinkers, along the "notched flat cobbles" at sites Bellavista I and El Visal, as are cobbles with an equatorial groove, or "equatorial grooved cobble". Instead, Mocha assemblages comprise a very expedient toolkit, dominated by tools manufactured from bone and shells. This island contains sea lion colonies and an abundance of fish and birds. While there is no specialized toolkit for hunting these animals, the sites do indicate the consumption of sea lion, fish, and shellfish. What is more striking about this occupation is the presence and consumption of terrestrial mammals – such as the nutria (*Myocastor coypus*) and the pudu (*Pudu pudu*) – which can only by explained by their intentional transportation or even translocation by humans. Translocation is defined by Griffith et al. (1989:477) as the "intentional release of animals in the wild in an attempt to establish, reestablish, or augment a population."

Unfortunately, this occupation is difficult to evaluate, given its chronological and geographical isolation and its artifactual and faunal peculiarities. It has been proposed (Vásquez, 1997; Quiroz, 2001; Contreras and Quiroz, 2011; Campbell and Quiroz, 2015) that this occupation might not be related to the adjacent mainland, but is rather the product of hunter–gatherer navigators from farther south (from the Reloncaví Sound-Chiloé island area) moving to more northern areas. However, this presence of southerners – if such is the case – did not endure, and Mocha, like the rest of the Araucanian coast and islands, seems to be devoid of human occupation until ~2100 cal BP (~150 cal BC) (Van Meurs and Gordon, 1989). After that date, new sites and dates appear; soon after, so do the first manifestations of ceramics.

In light of our discussion concerning the dynamics of human presence at islands, it is fundamental to know whether the groups that reoccupied the coast starting in ~2100 cal BP (~150 cal BC) practiced a hunter–gatherer economy, or some kind of food production. On the one hand, the archaeological research for each of the Araucanian islands is dissimilar, while on other hand it has been unable to provide clear and comprehensive answers to that question.

For the Concepción locality, there is no direct evidence for Quiriquina island, which was very probably the only remaining island by that time. The closest record comes from the site Talcahuano 1, dated to ~150 AD. This site has been interpreted as a hunter–gatherer site with ceramics already present (Bustos and Vergara, 1998, 2001). This same pattern seems to continue 300 years later at the Lenga-2 site, dated ~450 AD (Quiroz, 2010; Quiroz and Sánchez, 2010). At this site, the faunal remains indicate the hunting and consumption of mostly sea lions, along with the use of ceramics. Still, this site is also very relevant since it documents the earliest appearance of guanaco (*Lama guanicoe*) at an Araucanian coast location.

Unfortunately, there is no botanical evidence for these sites (Table 3): there is no date for the arrival of food production to this area. Still, by using the regional archaeological framework as a reference, the Early Ceramic/Late Ceramic threshold (950 cal BP; 1000 cal AD) can be taken as the maximum late date for the presence of food production. In light of this, and although the data is still insufficient, it is possible to hypothesize that after ~2100 cal BP (~150 cal BC) Quiriquina was reoccupied by hunter–gatherers, and not by food-producer groups.

The above scenario differs from that of Santa María island. At this island, the earliest evidence for human occupation – not counting the Middle Archaic-like artifacts mentioned above – is dated ~1700 cal BP (~200 cal AD) at the site SM-39. In this case, Massone et al. (2012a) has proposed that the "Ocupación Temprana I" (~1700 cal BP [~200 cal AD]) and the "Ocupación Temprana II" (~1550 cal BP [~350 cal AD]) do not exhibit ceramics, while the "Ocupación Temprana III" (~1400 cal BP [~550 cal AD]) and the "Ocupación Temprana IV" (~1350 cal BP [~600 cal AD]) do. Beyond

Table 3
Middle Archaic to Late Ceramic Araucanian coast mainland and island archaeological sites' faunal and botanical remains data. (The Late Ceramic period sites included are those with dates up to a calibrated Median Probability of ~800 BP [~1150 AD]. For the Early Ceramic and Late Ceramic periods, only sites in the Concepción, Santa María island and Mocha island localities are included.)

