PALEOECOLOGY AND SEDENTISM OF EARLY COASTAL HUNTER-GATHERERS IN NORTH CHILE

By

Teresa Cristina de Borges Franco

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Approved:
Professor Tom D. Dillehay
Professor Tiffiny A. Tung
Professor John W. Janusek
Professor Maria Luisa Jorge

To my parents, Teresinha and Augusto,
and to my uncle Itamar (in memory).
This journey would not be possible without
the love and support of my family.

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CHAPTER I

INTRODUCTION

An important research question in the archaeology of the west coast of South America is focused on maritime adaptations, sedentism and cultural complexity. Within this issue, the central point of this thesis is in the early complex maritime hunter-gatherer societies that once lived in the circumscribed environments of river deltas in the arid north of Chile on the Pacific coast during the early-middle Holocene from ~7,500 to ~4,000 BP. This research takes a paleoecological approach, with a focus on the seasonal growth-ring studies of shellfish, to investigate sedentism and seasonality of resource procurement at two Chinchorro archaeological sites, Camarones 14 and Camarones Sur, on the north coast of the Atacama Desert. As part of the development of early maritime societies along the west coast of South America, this project also investigated the seasonality of procurement of shellfish remains at the Huaca Prieta mound on the north coast of Peru, which presents a different type of Preceramic social complexity from ~7,500-4,000 BP. This is a period, in which coastal environments became more intensely exploited, promoting the development of a specialized technology that expanded human exploitation of the sea.

During the Early-Middle Holocene (~8,000 to 2,500 BP) in the coastal Central Andes, interaction between human populations and maritime environments increased. Coastal environments became more intensely exploited. In many parts of the world, this contributed to increased social complexity and sedentism among hunter-gatherers

(Moseley 1975, 1988; Yesner 1980; Rowley-Conway 2001; Erlandson and Jones 2002; Arnold 2004; Marquet et al. 2012). The exploitation of and adaptation to changing coastal environments also brought specialized knowledge. This involved shellfish gathering and fishing, the use of specific artifacts such as nets, harpoons, and hooks for fishing and hunting, and greater understanding of the physical and biotic maritime environments, including aquatic organism's behaviors and marine currents. Such technological, social, and ideological transformations led to different avenues of social complexity during the Holocene period (Moseley 1975, 1988, 1992b; Yesner 1980; Erlandson and Jones 2002; Arnold 2004; Marquet et al. 2012; Santoro et al. 2012).

To better understand the emergence of preindustrial complex coastal societies, it is necessary to focus on the changing interactions between humans and their environments, particularly the linkages between maritime adaptations, mobility patterns, and socio-economic transformations. Thus, the goal of this dissertation is to examine how early coastal communities interacted with the maritime ecosystem of the arid central-north Pacific coast of South America. It asks whether increased cultural complexity was associated with a sedentary lifeway at three early archaeological sites in Peru and Chile.

The working hypothesis is that, during the middle Holocene, sedentism in selected small, circumscribed river deltas fostered social complexity. What stimulated this was the year-round management of subsistence resources, an advanced maritime technology, and exchange networks between neighboring populations.

Two different maritime societies are investigated here: the coastal desert hunter-gatherers related to the Chinchorro culture of northern Chile, specifically Camarones 14 and Camarones Sur sites (~7,500 - 3,500 BP) located in the delta of the Camarones River valley (Schiappacasse and Niemeyer 1984; Rivera 1984), and the Huaca Prieta site (~6,700 to 3,500 BP) located in the Chicama River valley of northern Peru (Bird et al. 1985; Dillehay et al. 2012b) (Figure 1.1). Both Chinchorro sites are part of several sites distributed between Ilo in southern Peru and Antofagasta in northern Chile associated with this culture dated from 7,500 to 3,000 BP. The Chinchorro are known for their artificial treatment of human bodies (Figure 1.2) (Arriaza 1995), while Huaca Prieta is related to maritime hunter-gatherers and incipient horticulturalists. The site of Huaca Prieta is dated to between 14,500 cal BP and 3,455 cal BP [1] (Dillehay et al. 2012b). The large ceremonial mound at the site has constructive phases dated from 6,800 to 3,000 BP (Dillehay et al. 2012b). The latter is the period investigated in this research, which is concentrated in the use of the mound as a ceremonial site.

All of these sites are representatives of the emergent ideology and cultural diversity that started to be develop during the early-middle Holocene in the Central Andes and before the adoption of pottery (Dillehay 2004; 2008; Dillehay et al. 2012b). What is not well established is the role of sedentism in the emergent complexity seen in the period. In this sense, there is a need for more solid archaeological and ecological data to prove the connection between sedentism and emergent complexity in this period.

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[1] ~12,800 BP and 3,300 BP

[2] Oxygen isotope analysis will be discussed in detail later in Chapters 3 and 4.

[3] Chagas' disease (American tripanosomiasi) is parasitic infection that affects the heart caused by *Trypanosoma cruzy*, a protozoan transmitted by a bloodsucking bug.

[4] Initially the Maritime hypothesis was based on the consumption of shellfish and large fish, and

Figure 1.1: Map of the study region including Huaca Prieta, Camarones 14 and Camarones Sur, and some of the main modern-day coastal cities along the coast.

Seasonality and Sedentism: Methodological Interface

On a global level, the most reliable evidence for sedentism stems from seasonality studies of faunal remains (Lieberman 1998; Bar-Yosef 1998; Marshall 2006; Reitz et al. 2012), specifically annual growth-ring studies of certain shellfish species (Billings 2001; Quitmyer and Jones 2012). This approach is based on the predictability of the annuli formation on seashells during annual growth cycles (e.g. spawning, nutrition) (Claassen 1998). By suggesting the season of shell collection, isotope analyses of shells can reinforce seasonality studies (e.g. Bernstein 1990; Claassen 1998; Russo 1998; Billings

2001; Quitmyer and Jones 2012). The calcium carbonate ($CaCO_3$) produced by shells is at or near oxygen isotopic equilibrium with the seawater, and thus they can be used as an indicator of paleotemperatures (Quitmyer and Jones 2012; Andrus and Thompson 2012; Andrus 2012). This is based on the relation between water temperature and oxygen isotopes (^{18}O and ^{16}O); these are dependent variables, and the rise in one will be related to the decline of the other (Andrus 2012). Certain temperatures are associated with different times of the year. These can be estimated from isotope analysis of shells (Andrus 2012).

The combination of annual shell growth rings and isotope analyses provides a solid base to analyze the seasonality of shells captured for consumption (Andrus 2011). These two methods were tentatively applied to analyze the seasonality of human occupation at Camarones 14. However, as discussed later, oxygen isotope analysis on selected marine shell species from Camarones 14 produced unreliable data[2]. Therefore, the degree of sedentism at Camarones 14, Camarones Sur, and Huaca Prieta was indirectly measured by seasonal growth on seashells. The study of annual shell growth rings performed on shells from sites in both study areas brought mixed positive results. These results in turn were examined in relation to ecological and economic aspects, as well as to emergent social complexity.

The role that marine resources played in the development of sedentism (Yesner 1980) and the subsequent rise of complex societies along the central Andean coast is well established for the middle-late Holocene (~4,500 - 3,750 BP) (Moseley 1975, Moseley and Feldman 1988). The appearance of sedentary communities, together with an increase in social complexity, is seen in the site monumentality when large and non-domestic

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[2] Oxygen isotope analysis will be discussed in detail later in Chapters 3 and 4.

architectural structures appeared along the north-central coast of Peru about 4,500 BP (Moseley 1975; Quilter and Stocker 1983; Moseley and Feldman 1988). These complexes of public buildings are in general indicative of corporate labor, social hierarchy and political centralization; some examples are Aspero, El Paraiso, Alto Salaverry, and Bandurria (Moseley 1975; Quilter and Stocker 1983; Moseley and Feldman 1988; Haas and Creamer 2004). The site of Huaca Prieta is one of the earliest coastal sites with large non-domestic architecture; dated to ~7,500 BP, it pre-dates those complex developments (Dillehay et al. 2012b), and it is characterized as a ceremonial and mortuary place (Dillehay, personal communication 2014).

The role of marine resources and the rise of complex societies are underlined by the Maritime Foundations of Andean Civilization Hypothesis proposed by Moseley (1975). It predicts that in the middle-late Holocene, the richness and stability of maritime resources influenced the development of sedentary, complex societies in the Central Andean area. This dissertation's intents to contribute to the discussions of early Chinchorro complexity possibly associated with sedentism and a maritime lifeway as initially proposed by Schiappacasse and Niemeyer (1984), and later by Arriaza (1995). It also brings to the discussion the role seasonality and sedentism in the context of the large ceremonial site of Huaca Prieta (Dillehay et al. 2012b).