Period	Site	Faunal remains[a]	Botanical remains
Middle Archaic-like contexts	La Posada 3		
	El Arenal 5		
	Co-1		
	Playa Negra 5		
	SM-28		
	SM-29		
	SM-39		
	Quiriquina I	Birds. Fishes. *Otaria* sp. Shellfish.	
	Quiriquina II		
	Rocoto I	*Otaria* sp. Shellfish	
	Vacas 1	Birds. *Otaria* sp. Shellfish.	
	Co-4	Shellfish	
	Piures 4	Shellfish	
Middle Archaic	Co-3	Birds. Delphinidae. Fishes (*Sicyases sanguineus*, *Trachurus symmetricus*). *Otaria* sp. Shellfish.	
	Le-2	Birds (*Spheniscus* sp., among others). *Cetacea. Chelonioidea.* Fishes (*Cilus gilberti*, *Sicyases sanguineus*, *Trachurus symmetricus*). *Lontra felina. Myocastor coypus. Pudu pudu. Otaria* sp. Shellfish.	
	Playa Negra 9	Birds (*Spheniscus humboldtii*, among others). Delphinidae. Fishes (Merluccius sp., *Thyrsites atun*, *Trachurus symmetricus*). *Otaria flavescens*. Shellfish.	
	La Trila	Shellfish	
	Chome 1	Birds. Canidae. Fishes (*Cilus gilberti*. *Paralichthys* sp. *Trachurus symmetricus*). *Lontra felina. Myocastor coypus*. Otaria sp. Shellfish.	
	Talcahuano 1	Birds. Fishes. *Otaria* sp. Shellfish. "Terrestrial mammals".	
	Co-2	Fishes (*Trachurus symmetricus*)	
	Bellavista I	Birds. Fishes. *Otaria* sp. Shellfish.	
Late Archaic	El Visal	Birds (*Pelecanus thagus*, Fulica sp.). Fishes. *Myocastor coypus. Otaria* sp. *Pudu pudu*. Shellfish.	
	Bellavista I	Birds. Fishes. *Otaria* sp. Shellfish.	
	P30-1	Birds. Cetacea. Fishes. *Myocastor coypus*. *Otaria flavescens*. *Pudu Pudu*. Rodentia. Shellfish.	
	P27-1	Birds. Fishes. *Myocastor coypus. Otaria flavescens. Pudu Pudu*. Rodentia. Shellfish.	
	Co-2	Peces (*Trachurus symmetricus*)	
	Monkul-1	Shellfish	
	Le-4	Birds (*Phalacrocorax* sp.). Cetacea. Fishes (*Sicyases sanguineus*). *Otaria* sp. Shellfish.	
	P25-1		
	Talcahuano 1	Fishes. *Otaria* sp. Shellfish. "Terrestrial mammals".	
	P21-1		
	SM-39	Amphibia. Birds. Cetacea. Fishes. Shellfish. *Otaria* sp.	Asteracea, *Chenopodium* sp., Cyperarceae, Fabaceae, *Fragaria* chiloensis, *Galium* sp., *Muehlenbeckia hastulata*, *Plantago* sp., Poaceae
	Laguna Huairavos[a]		Burning event
Early Ceramic Period	Lenga-2	Birds (*Phalacrocorax* sp.). *Calyptocephalella gayi*. Fishes (*Eleginops maclovinus*, *Thyrsites atun*, *Trachurus symmetricus*). *Lama guanicoe*. *Otaria flavescens*.	
	P10-1[b]	*Otaria* sp.	
	SM-39	Amphibia. Birds. Cetacea. Fishes. Shellfish. *Otaria* sp.	Asteracea, *Chenopodium* sp., Cyperarceae, Fabaceae, *Fragaria chiloensis*, *Galium* sp., *Muehlenbeckia hastulata*, Plantago sp., Poaceae
	La Candelaria[c]		
	P25-1		
	P22-1	Birds. Camelidae. Cetacea. Fishes (*Aunchenionchus variolosus*, *Pinguipes chilensis*, *Trachurus symmetricus*). *Otaria* sp. Shellfish.	