By comparing Chinchorro to the Huaca Prieta mound, this thesis examines whether the same principles proposed in the Maritime Hypothesis (Moseley 1975) are at the basis of both societies. This is done by studying the Chinchorro sites and the evidence they provide with respect to sedentism, cultural complexity, and mobility patterns. The Chinchorro situation is then briefly compared to similar patterns at the Huaca Prieta site.

This dissertation also sheds new light on how the development of small-scale middle Holocene coastal societies led to the rise of sedentism and cultural complexity along the central Andean coast.

Coastal Environment and Human Adaptations

The attractiveness of coastal environments for human exploitation relies on the productivity and stability of its resources as well as species diversity. These factors, combined with rich river beds, often allowed human groups to settle on a more stable basis, perhaps leading to sedentism as well as increase in cultural complexity (Moseley 1975; 1992; Yesner 1980; Erlandson and Jones 2002; Arnold 2004). For example, studies on late prehistoric Holocene maritime societies of coastal California demonstrate the relatively high social complexity of the Chumash (Erlandson and Jones 2002; Arnold 2004; Erlandson et al. 1996 in Jones 2002). During the late Holocene, the Chumash developed a sedentary lifestyle, social stratification, and a hierarchical political organization (Jones 2002). Their cultural materials were primarily oriented toward public rituals and subsistence activities. Other examples include the Pacific Northwest Coastal Indians, as well as the Ertebølle prehistoric culture of northern Europe and the Las Vegas and La Paloma sites of the Pacific central coast of South America (Stothert, 1985; Benfer, 1990; Ames 1994). These maritime societies had economies that integrated aquatic and terrestrial environments, thus providing a foundation for permanent settlements and emergent complexity. How such complexity took shape in each society varied, depending upon local political, social and ideological systems, the degree to which they exploited maritime environments and their surroundings, as well as an extended year-round site occupation. In this sense, sedentism provided the opportunity for groups to gain knowledge of the environment and to exploit it during the whole year. They acquired intimate knowledge of the movements of schools of fish, maritime currents and the behavioral ecology of aquatic organisms; such acquired knowledge was fundamental to increased cultural complexity (Yesner 1980; Arnold 1992; Ames 1994; Erlandson et al. 2011; Álvarez-Fernández 2011; Braje et al. 2011).

Research Problem

Moseley's (1975; Moseley and Feldman1988) hypothesis about the Maritime Foundations of Andean Civilization (MFAC), or Maritime Hypothesis, argues that in its first stage of development between ~4,500-3,750 BP, sedentism, social complexity, monumentality, and population growth were supported mainly by an economy based on marine resources. What is not known is whether Andean Civilization had its roots in earlier coastal cultures, such as the Chinchorro with maritime technology and complex culture as seem in its burial patterns. New data from Huaca Prieta already show that early manifestations of monumentality predate the monumental sites of the coastal Andes by at least 2,000 years ago (Dillehay et al. 2012b).

Although the economy and mortuary patterns of the Chinchorro culture are generally understood (Rivera 1991, Arriaza 1995, Santoro et al. 2005), its mobility patterns are poorly known, and sedentism has not yet been demonstrated for this culture (Rasmussen 1998; Billings 2001). Thus, a basic question is whether the Chinchorro culture was sedentary and to what extent sedentism fostered cultural complexity. The culture's emergent complexity is reflected in its advanced mummification of the dead, as well as in the evidence for diseases characteristic of a settled population (Arriaza 1995, Arriaza et al. 2008; Standen 1997; Santoro et al. 2012).

Arguments for the Chinchorro sedentism are mainly supported by evidence of a full-time maritime economy and lifestyle (Schiappacasse and Niemeyer 1984; Arriaza 1995; Arriaza et al. 2008; Santoro et al. 2012). For Arriaza (1995) some diseases associated with a maritime lifestyle reinforce these arguments. For example, infections caused by tapeworm parasites (*Diphyllobotrium pacificum*) associated with the consumption of raw fish and chronic ear infections (external auditory exostosis) indicative of diving in cold waters (Arriaza 1995; Arriaza and Standen 2002; Arriaza et al. 2008) were registered in Chinchorro mummies. Chagas' disease was also suggested as an indirect evidence of year-round occupation among the Chinchorro (Arriaza et al. 2008). Evidences of contamination were found in pre-Chinchorro and Chinchorro mummies from 9,000 to 3,500 BP and some other later sedentary populations reinforcing the hypothesis that it is a disease associated with more permanent settlements (Guhl et al. 2000; Aufderheide et al. 2004)[3]. This is a disease common associated with adobe habitation (mud dwellings) where the bug vector nests, but human infection also occurs by the ingestion of contaminated food, by the feces of the bug vector or by the raw meat from infected mammals (Coura et al. 2002). Chagas' disease is also found in early non-sedentary hunter-gatherer groups (7,000-4,500 BP) in Brazil suggesting that human contamination by Chagas' disease precedes human dwellings (Lima et al. 2008; Ferreira et al. 2011) and it is not a strong evidence for sedentism. Even so, attempts to demonstrate sedentism with hard data has yet to produce concrete results (Rasmussen

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[3] Chagas' disease (American tripanosomiasi) is parasitic infection that affects the heart caused by *Trypanosoma cruzy*, a protozoan transmitted by a bloodsucking bug.

1998; Billings 2001); providing such evidence is the purpose of the research reported here.

This doctoral research involves both fieldwork and laboratory analyses. It stresses the relationships between resource seasonality, the local environment, mobility patterns, and the complexity of the Chinchorro culture, which developed an advanced ideological system manifested in human mummification and burial patterns (Arriaza 2003), plus a sophisticated technology oriented toward maritime resources (Bird 1943, 1946). To date, most studies of Chinchorro culture have concentrated on nutrition, technology, mortuary, and genetic patterns (e.g. Rivera 1991; Standen and Arriaza 1999; Arriaza et al. 1998; Standen 2003; Santoro et al. 2005). Little attention has been given to the seasonality and permanency of occupation at residential sites (e.g., Rasmussen 1998; Billings 2001; Standen et al. 2004). The exceptions are the studies that investigated sedentism realized by Rasmussen (1998) in the Yara site (southern Peru) and by Billings (2001) in the Camarones Sur and Quiani sites (northern Chile). Although faunal and botanical data pointed to summer and winter occupation at the Yara site, no evidence of domestic structures were found to reinforce year-round occupation, and data was not sufficient to corroborate sedentism (Rasmussen 1998). Billings' research based on shell's isotopic analysis indicated that shells were seasonally collected but not year-around. Neither study, however, presented concrete evidence of sedentariness.

As noted earlier, understanding the mobility patterns of Chinchorro residents is thus essential for identifying and explaining complexity and the initial impulses toward early maritime civilization along the coast of the Central Andes. Although a few paleoenvironmental studies have occurred in the study area (e.g., Llagostera 1979;

Jerardino et al. 1992; Sandweiss et al. 1996; Sandweiss et al. 2003; deFrance et al. 2004), they did not ask questions about the intersection between environmental change, seasonality and the permanency of site occupation. An exception along the south Central Andean coast is the interdisciplinary research conducted at Quebrada de los Burros, in southern Peru (Lavallèe et al. 1999; Lavallèe et al. 2012). It is an early site, dated between 10,000 to 6,500 BP that suggests year-round occupation as early as 8,000 BP. This conclusion is based on a combination of sclerochronology data and botanical remains from the site (Lavallèe et al. 1999; Carré et al. 2009; Lavallèe et al. 2012).

In fact, there are a number of shell mound sites distributed along the desert coast of southern Peru and northern Chile (Jerardino et al. 1992) that attests to the use of maritime resources as early as 9,000 to 7,000 BP (Llagostera 1979; Rivera 1991; Muñoz and Chacama 1993; Santoro et al. 2005; Sandweiss et al. 1996; deFrance et al. 2004). This is shown not only by the shells themselves, but also by the range of artifacts exclusively used to exploit maritime resources such as fishhooks, harpoons, weights, and lines. It is also substantiated by the long duration of this maritime tradition from 7,000 to 2,500 BP (e.g. Rivera 1991; Llagostera 1992; Arriaza et al. 2008; Santoro et al. 2012; Marquet et al. 2012). By at least 7,000 to 6,000 BP, the ability of people to harvest the predictable and abundant resources available along the Pacific coastline allowed them to increase their numbers and to reside in semi-sedentary and possibly sedentary communities. Funerary elements associated with Chinchorro burials (Standen 2003) dating between 7,500 and 4,500 BP show an advanced maritime culture and social life. Also, their mortuary rituals, in which the mummies interacted with the living (Arriaza 1995), and burial places contributed to a collective memory. This signals certain complex behaviors of the Chinchorro society (Marquet et al. 2012; Dillehay 2012). A few studies have examined settlement patterns, and economic and social activities (e.g., Schiappacasse and Niemeyer 1984). More recent studies investigated the emergence of social complexity by looking at the connections between body mummification, climate change, and population size (Marquet et al. 2012). Nonetheless, they have not produced hard scientific evidence of a sedentary lifeway for Chinchorro culture (e.g., Rasmussen, 1998; Billings 2001). As Dillehay (2012) points out, "sedentism or restricted mobility" should be a key to understanding Chinchorro society, particularly given the nature of their ideology and their attachment to their ancestors and sacred funerary places.

In northern Peru, at the other extreme of the coastal desert, is Huaca Prieta, one of the earliest mound-building sites on the Andean coast. The site's complexity is reflected in the monumentality of its construction dated between ca. 7,500 and 4,000 BP, in the "growth and density" of its population and in its technology, notably its cotton weaving and fish netting (Dillehay et al. 2012b). The Huaca Prieta site offers an opportunity to study sedentism and its relationship to cultural complexity in a milieu quite different from that provided by the Chinchorro culture. The comparison between these two different societies can shed light on the intersection points between cultural complexity and mobility patterns.

Research Data

Chinchorro sites contain shellfish species that exhibit annual growth rings, mainly *Concholepas concholepas* (Bruguière 1789) and *Mesodesma donacium* (Lamarck 1818). These growth rings can be studied systematically, along with oxygen isotope studies, to determine seasonality and can help to assess the presence and degree of sedentism at domestic sites (e.g., Bernstein 1990; Claassen 1998; Russo 1998; Billings 2001; Quitmyer and Jones 2012; Andrus 2012). This study uses such hard archaeological and paleoecological data from selected Chinchorro sites to examine mobility and sedentary patterns. For the comparative analyses, Tom Dillehay provided both modern and archaeological shell collection samples of the genera *Semele* from the Huaca Prieta site and from the seashore environment. The archaeological shells were from the 2007-2011 excavations at the site; they primarily came from human burials (Dillehay et al. 2012b; Dillehay, personal communication).

For this research, the degree of Chinchorro sedentism was tested directly through the excavation and/or profile sampling of stratified shell mound deposits. This was combined with the analysis of annual shell growth rings of *Concholepas concholepas* from the sites of Camarones 14 and Camarones Sur, both located in the lower Camarones Valley. Together, these two sites contain deeply stratified deposits representing at least six millennia of occupation (Schiappacasse and Niemeyer 1984; Rivera 1984) and thus lend themselves to this kind of study.

Regarding the shell analysis, *Concholepas concholepas* does not show clear annual or seasonal marks in its morphological structures (Guzman 2004; Fernández et al. 2009). This is a highly complex mollusk species, and its use as a seasonal proxy is not yet well established (Falabella et al. 1991; Guzman 2004; Guzman et al. 2007; Lazareth et al. 2005; 2007). The methodology applied here is the first attempt to study seasonality of the shell's formation using specific morphological patterns of the shell's growth lines when observed in a cross-cut section, mainly the angles of the shell growth lines. As a new attempt, more studies are required to tests its viability. However, the positive results found here show its potential use as a seasonal indicator and encourage its application in future analysis.

In summary, to determine the degree of sedentism and its different layers (e.g. physical sedentism, ceremonial sedentism), this dissertation examines three well documented sites, that is, two Chinchorro sites along the northern Chilean coast and Huaca Prieta on the northern Peruvian coast.

Specific Research Objectives

The specific objectives of this research are:

1) To demonstrate the systematic relationship between the physical characteristics of *Concholepas concholepas*, that is, the internal shell's growth rings and the seasons of the year on the north coast of Chile. This work is based on modern samples.

2) To apply the results to the shells collected at Camarones 14 and Camarones Sur sites. This is done to assess the seasonality of site occupation during the Middle Holocene period.

3) To show the systematic relationship between the physical characteristics of *Semele* sp., that is, the internal shell's growth rings, and the seasons of the year on the north coast of Peru. This work also is based on modern samples.

4) To apply the results of this analysis to the shells collected at Huaca Prieta site. This is done to assess the seasonality of site occupation during the middle Holocene.

5) To shed more light on the mobility patterns of past human societies at these localities and their intersections with early cultural complexity.

Emergent Cultural Complexity and Sedentism

As used here, sedentism is defined as a reduction in mobility when the nuclear base of a group subsists year round in the same area (Hitchcock 1987; Kelly 1998, Bar-Yosef 1998; Kelly et al 2005). It is not an irreversible process, or "point of no return" (Bar- Yosef et al. 1989; Kelly 1992). It can be an event in flux. Varying degrees of sedentism are possible as groups move in and out of sites due internal or external pressures or a group's decisions. During a transition period, groups can fluctuate between nomadic and a sedentary patterns, using both permanent and temporary residential bases (Kelly et al 2005).

The traditional view was that agriculture and sedentism were symbiotically dependent on each other. Such association is no longer accepted unconditionally. Recent studies indicate that in many areas, forms of agriculture precede sedentism by many centuries (Kelly 1992; Marshall 2006). Archaeological indicators of sedentism are many and varied (Marshall 2006). For example, some indicators of sedentism in the Near East are stone house structures, heavy-duty material culture, cemeteries, commensal faunal species, thickness of deposits, storage pits, and animal seasonality (Boyd 2006). Other indicators are social stratification, selected diseases, and signals of stress in human bones (e.g., Harris Lines). These indicators, however, are not accepted without restrictions and are still a matter of discussion. For Bar-Yosef and Meadow (conf. Boyd 2006), the most reliable guide to seasonal or year-round occupation is biological evidence (Lieberman 1998; Bar-Yosef 1998), essentially the seasonal presence of commensal animals. To understand hunter-gatherer mobility patterns during the Late Holocene, paleoenvironmental approaches have been applied, such as shell ring analyses (e.g.

Quitmyer et al. 2005), isotope analyses of shells (eg., DeMasi 2009; Andrus and Thompson, 2012), and evidence from human bones (Borrero and Barberena 2006). In this research, biological markers are used to attempt to distinguish between seasonal and permanent occupation at the Chinchorro sites and at the Huaca Prieta site. As detailed later, the methodology applied embraces fieldwork, along with biological and physicochemical analysis.

As Kelly (1992) points out, resource abundance is not the only condition that leads to sedentism, but it is a necessary one. Archaeological research along coastal areas demonstrates that a rich marine environment can provide resources year-round (Yesner 1980). In the Central Andean coast, the main stay of maritime subsistence was the abundance of anchovies (*Engraulis ringens*), which can be dried or crushed into flour for long-term storage. Thus, anchovies could provide food supply for the whole year and in periods of scarcity, as occurred during the El Niño episodes. In this fashion, a maritime economy[4] became the bases for sedentism and social complexity in the area (Moseley 1975; 1992). These effects became visible later with the appearance of monumental architecture about 5,000 BP (Moseley and Feldman 1988). Subsequent studies brought in the role of plants during this transition (Raymond 1981). As Quilter and Stocker (1983: 555) point out, it was a combination of factors such as “subsistence, exchange, and ideas”, in which marine resources were an important element that led to the development of new forms of “social and political integration” and hence, the development of early complex societies in the Andes.

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[4] Initially the Maritime hypothesis was based on the consumption of shellfish and large fish, and later was showed that the most substantial food supply came, in fact, from small fish shoals, mainly anchovies (Moseley 1975; 1992).

Sedentism leads to changes in the structure of a society creating new ways to produce, process and store food, new building technologies, greater specialization, more rapid population growth, social stratification, and centralized political organization (Kelly 1992; Kelly et al. 2005; Marshall 2006). Such elements are an integral part of what cultural "complexity" implies and are generally part of the neo-evolutionary perspective (McIntosh 1999). In this approach, cultural change is built on the interrelationship between the complex elements described above. These become guideposts to recognize different stages in a society's evolution (McIntosh 1999). However, political centralization is often overemphasized (McIntosh 1999), masking other aspects of emerging social complexity such as ideology, new technologies, and even geographic mobility. For this dissertation, "emergent complexity" is understood as shifts in the parameters of hunter-gatherer social organization, specifically changes in geographic mobility patterns, readjustments in the ideological system, adoption of new technologies to exert greater control over the environment, and the deepening of a cultural identity and differentiation from "others" (*sensu* Price and Brown 1985).