Table 3 (*continued*)

Period	Site	Faunal remains[a]	Botanical remains
	Pajonal de la Dolores[a]		Burning event
	Hualpén 1		
	P5-1	Birds. Fishes (*Gobiesox marmoratus*, *Trachurus symmetricus*, Auchenionchus sp., Chondrichthyes). *Lama guanicoe*. Lycalopoex sp. Rodentia. Shellfish	Chenopodium quinoa-like
	P21-1	Birds (*Puffinus creatopus*, *Phalacrocorax* sp., among others). Cetacea. Fishes (Auchenionchus sp., *Cilus gilberti*, *Genypterus* sp., *Sicyases sanguineus*, *Thirsytes atun*, *Trachurus symmetricus*). *Galictis* sp. *Lama guanicoe*. *Leopardus* sp. Lycalopex sp. *Pudu pudu*. Rodentia. *Otaria* sp. Shellfish.	
	SM-6	Birds. Cetacea. Fishes. *Lama guanicoe*. Pinnipedia. Rodents. Shellfish.	Chenoppdium quinoa-like, *Cryptocaya alba*, *Cyperus* sp., *Muehlenbeckia* hastulata, Phaseolus vulgaris-like, *Rubus* sp., *Typha angustifolia*.
	P29-1		
	Montículo Norte	*Spheniscus* sp.	*Chenopodium* sp, Poaceae
Late Ceramic Period	Puerto Sur[d]		Burning event
	SM-25	Birds. Fishes. Mammals (marine and terrestrial). Shellfish.	
	P29-1		
	SM-26	Fishes. *Lama guanicoe*. Mustelidae. *Otaria flavescens*. *Pudu pudu*. Rodents. Shellfish.	
	Pajonal de la Dolores[a]		Burning event

[a] It is an environmental column, not an archaeological excavation.
[b] It is a looted and disturbed context.
[c] It is a looted context, it has a more appropriate Late Ceramic date.
[d] They are not ordered by quantitative or economic preponderance; it rather indicates just presence.

the chronological and artifactual differences, both occupations are likely related to hunter–gatherer groups (Massone et al., 2009, 2012a). The faunal remains include shellfish, sea lions, birds and fish, and without the presence of terrestrial mammals. On the other hand, archaeobotanical analyses have provided evidence only of wild plants, such as strawberries (*F. chiloensis*), maqui (*A. chilensis*), and quilo (*M. hastulata*). The earliest appearance of terrestrial mammals (camelids) and crops (quinoa [*C. quinoa*]) are dated to ~950 AD at site SM-6 (Massone et al., 2008; Silva, 2010). Prior to that, at ~1150 cal BP (~800 cal AD), an environmental column done at Pajonal de la Dolores detected a burning event, that could be related to the arrival of farming groups who needed to clear out the forest (Haberle et al., 2009; Massone et al., 2012b). Later and clearer burning events (Haberle et al., 2009; Massone et al., 2012b) have been detected at Puerto Sur (~900 cal BP [~1050 cal AD]) and also at Pajonal de la Dolores (~800 cal BP [~1150 cal AD]), these along with the well-documented existence of an economy that included food production (Massone et al., 2008, 2012b; Silva, 2010). These later burning events are thus clearly framed within the Late Ceramic period. Finally, diet isotopic evidence from four individuals dated to the "Ocupación Temprana" I, III and IV indicates a diet heavily focused on exploiting marine resources, with values of −13.5‰ ± 0.9 for delta ^{13}C and 20.0‰ ± 1.2 for delta ^{15}N (Massone et al., 2012a). This evidence would indicate that Santa María was certainly occupied for the first time during the late Late Archaic and by hunter–gatherer groups. This implies that the 10 km gap that separates the island from the mainland was finally overcome, very likely requiring more sophisticated navigation technology than had been used previously or was used contemporarily at Quiriquina.

Mocha island, in turn, provides a different scenario than Quiriquina and Santa María. At this island, the earliest date for reoccupation is ~1850 cal BP (~100 cal AD) at site P25-1 (Sánchez, 1997). It is followed by a date of ~200 AD at site P21-1 (Campbell and Quiroz, 2015), which since it was obtained via TL, indicates the presence of ceramics. However, these contexts do not provide information about the economy of these groups. Significant evidence comes from a palynological column at Laguna Huairavos (Le-Quesne et al., 1999), which dates a massive burning event at ~1600 cal BP (~300 cal AD) and which was interpreted as representing the arrival of farming groups, who needed to clear out the forest. In contrast to Santa María, Mocha presents a more eloquent record for the Early Ceramic period, represented at least at sites P10-1, P21-1, P22-1, and P25-1 (Vásquez, 1994; Vásquez and Sánchez, 1994; Constantinescu, 1997; Sánchez, 1997; Quiroz and Sánchez, 2005; Goicovich and Quiroz, 2008; Quiroz, 2010), and with the presence of several non-endemic (translocated?) animal species such as grisons (*Galictis* sp.), guanaco (*Lama guanicoe*), wild cats (*Leopardus* sp.), foxes (*Lycalopex* sp) and pudu (*Pudu pudu*) (Quiroz and Sánchez, 2005; Goicovich and Quiroz, 2008). The earliest presence of camelids and possible crops (*C. quinoa*-like seeds) has been dated to ~1100 cal BP (~850 AD) at the site P5-1 (Rojas and Cardemil, 1995; Sánchez et al., 2004). Rather similarly to Santa María, since ~1000 AD and framed within the Late Ceramic period, there is solid evidence of an economy that includes food production (Sánchez, 1997; Sánchez et al., 2004; Campbell, 2011; Roa et al., 2014). In addition, the earliest manifestation of public architecture building (earthen mounds) has been dated to ~1000 cal BP (~950 cal AD) at the Montículo Norte site (Campbell, 2011). From this evidence, it is clear that the reoccupation of Mocha occurred during the late Late Archaic, although it is not clear whether it was carried out by hunter–gatherers or food-producers. Still, what seems to be clear is that this population arrived at the island with ceramics and by crossing a larger track than that at Santa María.

4. Results and discussion

The evidence presented for the Araucanian islands seems to indicate that in all cases they were first occupied by hunter–gatherers. However, the different rhythms and peculiarities that this process – and processes – entailed speak of rather different human occupation and colonization trajectories, which in turn require a more thorough discussion. It is not possible to equate those first occupations with colonization.

First, the very idea of an island has to be discussed. Islands have played an important role in the formulation of anthropological and biological hypothesis since at least the 1960s (Erlandson and

Fitzpatrick, 2006). In that context, the Polynesian islands emerged as "the island paradigm," popularizing the "island as lab" model (Mead, 1957; Evans, 1973; Kirch, 1984). However, this paradigm does not fit all islands. How we think about islands has undergone a reassessment, which has proposed that it is difficult, if not unfruitful, to approach them disregarding their larger geographical and social contexts (Broodbank, 2002; Mitchell, 2004; Jones et al., 2007; Dawson, 2011).

This point becomes clearer when one tries to use concepts like "discovery", "colonization", and "establishment", so common to island research. Specifically, the first of these concepts loses its value in cases where there is constant inter-visibility between the island(s) and the mainland. The other two concepts also diminish in meaning because, as (Broodbank, 2002) notes for the Cyclades islands in the eastern Mediterranean, "if too stringent a definition of establishment is applied to individual islands, the majority will never qualify as anything more than contingently colonized, yet many did succeed in sustaining communities over considerable periods of time".