Archaeological and ethnological data suggest that such social complexity frequently occurs following sedentism but before the emergence of intensive agriculture (Brown 1985; Price and Brown 1985; Borrero and Barberena 2006). Furthermore, the way human populations establish their settlements and organize themselves in physical space is culturally constructed, which means it varies due different adaptive strategies, previously existing social structures, and ideological interactions (Dillehay 2005). Anthropological studies of public and private space show that such cultural definitions structure social interactions, both unifying and differentiating what is considered appropriate behavior in such spaces (DaMatta 1987). In addition, the way domestic space is divided architecturally also reflects on-going social transformations (Hodder 1990; Bogucki 1999; Wilson 1988 in Dillehay 2006). Ritual space is an example. At Chinchorro, changes observed in funerary areas show a different contextualization of the dead with respect to domestic space (Standen et al. 2004). Thus, how space is organized reflects a network of social interactions within a society. As such spatial structures change, so too does the underlying social structure. In short, the long transitional period in hunter-gatherer mobility provides a rich source from which to view how sedentism led to changes in the use of space, in social structure, in ideology, and in settlement patterns. In this fashion, a maritime economy and society contributed to the rise of early civilizations along the Pacific coast of the Central Andes.

The Chinchorro culture's elaborate mortuary patterns suggest a degree of social complexity that rivals that of any known contemporary societies (*sensu* Santoro et al. 2004 – Final Proof). This includes the mound building at Huaca Prieta, one of the earliest sites of this type along the central Andean pacific coast. At Huaca Prieta, social complexity is reflected not only in its monumentality and construction phases, but also in its textile manufacture, cotton waving, fish netting, and in the "growth and density" of its population (Dillehay et al. 2012b). For the late Holocene in Peru, Moseley's (1975) maritime model for the Pacific coast of the Andes partly explains early sedentism and social complexity. It does not, however, account for earlier middle Holocene maritime cultural developments. The Chinchorro culture and the Huaca Prieta site thus present ideal settings to study middle Holocene relationships between maritime adaptations, sedentism, and an emergent cultural complexity.

The Cultural Context

Evidences for early sedentism and complexity along the Central Andean coasts come from sites dated from 8,000 to 5,000-4,500 BP. For instance, at the Las Vegas site in the southwestern Ecuadorian lowlands, a proposed sedentary group with a diversified economy and indications of plant domestication existed between 8,000 to 6,600 BP (Stothert 1985, 1988; Lavallée 2000). On the central coast of Peru, the Paloma (7,800-4,800 BP) and Chilca (5,500-4,500 BP) sites (Benfer 1982, 1990; Lavallée 2000) were primarily sedentary fishery villages with small circular houses made of reeds and covered with grass (see Figure 1.2 for sites). Bodies lying on their sides and wrapped in mats of woven reeds were buried inside these circular houses (Quilter 1989; Lavallée 2000, Moseley 2001). Paloma funerary patterns denote a preoccupation with the preservation of the dead and their interconnections with the living. Exotic objects, such as *Spondylus* shells from Ecuador and obsidian from the mountains, show contact with outside areas.

Additional evidence for early complexity is revealed in the monumental architecture along the north and central coast of Peru, as at Huaca Prieta in the Chicama Valley (Bird et al. 1985; Dillehay et. al. 2012b), El Paraíso in the Chillon Valley (Quilter and Stocker 1983; Quilter 1985), as well as all other sites in the Norte Chico[5] with signs of early centralized societies (Haas and Creamer 2006) such as Aspero (Moseley 1975; Feldman 1985) and Caral (Shady S. et al. 2001) in the Supe Valley, and Bandurria at the Huaura Valley (Fung 1988) (Figure 1.2). With the exception of Huaca Prieta, these sites date from about 4,500 to 3,800 BP (Pozorski and Pozorski 2008). With a mixed economy

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[5] It is an area in the central coast of Peru between the river valleys of Fortaleza, Pativilca, Supe, and Huara with dense concentration of sites (from 5,000 to 3,800 BP) with early signs of monumentality and social complexity indicated by architectural features (sunken circular plaza and monumental constructions) (Haas and Creamer 2006).

supported by marine and wetland resources, as well as agriculture, the emergence of cultural complexity at the Huaca Prieta mound pre-dates those earlier sites, with the constructive phase beginning about 6,800 BP. As Dillehay (et al. 2012b) observes, Huaca Prieta is one of the "earliest developments of cultural complexity in the Americas" and a place where several innovations occurred, for example, in technology, architecture, textile, and iconography. Complexity at Huaca Prieta is also suggested by the increase of the local valley Preceramic population (Dillehay et al 2012b).

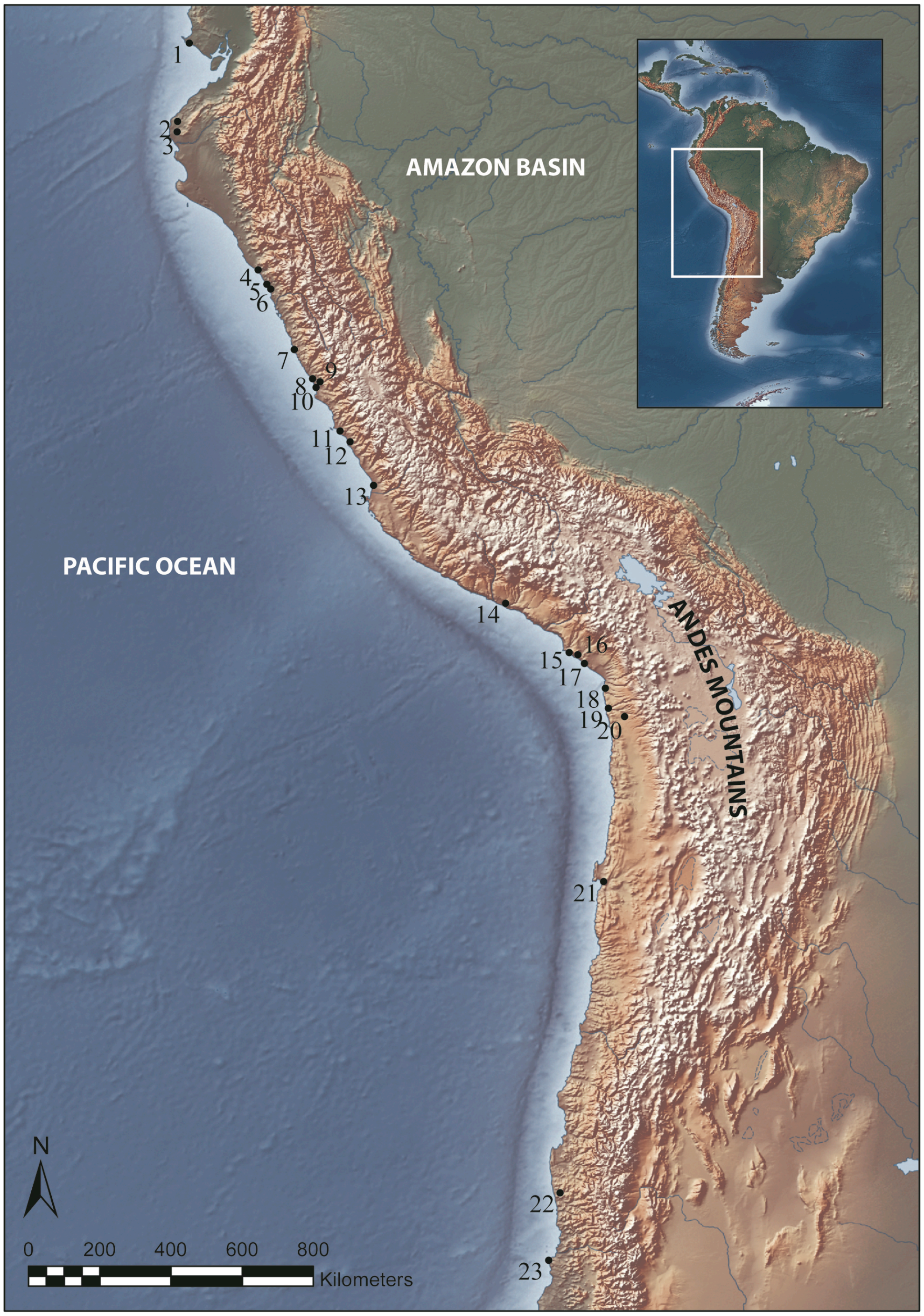

Figure 1.2: Main sites mention in the thesis: 1) Las Vegas; 2) Siches sites; 3) Amotape; 4) Huaca Prieta; 5) Alto Salaverry 6) Paiján sites; 7) Los Gavilanes; 8) Aspero; 9) Caral; 10) Bandurría; 11) El Paraíso; 12) La Paloma; 13) Chilca; 14) Quebrada Jaguay; 15) Ring Site; 16) Quebrada Tacahuay; 17) Quebrada de los Burros; 18) Morro 1-6, Playa Miller 8; Quiani 19) Camarones 14 and Camarones Sur; 20) Tiliviche-1; 21) Quebrada Las Conchas; 22) Huentelauquén; 23) Curaumilla-1.
(Map elaborated by Werner Hertzog and Matthew Velasco)

In the Atacama Desert, the early Holocene period was more humid than it is today (Grosjean et al. 2007). However, between ~7,500 – 4,000 BP the climate became more arid (Grosjean et al. 2007). It was during this period that the Chinchorro societies flourished and the cultural complexity increased; the Chinchorro became highly adapted to the maritime environment and the surrounding desert ecology (Rivera 1991; Núñez 2000; Llagostera 1979; Bird 1943, 1946). Several models of Chinchorro complexity have been proposed (Llagostera 1979; Rodriguez and Ovalle 2001; Marquet et al. 2012). They concentrate mainly on the Chinchorro's elaborate mummification patterns (e.g. Arriaza 1994, 1995; Arriaza et al. 1998; Aufderheide et al. 1993; Standen et al. 1999; Aufderheide et al. 1993). In addition to studies on mummies, advances also have been made on chronology and settlement patterns. Chinchorro mobility patterns, however, are not well understood, and different models have been proposed. For the early periods of pre-Chinchorro occupation, from about 9,500 - 10,000 BP (Acha 2 site), archaeological data point to mobile or semi-sedentary patterns with the establishment of temporary camps and the exploitation of coastal and inland valleys (Muñoz and Chacama 1993; Rodriguez and Ovalle 2001). Based primarily on bioanthropological data (mummies characteristics and diseases), Arriaza (1995) proposed early sedentism for Chinchorro coastal hunter-gatherers and its intensification by 5,000 BP. However, animal and plant domestication in the region suggests that sedentism may have begun around 4,000 BP and was fully established by 2,900 BP at the site of Chiu Chiu-200 in the middle course of the Loa River (Rivera 1991).

In northern Chile, near Arica, the artifacts found in the shell mound of Quiani I about 6,170 BP (Bird 1943) were shell fishhooks associated with the Chinchorro culture

(Schiappacasse and Niemeyer 1984); however, no mummies were found at this site. Farther south, near Antofagasta, a shell mound at Pisagua revealed a combination of specialized maritime technologies, including composite hooks and highly elaborate funerary patterns, including mummification in the Chinchorro style.

Sedentism has shown early signs in the northern coast of Peru, and later in northern Chile. With different configurations - ceremonial and architectural manifestations - cultural complexity, on the other hand has early evidences in sites from both areas. It is in this scenario marked by great cultural diversity that Huaca Prieta as well as the Chinchorro were integrated and followed different paths to cultural complexity.

Transhumance and the Soft Territoriality Models

Two models have been proposed for early maritime adaptation in northern Chile: the transhumance (Núñez 2000) and the soft territoriality (Schiappacasse and Niemeyer 1984) models. The first is used to explain the early-middle Holocene groups mobility. It is based in the circulation of forager hunter-gatherers between the coast (e.g., Camarones 14) and riverine inland oases (e.g., Tiviliche site), with a wide variety of products moving between both areas. This circuit suggests a semi-sedentary pattern that linked socio-economic networks with increased complexity. Transhumance consolidated a semi-sedentary pattern in both zones, which is reflected in lithic workshops, cemeteries, permanent houses, and discard deposits (Núñez 2000). In another model, Schiappacase and Niemeyer (1984) proposed the “soft territoriality” approach, which implies that forager hunter-gatherers were living at permanent bases, with part of the group moving to distant areas for extractive activities. These groups occupied transitory camps in different ecological zones and sought complementary and prestige resources. The variability of zones and the choice of settlements at different localities provided access to multiple resources and favored sedentism. Soft territoriality also facilitated social exchange between neighbors, and expanded and diversified the areas of exploitation. The soft territoriality model sheds light on the adaptation process in the arid coastal environment of north Chile. Resources were limited there, and social networks between coastal desert oases played an important role.

The Overexploitation of Resources

A semi-sedentary to sedentary lifeway in circumscribed areas where resources are restricted can impact local ecosystems, especially if such exploitation is intense (Jerardino et al. 1992). For central Chile, indicators of overexploitation of resources have been suggested at the coastal hunter-gatherer site of the Curaumilla (Jerardino et al. 1992), with its preceramic phases dating between ~8,500 and 4,700 BP. Analysis of *Fissurella limbata* and *Concholepas concholepas* shells from this and other sites shows variation in the mean sizes of shells through time. The shell size of these species decreased three times during the periods of human occupation. Although it was recognized that environmental factors could have produced similar reductions, it was concluded that the local environment had been modified by site inhabitants (Jerardino et al. 1992). Baéz and colleagues (2004), studying variations in the size of *Concholepas concholepas* in early-middle Holocene sites of central Chile (from about 10,120 and 5,540 BP), observed that humans were exploiting shells without selecting for shell (i.e., meat) size. Their samples varied from 20 to 145 millimeters in size, indicating that both young and young adult specimens were primarily exploited, but the majority of the samples correspond to the first stage of maturity. Collection of variable specimen sizes had a direct impact on species reproduction and the local ecosystem, thus affecting the resilience of shellfish species locally. Variations in abundance of *Concholepas concholepas* species compared with the variability of the record for *Retrotapes rufa* (locally known as "*almejas*") and *Mesodesma donacium* (locally known as "*machas*") led the authors to also conclude that paleo-climatic changes, notably sea level variations, also influenced the extraction of species by humans (Baéz et al. 2004). El Niño events too are sources of dramatic changes, including the massive mortality and demographic explosion of some marine species (Moreno 2004). Thus, in studying shell size selection, availability, and seasonality, both human factors and ecological impacts must be considered.

Prehistoric populations living in the same area year-around and intensively exploiting local resources had to carefully manage their surroundings. In order to avoid resource depletion, they developed solutions for periods in which natural phenomena like El Niño disrupted the local ecological balance. Consequently, a secondary research goal is to examine any impact that human or natural events had on local subsistence and the responses to these changes. Sedentary societies had to manage resources and avoid overexploitation of local resources. From an archaeological perspective, there are several ways to identify such changes: 1) by the substitution of one resource for another in times of stress; 2) by technological improvements that amplified the range and diversity of resource exploitation, as with fishing technology and settled agriculture; and 3) finally, by intensifying bonds of reciprocity with neighbors or exchange networks, thus creating support system for periods of scarcity. In the case of the Chinchorro, groups were living in circumscribed areas where "low energy" easy accessible resources like shellfish were limited. As a result, they probably developed internal strategies to manage resource scarcity. Such strategies would include evidences of technological improvements, the reinforcement of social ties with other groups, and the intensification of group identity and ideology to maintain group cohesion (Schiappacasse and Niemeyer 1984; Arriaza and Standen 2002).

Geographic Context and Previous Research at Camarones 14 and Camarones Sur Sites

The study region is the seashore portion of the dry, arid environment of the Atacama Desert. It extends along the western side of South America from latitude 18° S to 27° S (Santoro et al. 2005) (Figure 1.3).

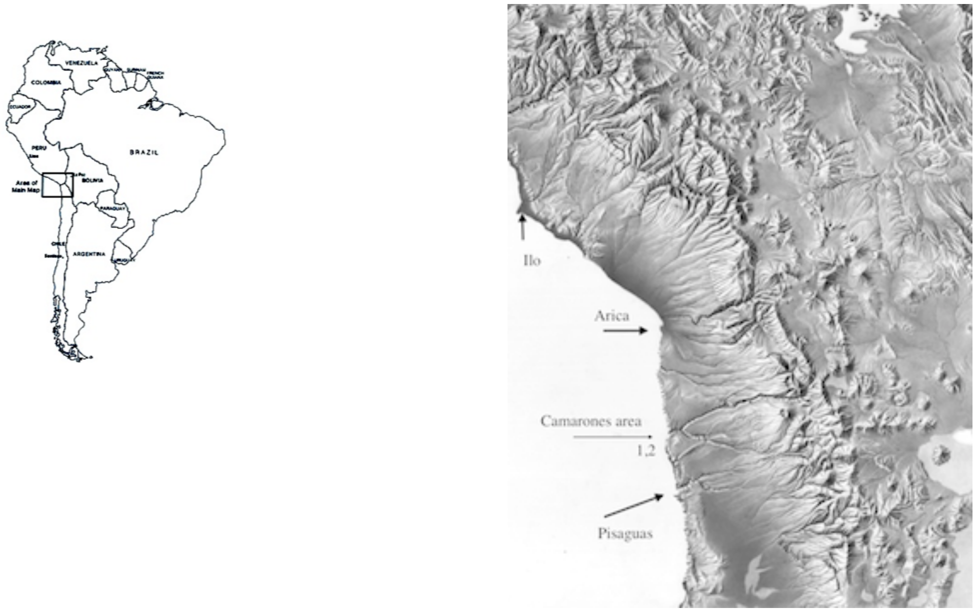

Figure 1.3: Map showing the Camarones area where the sites of Camarones 14 (1) and Camarones Sur (2) are located. Also noted are the main coastal cities in the region (source: free access).