In this context, the Araucanian islands in particular cannot be disentangled from the mainland because their inter-visibility and proximity very probably prevented them from ever being fully isolated units. In addition, terms such as "discovery" (the islands were always there) or "colonization" become difficult to use. I tried to avoid those concepts in the above sections. Instead, I used more neutral concepts such as "arrival" or "occupation", which only indicate the presence of humans on those islands and do not imply sustained inhabitation.

In the case of the Concepción locality, the different islands (the Bio-Bio river mouth archipelago during the Middle Archaic and only Quiriquina from the Late Archaic onwards) very probably constituted a single social unit with the mainland, and therefore to consider them as "islands" is particularly misleading. For this reason, in this case I am interpreting the evidence of occupation on the mainland as implying occupation on the island or islands as well. It is perfectly plausible that these islands were never colonized, as their closeness to the mainland allowed for short and reliable back and forth trips. Still, the occupations of these islands should have necessitated the use of some kind of navigation technology, for which we do not have any direct evidence, or any idea of their age.

The case of Santa María and Mocha islands is rather different from the one described above, requiring a more comprehensive discussion, given the islands' major distances from the mainland, their human occupation trajectories and their archaeological assemblages. Santa Maria presents effective occupation after ~1700 cal BP (~200 cal AD); Mocha, in turn, presents an initial moment of occupation in ~3400 cal BP (~1450 cal BC), then a population hiatus, and again occupation after ~1850 cal BP (~100 cal AD).

Santa María and Mocha islands then lead us to the question – beyond the "occupation-colonization" issue – of why people were apparently unable to reach them for so many years. According to the traditional model, these islands would not be considered distant from the mainland and are, in addition, abundant in marine and coastal resources, although their small size cannot be totally disregarded.

An answer to this question could be found in the islands' geographical setting and, using this perspective, in the native navigation technology and skills that existed along the Araucanian coast. Insofar as geography, it is noteworthy that the entire South American Pacific coast north of Chiloé island and the archipelagic Patagonian Channels is virtually devoid of islands. Therefore, it is feasible to suppose that the people inhabiting most of the South American Pacific coast had no need to develop navigational techniques beyond those used for longitudinal coastal movement or nearshore activities. In contrast, the territory from Chiloé Island and southwards exhibits a long history of navigation (Rivas et al., 1999; Gaete and Navarro, 2004; Gaete et al., 2004; Ocampo and Rivas, 2004; Orquera et al., 2011) dating back to 6000 cal BP.

It is this latter area that has been proposed as the origin of the early Late Archaic occupation of Mocha. Regarding this occupation, it is also quite remarkable that it implies the transportation – or even translocation – of mainland species such as nutria and pudu, which are nearly absent at previous and contemporary sites along the mainland Araucanian coast. Was this some kind of "voyage kit" similar to those used by the Polynesians when they explored and colonized the Pacific islands? In addition, if these southern navigators were able to reach Mocha, why we do not also find traces of their presence on Santa María or the mainland?

This geography-navigation factor also implies that in some moment during the late Late Archaic, the peoples along the Araucanian mainland coast developed navigation technology for traveling back and forth across a distance of up to 30 km, thus reaching Mocha and Santa María islands. This voyage should not be treated as open-sea navigation since the departure and arrival points were always in sight. However, it exhibits certain characteristics – strong currents and winds – that are similar to open-sea navigation. It is important to point out that this interpretation does not deny the existence of a previous navigation tradition, which may have served as the basis for developing the technology to reach Santa María and Mocha islands. Contreras and Quiroz (2011) have proposed that the Araucanian coast – with its complex set of presently existent and non-existent islands – might be considered as a fourth nucleus of early navigation development, along with Chiloé island, the Otway Sea-Strait of Magellan, and the Beagle Channel (Legoupil and Fontugne, 1997; Rivas et al., 1999; Orquera et al., 2011).