To the east, the Cordillera de la Costa borders the desert coastal plains. The arid Atacama coast is divided into four ecological subareas (Nuñez 2000) the fertile river deltas; 2) the desert coast between the deltas, which can extend more then 900 km between rivers; 3) the transverse valleys with vast salt flats left behind by Pleistocene lakes; and 4) the Andean highlands, above 2000 meters. In the Atacama area, water sources are restricted to rivers that come down from the mountains (Llagostera 1979). The deltas of the Lluta, Azapa, Vítor and Camarones rivers emerge along the arid coast as fertile zones presenting "oasis conditions" (Nuñez 2000). In the ocean, the cold waters of Humboldt Current, rich in planktons, are responsible for the abundance of fish, mollusks, marine mammals and other maritime organisms, as well as birds. This fragile ecosystem is disrupted every few decades by severe El Niño episodes (Quinn 1987), which impact not only marine life, but also terrestrial ecosystems (Holmgren 2001).

Despite these uncertainties, hunter-gatherer societies successfully adapted their culture to this challenging environment.

Schiappacasse and Niemeyer (1984) describe the Camarones Valley as a cut in the highlands that crosses the desert "pampa" and the coastal cordillera. The valley is surrounded by the high walls of the coastal cordillera, which are about 1,000 meters high. The delta of the valley is defined on both sides by high cliffs, with Punta Norte on the north side and Punta Camarones on the south side (Schiappacasse and Niemeyer 1984; Billings 2001). An ample fluvial-marine terrace, at an elevation of 35 meters above sea level, characterizes the south side of the delta (Figure 1.4). The Camarones 14 site is located on this terrace. Further south, facing the ocean, is the Camarones Sur site. The Pacific coast of north Chile, specifically at the Camarones Valley, is characterized by high maritime productivity in a circumscribed environment. What led to the selection of this area for study was the long and positive adaptation of the coastal groups living there.

Figure 1.4: showing the delta of Camarones valley and the location Camarones 14 and Camarones Sur (source: Google maps).

Preceramic cultures of fisher-hunter-gatherers left clear archaeological traces behind. Early research carried out at the Camarones 14 site (Schiappacasse and Niemeyer 1984) suggests that the Camarones Valley is one of the places where human mummification first began, perhaps as early as 7,000 BP (Standen et al. 2004). Later, the practice spread north along the Chilean coast, eventually reaching the south Peruvian coast (Santoro et al. 2005). This situation makes Camarones 14 and Camarones Sur important sites to study the relationship between sedentism, social complexity, and adaptation to a dry coastal environment.

Camarones 14 and Camarones Sur have been selected for study due to their data potential, their geographical position in a fertile coastal delta, their possible connection to inland areas, and the long period of their occupation. Camarones 14 (Schiappacasse and Niemeyer 1984) provides the earliest evidence of mummification around 7,000 ± 135 BP (I-11431) (Schiappacasse and Niemeyer 1984; Santoro et al. 2004 – Final Proof). Camarones Sur (Rivera 1984) presents an exposed profile of about 5 meters. This profile covers a timespan of about 5,000 years from about 5,500 to 600 BP (Rivera 1984; Rivera personal communication 2012). It provides a deep stratigraphic column to be sampled for diachronic analyses. As stated before, these sites are located along a delta that empties into a circumscribed bay enclosed by high mountains and by the desert. They also had access to a rich marine coast. This combination is ideal to study seasonality and the role that terrestrial and aquatic environments played in subsistence strategies. In this case, it provides insights into the complex forms of social organization and technology that maritime forager hunter-gatherer developed.

The valley forms a corridor that extends to the east connecting the delta of the Camarones River to the Andean highlands. The desert surrounds the valley, which is itself enclosed by the Cordillera de la Costa and its sand dunes. Human populations exploited the rocky littoral, the sandy beach, the seasonal *lomas*[6], and the nearby valley, including marshy plants close to the lagoon (Figure 1.5 and Figure 1.6). Consequently, the area has the pre-requisites for a sedentary life and social complexity. Moreover, the Camarones Valley also is a nodal point between the coast and the intermountain region. This provides an opportunity to study contacts between the two regions during the early-middle Holocene. Finally, it is a chance to look at how societies that faced an uncertain environment developed adaptive mechanisms of resources management, exchange, and social networks.

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[6] *Lomas* are not in the delta, properly, but inside the valley (see chapters 2 and 4).

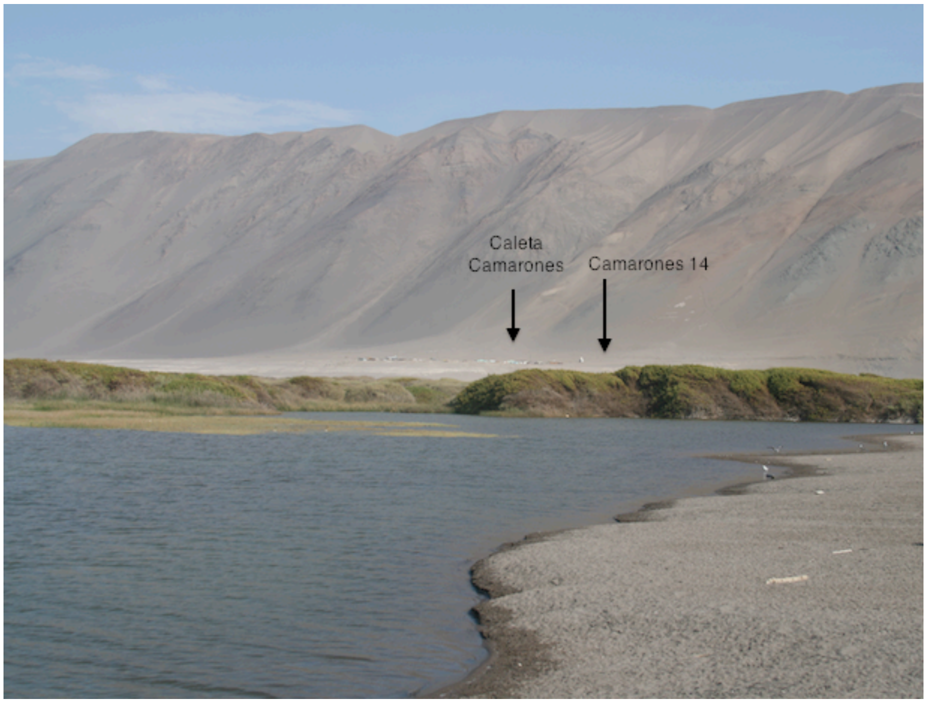

Figure 1.5: Camarones river delta showing the south portion of the valley's mouth with its lagoon. The site of Camarones 14 and the fishing village of Caleta Camarones are in the background close to the high hills (author's photo).

Figure 1.6: The desert coast of the Atacama and the surrounding area at Camarones Sur site (author's photo).

Previous Research at Camarones 14 Site

The site is located on a marine terrace formed on the south portion of the Camarones River valley. Between the years of 1976 and 1977, Schiappacasse and Niemeyer (1984) carried out excavations at this site. It is characterized by two main occupations. A more recent one was contemporary with Inca domination. The other is an early occupation by a small-scale community of maritime foragers that dates to the early-middle Holocene. It is related to the Chinchorro culture.

During Schiappacasse and Niemeyer's work, surface ceramic fragments were found on the site. The excavation followed the natural layers of the ground and in extended surfaces, demarcated by a square system of 2 x 2 meters for the majority of the sectors. The early occupation of the site corresponds to the Chinchorro and was dated between 7,420 ± 225 BP to 6,615 ± 390 BP (Schiappacasse and Niemeyer, 1984: 26).

Twenty-three human burials were found. Of these, five were artificially mummified (classified as "mommias de preparación complicada"), and another one had a clay mask. All the artificial mummies were of children, and one of them was dated at 7,000 ± 135 BP (Schiappacasse and Niemeyer, 1984: 26). The preceramic occupation had shell and thorn fishhooks and no ceramics. Notably among lithic artifacts were bi-pointed projectiles in which the proximal area is convex and the distal is in pointed. These projectiles were used as spear points, as is attested to by the bi-point that traversed the vertebra of a sea lion. Other types of points were also recovered, a few with the distal area in a pointed end and the proximal with a concavity that formed a barbs on each of the two sides (see Schiappacasse and Niemeyer, 1984: 55, Figure 26). Some other lithic artifacts were also found such as "*limas*" (a fusiform artifact) and "*serras*" (saw), both used in the manufacture of shell fishhooks. Also part of the lithic material uncovered were: "*morteros*" (pestles), unifacial and some bifacial implements from scrappers, projectile points and preforms, along with retouched flakes, cores, chip and other chopping remains. Abundant fragments of vegetation, as well as fish and shell remains, were also part of the context of the occupation. The most prevalent animal remains were of *Otaria flavescens* (sea lion). Additional information about faunal remains and artifacts from this excavation are discussed later in chapters 2 and 5.

Previous Research at Camarones Sur Site

Camarones Sur is located on a narrow sloping strip of the Cordillera de la Costa, between the mountain and the ocean. It is an unstable area in which earthquakes are common[7]. The surface area of the site covers approximately 72,670 square meters (Billings, 2001). Camarones Sur has shell concentrations with layers mixed with botanical and animal bone remains. Also found are hearths with ashes and burned calcined soil, sand, stones, human bones and different types of artifacts. The successive occupational layers were the result of human activity, as well as the natural accumulation of sediments carried down from nearby surrounding slopes in which the site occupation was established. In general terms, the Camarones Sur site can be described as a mound with a matrix composed by sand intercalated with shells and other organic components.

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[7] In the south direction, down the slopes at the end of the terrace, there is a good point for fishing and mollusks gather. This zone, named as Molle, is used nowadays by fishermen from the Caleta Camarones as a launching area for the boats and as a point to enter in the sea to collect mollusks or to fish. However, all this area, including where the site is located, is considered a risk area (Liutenant Carabinero, Berzesio Toro, personal information, september 2007), and former attempts to construct a deposit for the boats were abandoned due to by the tectonic instability of the place.

Mario Rivera (1984) excavated the site in 1979. He worked with the Instituto de Investigaciones Arqueologicas y Restauración Monumental de la Universidad de Chile and researchers from the Universidad del Norte Antofagasta and the Universidad de Chile. The aim was to verify the deepness and nature of the archaeological matrix and to identify the occupational units of the site (Rivera 1984; Rivera 2002; Rivera et. al. 1998). Two sectors were opened and the excavation reached about 5 meters deep (Rivera 1984; Rivera 2002). In a preliminary analysis, Rivera (1984) defined two occupational units, a ceramic and a Preceramic one. The most recent was dated to around 1,050 ± 110 BP (900 AD; Charcoal sample - GaK-8644). It reflects the establishment of a ceramic population of the San Miguel type (dated around 800 to 1200 A.D.) along the coast. This type is associated with the "Desarrollo Regional" period (RDA), a post-Tiwanaku period occupation. The occupation yielded ceramic and woven textiles that used monochromic and polychromic techniques. Also found were fish (mainly Scianidae) and cultivated plants, notably maize (*Zea maiz*), potatoes (*Solanum*) and squash (*Cucurbita*).

The earlier and deeper preceramic unit is related to hunter-fisher-gatherer groups, identified by Rivera (2002) as a Chinchorro occupation. He divides this unit into Chinchorro III and II. Phase III is related to a transitional period in which some woolen textiles and early ceramics occur and is associated with a later Chinchorro context (around 3,500 to 2,500 BP). The Chinchorro phase II is related to the earlier occupation, between 5,700 to 3,500 BP, and it is characterized by the occurrence of well elaborated fishing artifacts, like fishhooks, harpoons, cotton fishing lines, weights, ring-necked nets ("chinguillo"), grinding stones, and hand stones. Based on a charcoal sample collected from a hearth about 4.97 meters deep, the site was radiocarbon dated to 5,640 ± 160 BP

(Charcoal sample - GaK-8645). That date put the site in the Classic Chinchorro and the Transitional epochs (Arriaza 1995; Billings 2001). In the same context there were also grinding stones deposited over a compacted layer of dry plants.

For the faunal remains, the studies available are not specific to each of the occupational phases. For the whole context of the site, however, the majority of the fauna exploited were local and from the marine environment (Table 1.1) (Rivera s/d). The exception is Cathartidae, a new world vulture that is common in the area (*Cathartes aura*). Also found was Felidae, possibly *Lontra feline,* a small marine carnivore of this Family that is still found in the area.

Table 1.1: Faunal remains from Camarones Sur (source Rivera s/d)

	Invertebrates	
Phylum Mollusca	Class Gastropoda	*Concholepas concholepas* (“*loco*”)
		Fissurela crassa (“*lapas*”)
		Fissurela picta
		Fissurela maxima
		Tegula tridentata
		Crepipatella dilatata
		Oliva sp.
	Class Bivalvia	*Choromytilus choro* (“*choro*”)
		Perumytilus purpuratus (“*chorito maico*”)
	Class Polyplacophora	Family Chitinidae (“*chitons*”)
Phylum Arthropoda	Class Crustacea	*Pachycheles* sp.
	Infraorder Brachyura	2 unidentified species (crabs)
	Vertebrates	
	Class Pisces	4 unidentified species
	Class Aves	Spheniscidae (penguins)
		Cathartidae (new world vultures)
	Class Mamalia	Felidae
		Otaria flavescens (sea lion)
	Ordem Cetacea	Mysticeti
		Odontoceti

Billings' (2001) research also produced a series of radiocarbon dates from charcoal samples collected from column samplings. This work positioned the site in the Middle/Late Holocene period, with dates ranging from 4,510 ± 67 BP to 3,624 ± 64 BP (Billings 2001: 72).

Her work relied on oxygen isotopic analyses of shells to investigate whether the fact that the Chinchorro were sedentary that may have been a factor in the Chinchorro complex funerary tradition as postulated by Arriaza (1995). Billings' research covers the Camarones Sur site and the site of Quiani (Arica, Chile), another Chinchorro site. The results, however, did not show a sedentary occupation for these sites. It is possible that Camarones Sur had been a space were people congregated for funerary rituals, for feasts, and for food preparation, but did not stay there on a regular basis[8].

Camarones Sur is a large, deep site located on the edge of a cliff parallel to the coastline. The terrain has a certain degree of inclination from about 30 to 45 degrees. The area's tectonic instability and the site's position intensify sedimentary deposits generated not only by the winds but also by sand and stone debris that works its way down the slopes. Even so, given the thickness of the overlying strata, the depository process at this site was more rapid than what took place at Camarones 14, where the terrain has a gentle slope. This suggests a dynamic occupation illustrated not only in a full use of cultivated plants, and subsistence technology, but by the intensive use of the site. For the early layers, in which fishing equipment and gridding stones were part of their tool kit, Rivera's (2002) data places such activities within the Chinchorro cultural context. This

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[8] Small seismic activities are common in the area. In 2008, during the 3 months of excavation in the Camarones area for this research, one major earthquake and its after shocks occured in northern Chile achieving a 6.7 magnitude in the research area. Rocks tumbled down the slopes near the Camarones Sur site.

occupation was followed by a post-Chinchorro phase in which domesticated plants and ceramics were already part of a subsistence economy and related technology.

Billings' (2001) work points to the seasonal character of the site. Perhaps the site was used intermittently at first by populations who exploiting the area. Initially they relied on marine life, and later they brought in new elements from inland areas, as seen by the domesticated plants that were in full use by the post-Chinchorro communities.

Camarones Sur together with Camarones 14 indicate the long-standing use of the area by human societies. Their histories span the transformation of the archaeological context from marine foraging hunter-gatherers to agro-ceramists, a transition embedded within a sacred landscape. The long-term use of these sites also shows a strong continuing connection between the human communities and the landscape, and how it played into funerary ceremonies. At Camarones 14, a pattern of artificial mummified bodies buried in a domestic cemetery dates back to about 7,400-7,000 BP (Shciappacasse and Niemeyer 1984).

To find evidence for sedentism at Camarones 14 and Camarones Sur, this research examined the seasonal growth ring patterns formed on shells. Shells of *Concholepas concholepas* were sampled at both sites and complemented with oxygen stable isotopic analyses. Giving its early chronology starting about 7,400 BP, Camarones 14 was chosen as the target site. Parallel work with material from this site included radiocarbon dating, paleobotany (phytoliths/palinology/macro-remains), zooarchaeology (mainly in shells), coprolites, and geology (sedimentology).