An alternative answer to the question of human's late arrival to Santa María and Mocha islands is that adjacent mainland coastal hunter–gatherers were able to reach the islands during the Middle Archaic. This proposal would entail disregarding the geography-navigation factor outlined above, giving credence to the Middle Archaic-like artifacts at Santa María, and considering the ~3400 cal BP (~1450 cal BC) occupation of Mocha as potentially ascribable to these groups. In this case, these hypothetical occupations of Santa María and Mocha would be considered sporadic and/or focused on certain activities, leaving behind almost imperceptible traces. However, left unanswered is why these occupations did not endure in these two insular systems, both with an abundance of marine and coastal resources. Nor does it explain the 1000-–1500-year gap between these occupations and the next ones.

Finally, and in order to complement the above points, we must return to the "occupation-colonization" issue. In other words, the question of whether it is possible to say that these islands were colonized, or had a permanent and enduring human presence, in some moment of prehistory, and also of whether we should expect that hunter–gatherers colonized these islands.

Based on the evidence presented, and in chronological order, the Bio-Bio river mouth archipelago is the strongest candidate in the Middle Archaic for island colonization by hunter–gatherers. However, its proximity to the mainland may have precluded colonization, meaning instead that these islands were only visited. Perhaps these visitations – although very infrequent – are also the case with Santa María and Mocha islands, especially when one considers their significant distance from the mainland. In relation to these two islands a good explanation for the absence of sustained inhabitation or more frequent visitation could be related to the following three non-exclusionary factors: 1) the hunter–gatherer groups' economy, which requires a larger area than that of food-producer groups for their subsistence, to the point that such

small islands as Santa María and Mocha were not suitable for them; 2) the hunter–gatherer's small scale society, which generated that for their social and biological reproduction must be in contact to other populations, and therefore turning unattractive an island located 10–30 km from the mainland; and 3) a lack of resources that significantly differed from what was already available on the mainland; for example, obsidian and chert exploitation has been proposed as the reason behind the sporadic but recurrent visitation of some Mediterranean islands (Dawson, 2011).

In this scenario, the proposed regional coastal hiatus during the Late Archaic very probably interrupted any links established by people between the mainland and their occupation or utilization of the islands. This should be certainly the case at the Bio-Bio river mouth archipelago, which presents signs of occupation during the Middle Archaic.

Following this, after ~2100 cal BP (~150 cal BC), there is evidence of human presence on the Araucanian coast again. However, it is not at all clear if these groups constitute a completely new population stock, correspond to early Late Archaic remnant populations, or a combination of both. It is also relevant to mention that from this moment onwards terrestrial mammals seems to achieve a more significant place on the Araucanian coast people diet. While for the Concepción locality – that is, Quiriquina – and Santa María this human presence would be in the form of hunter–gatherer groups, for Mocha it may have been in the form of food-producer groups. However, for the moment the archaeological evidence dated to the late Late Archaic and most of the Early Ceramic period at the islands does not support the claim of a permanent and enduring human presence. Those sites are extremely shallow, small, and localized; most of the materials ascribed to these island populations come from unexpected findings by local residents, rather than from controlled archaeological excavations.

In this light, to the case of Quiriquina we can apply the same explanation for the Middle Archaic, whereby as a result of its proximity to the mainland, the island was visited but not colonized. Meanwhile, for Santa María and Mocha islands, the accumulation of sites and numerical dates, as well the increase in the sites' size, that starts around the Early Ceramic Period/Late Ceramic period threshold (~950 cal BP [~1000 cal AD]) can be taken as evidence that these islands were colonized from that moment onwards.

In addition, the archaeological record indicates that this permanent and continuous occupation lasted until the arrival of Europeans (1550 AD) and even later (late 17th century). The people inhabiting these islands since ~950 cal BP (~1000 cal AD) remained aligned with the mainland, translocating and replicating mainland cultural and economic patterns. This point also finds support in the rich ethnohistoric written and graphic records (16th–17th centuries), which describe the existence of fully established populations on these islands that maintained economic, social, and ideological links with the mainland ones.

The dating for this colonization or permanent occupation is what remains a mystery, although based on the current evidence it should be no older than ~1700 cal BP (~200 cal AD) for Santa María and ~1850 cal BP (~100 cal AD) for Mocha. On the other hand, the navigation devices employed for these trips are unknown. The closest references to them appear in 17th century ethnohistoric sources, which indicate the use of some kind of "maguey" (*Puya* sp.) and "totora" (*T. angustifolia*?, *Cyperus* sp.?) rafts, able to transport groups of up to 30 people (Rosales, 1877[1674]; Quiroga, 1979 [1692]; Rosales, 1991[1674]).

The above points thus imply that both Santa María and Mocha islands were colonized or permanently occupied quite probably by food-producer groups. Although it is difficult to trace the moment when food production was deployed by these populations, the abovementioned burning events and the Late Ceramic period record appear to indicate that incorporation of this new economic strategy occurred during the Early Ceramic period (1550–950 cal BP [400–1000 cal AD]), and that by ~950 cal BP (~1000 cal AD) it was in full swing. That said, this interpretation does not mean to overlook the islands' long history of sporadic visits and occupations, mostly by hunter–gatherer groups. In turn, this means that colonization of these islands becomes a viable, attractive, and/or necessary enterprise only when food production was in action, along a social scenario marked by the emergence of public architecture, higher population densities across Araucania, and the development of more complex socio-political arrangements. This may be a coincidence, and there is no causal relationship between these events. Still, in both cases the existence of a food-producing economy would entail a more sedentary lifestyle and also very likely the development of different ideologies related to territoriality and social identity. This lifestyle is more conducive to leaving a richer archaeological record, thus increasing the likelihood of finding these groups' sites, compared to those of more mobile hunter–gatherers.

It is good to know that this situation, particularly the cases of Santa Maria and Mocha islands, is not exclusive to the Araucanian coast. Research in the Mediterranean (Dawson, 2011) and the African coast of the Indian Ocean (Mitchell, 2004) also shows a pattern in which the colonization of certain islands, despite a previous history of visitation and utilization, occurred only when food-producing strategies were implemented – 5000 BC for the former, and 1 AD for the latter. The African case is especially striking given the coincident factor in which the islands – Pemba, Unguja, and Mafia off the Tanzanian coast – are located along an extended coast virtually devoid of continental islands.

It also implies that an overarching island colonization model does not fit all cases. In other words, despite some islands' abundant marine and coastal resources and proximity to the mainland, other factors can preclude their colonization by hunter–gatherer groups. Of those factors, this paper has singled out coastal geography and its effects on the development of navigation technologies, as well as the dynamic history – occupations, abandonments, a hiatus, and re-occupations – of the different peoples that inhabited the adjacent mainland.

These results lead to new questions: Why did hunter–gatherers not colonize Santa María and Mocha islands? Were they uninterested in colonizing them? Were they incapable of colonizing them? Why are the Early Ceramic sites at these islands so elusive? Were the mainland Early Ceramic groups just hunter–gatherers, or did they practice some form of food production? Did the mainland Early Ceramic groups who arrived or even colonized these islands "adapt" their lifestyles to the new areas? What changed on the islands or the mainland so that in ~950 cal BP (~1000 cal AD), colonization was carried out successfully? Was the development of food-producing strategies a requirement for the islands' colonization? - and if so, why?

I pose these questions, but I believe they go beyond the scope of this paper. Solving them requires better knowledge of the economy, social organization, artifact assemblages, and chronology of the different human trajectories that have appeared on the Araucanian mainland coast and islands. In addition, we must refine and reassess our theoretical assumptions and archaeological expectations concerning these processes.

5. Conclusion

The Araucanian islands present a case that allows for fruitful discussion about the concepts and assumptions typically used to approach island archaeology. They highlight the importance of

considering a complex and varied set of interacting factors, in order to document and explain the human dynamics leading to islands' occupation and colonization. An island's size, its proximity to the mainland or other islands, and the abundance of marine resources are very important factors, but they are insufficient for comprehensively explaining cases where hunter–gatherer groups do not succeed in colonizing an island. In this paper, from evidence in the Araucanian islands and mainland, there emerged two factors that should be systematically considered and assessed.

The first factor is a consideration of the navigation technology available to the mainland population at different times, and how much its development can be linked to peculiarities of the coastal geography where that population is settled. In other words, an archipelagic coast or a coast dotted with islands is not the same as a coast devoid of island for hundreds of kilometers. This, in turn, is very likely related to how space is conceived; what is near or distant can be very different for each culture.

The second factor is the particular human historical dynamics experienced on the mainland adjacent to an island or islands. This sets a sort of baseline, helping us to model our archaeological expectations and to understand phenomena – such as a population hiatus and/or the arrival of new economic arrangements and technologies – that the island data is unable to account for on its own. This, in turn, relates to the necessity of considering islands in relation to their adjacent mainland.

Specifically in relation to the Araucanian islands, this paper's conclusions can be outlined as:

- For the Middle Archaic (8000–3950 cal BP [6000–2000 cal BC]), the Bio-Bio river mouth archipelago was certainly occupied, although the evidence for colonization is not strong enough. Santa María and Mocha islands might have been occupied, but evidence for this is still extremely weak.
- For the early Late Archaic (3950–3200 cal BP [2000–1250 cal BC]), there is a continuation of the Middle Archaic situation. Also, there is evidence of a hunter–gatherer occupation at Mocha, which might be related to populations from farther south rather than the adjacent mainland.
- For the middle Late Archaic (3200–2100 cal BP [1250-150 cal BC]), no human evidence for the Araucanian coast and islands has been dated for the moment. The explanation that has been proposed is a population hiatus and therefore an interruption in the dynamics between the mainland coast and the islands.
- For the late Late Archaic (2100–1550 cal BP [150 cal BC-400 cal AD]), a reoccupation on the mainland coast occurs and the three Araucanian islands are occupied. Initially, Quiriquina was likely occupied by ceramic hunter–gatherers; Santa María, by aceramic hunter–gatherers; and Mocha, by ceramic hunter–gatherers or ceramic food-producer groups. None of these occupations seems to constitute a colonization.
- For the Early Ceramic period (1550–950 cal BP [400–1000 cal AD]), there is a continuation of the late Late Archaic situation. However, occupations at Santa María incorporate ceramics. Also, it is not clear if these groups developed food-producing strategies, although by the very end of the period there is evidence of terrestrial mammals (camelids) and crops (quinoa) at Santa María and Mocha. None of the islands seem to exhibit an indisputable permanent and continuous human presence.
- For the Late Ceramic period (950–400 cal BP [1000–1550 cal AD]), there is sustained evidence of food production at Santa María and Mocha. In addition, the accumulation of sites and numerical dates, as well the increase on the sites' size, seems to indicate that the islands have been colonized. The lack of equivalent archaeological data on Quiriquina does not allow for the same claim to be made for that island.

The above regional trajectory is remarkable since it would indicate that Mocha and Santa María islands were occupied or visited over several centuries, but that their colonization - the permanent establishment of people - was accomplished only when a food-producing economy was implemented. This does not imply that these two islands were unable to support groups using hunter–gatherer strategies, but rather that the current evidence indicates that hunter–gatherers did not settle permanently there.

Confirming these propositions requires more thorough research, which, one expects, will contribute to improving our understanding of the native human historical processes on the Araucanian and South American coast. In addition, it will provide more arguments and ideas for a comparative and comprehensive understanding of the human dynamics involved in the occupation and colonization of previously unknown and uninhabited territories.

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