Geographic Context and Previous Research at Huaca Prieta Site

Located on the delta of the Chicama River, Huaca Prieta (Figure 1.7) is part of a large complex of sites situated over a marine terrace formation (Sangamon) (Dillehay et al. 2012a). This area lies at the northern end of the Peruvian coastal desert. To the east are the Andean mountains, and on the west the rich waters of the Pacific Ocean are fed by the nutrient upwelling of the Humboldt Current. The rivers that run perpendicular to the coastline can dry up intermittently or they can provide a constant flux of water year around. The desert landscape is also broken up by slopes that range between 200 and up to 1,000 meters above sea level. Interspersed along the coastline are *lomas* fed by fog condensation where plants and fauna concentrate.

Figure 1.7: the mound of Huaca Prieta (Tom Dillehay's photo)

Moving south, the desert becomes more extreme, but the river valleys and lomas provided the water and food resources necessary to support early inhabitants (Sandweiss and Richardson III 2008). Later, irrigation and intensive farming transformed this region. The process began about 6,100 BP in the valleys or "quebradas" of the western slopes and about 4,400 BP in the coastal valleys (Sandweiss and Richardson III 2008 quoting Grieder et al. 1988; Quilter et al. 1991; Burger 1992; Shady Solis et al. 2001, Dillehay et al. 2005). Forager hunter-gatherers exploited marine resources as early as 11,000 BP; some examples are the sites of Las Vegas in Ecuador (Stothert 1988), Quebrada Jaguay (Sandweiss and Richardson III 2008; Sandweiss 2008) in Peru, and Huaca Prieta, itself (Dillehay et al. 2012a).

Huaca Prieta is a flat-topped large oval-shaped, Preceramic mound about 148 meters long, 62 meters wide and 32 meters high (Dillehay et al. 2012a) (Figure 1.7). Junius Bird first excavated this site in the 1940s. At that time, he interpreted the site as a permanent settlement with people living in small subterranean or pit houses (Bird et al. 1985). The mud walls were covered with cobblestones and the roofs were made using wood or whalebones. Subsistence activities included the use of domesticated and wild plants complemented by marine resources as fishes and mollusks, as well as hunting birds and mammals (Bird et al. 1985). Textile craft used dyed fibers and techniques that included weaving, knotting, looping and "twining with spaced wefts and exposed warps". Nets and stone sinkers for fishing were also used as well as coarse flakes, cores and hammerstones (Willey 1971). In 2006, Tom Dillehay and collaborators re-excavated Huaca Prieta (Dillehay et al. 2012a, 2012b). Thus, the area worked by Bird was expanded, and other areas of the mound, as well as the nearby sites, were also investigated.

The research of Dillehay and collaborators (2012b, 2012b online supplement) show that the mound at Huaca Prieta was actually a ceremonial and mortuary site. It was part of a settlement complex that included outlying domestic sites (Unit 16 and a food preparation locale, Paredones site) and raised beds for agricultural, where beans, chili pepper, and squash were cultivated. The mound itself was built by the local community and involved a small group of people in its construction (Dillehay et al. 2012b; 2012b online supplement). All of this original data brought new insights to the interpretation of Huaca Prieta and the "rise of early complexity" on the Peruvian coast (Dillehay et al. 2012b, 2012b online supplement).

As early as ~14,500 to 11,500 BP (Late Pleistocene), foragers along the northern coastal plains of Peru occupied the Sangamon marine terrace site at Huaca Prieta (Dillehay et al. 2012a). After a hiatus, another occupation was registered between ~7,900 and ~6,600 BP (~8,979 and ~7,500 cal BP) (Dillehay et al. 2012a, 2012b). The constructive phases of Preceramic occupation at Huaca Prieta are dated from ~6,640 BP to 3,100 BP (7,555 to ~3,500 cal BP) (Phase II to V). Subsequently, the ceramic period began around ~3,350 BP (~3,800 cal BP). During the later Cuspinique and Inca periods, the top of the mound was used for burials and rituals (Dillehay et al. 2012a, 2012b).

Human burials were found in all mound phases (Phases II to V). The evidence recovered from the mound building sequence (Phases III to V) reveals that the subterranean "houses" were postulated by Bird, in fact, burial chambers connected to a sunken plaza. No domestic structures or features like hearths, storage areas, or post-holes were found. Dillehay et al. (2012b, 2012 online supplement) suggests that a limited number of people participated in the mound construction and that numerous rituals occurred during the building process (Dillehay et. al. 2012b, 2012 online supplement). The mound's construction was the result of intentional and planned activity since its initial phase (*Phase II*) and not the haphazard result of gradual debris accumulation during the period of the site's occupation (Dillehay et al. 2012b). Dillehay's work at Huaca Prieta brought new insights for the interpretation of the site and the rise of early complexity along the coast of Peru (Dillehay at al 2012a; 2012b, 2012b online supplement).

Project Significance

The proposed research at the two Chinchorro occupational sites and at the Huaca Prieta mound will bring new data to bear on how early economies took shape and the role that sedentism played in generating social complexity. It also highlights the role that middle Holocene maritime adaptations played in the subsequent rise of Andean civilizations along the Pacific coast of South America. During the middle Holocene, the Chinchorro maritime culture was one of the most intense and sophisticated coastal adaptations in the world. Prior to that, the Huaca Prieta site was part of a settlement complex that shows an early degree of complexity emerging in the northern coast of Peru.

This dissertation thus attempts to elucidate the pathways that led to cultural complexity and possible sedentism at Chinchorro. It helps us to understand the emergence of complex societies and the transition to sedentism by early maritime hunter-gatherers. The use of avian, mammal, and shellfish remains to study seasonality and mobility patterns is not new in archaeological analysis. Shell growth-ring analysis, however, has not yet been applied to early coastal sites on the north coast of Chile. The proposed research will be the first time that shell growth-ring analysis has been applied to the study of seasonality and sedentism at Chinchorro. Similarly, seasonality work on shells, specifically through growth rings, has not been done on seashell remains at the Huaca Prieta site. Therefore, this work can bring new insights into seasonal activities there as well. Maritime adaptations continued and intensified along the Central Andean coast in the late Holocene. Thus the proposed research is important to understanding of the diversity of these adaptations at one locale in north Chile. In addition, a comparative analysis, based on data from the Huaca Prieta site in Peru, can shed some light on the role sedentism played in cultural complexity for the larger central coastal Andean region as a whole. Early adaptations may have set in motion organizational and social patterns that structured later complex societies.

Organization

The dissertation begins with an overview of the physical settings in which the cultural and social adaptations discussed here took place (Chapter Two). The desert coast from northern Chile and across Peru, is hemmed in by the vast Andean Cordillera.

To contextualize the sites and cultures studied, Chapter Two presents a panoramic description of the physical settings along with present day data on climate and temperature. It also describes two of the main characteristics of the area, the upwelling of the Humboldt sea current and El Niño oscillations. Data concerning the paleoclimate is also introduced. This provides a background for understanding the environmental transformations that occurred during the early and middle Holocene. It also gives a context for discussions regarding the biotic data at the research area. In addition the Camarones River is described in more detail, and data from modern fauna and vegetation are presented with a focus on seasonality.

The methodology applied in this research is explained in Chapter Three. This includes the fieldwork done at Camarones 14 and Camarones Sur. It covers stratigraphy and the macro divisions that are correlated with the work of Schiappacasse and Niemeyer (1984). It also presents shell sclerochronology with a description of preparation techniques for the shell growth lines and oxygen isotopic analysis.

Chapter Four focuses on interpreting data for the target species of mollusks: *Concholepas concholepas* for the Chinchorro sites and *Semele* for Huaca Prieta. It presents shell ring analysis procedures and their results for the three sites. Overexploitation are also presented and discussed in this chapter. This is done with the shells of *Concholepas concholepas* from Camarones 14 and Camarones Sur sites. Finally, it covers isotopic analysis.

Chapter Five centers on the remaining material recovered in Camarones 14. It is based on the excavation done at the site for this research. The chapter also discusses the botanical material, such as macro remains, pollens, and phytoliths. Fishhooks and artifacts used in shell industry are analyzed, as are lithic artifacts and the results of coprolite analysis. It also presents some fish identifications.

Chapter Six reviews the archaeological evidence for sedentariness and cultural complexity, related specifically to Holocene communities of maritime foragers.

Finally, Chapter Seven gives the conclusions. It brings together the archaeological evidence and the seasonal data generated by the shells analysis. The appendices present botanical material, including data on macro remains, pollens, and phytolith, coprolites, along with sediments samples from Camarones 14, raw data from the shell analyses, and cartographic plan from the Camarones valley mouth area. Not included is the fauna report for avian and mammal. Because this report was not submitted by the contacted research, this material was not discussed here and would be subject of future analysis.

For comparative purposes, in this thesis, ages are in years before present (BP) and uncalibrates. This was preferred because in former publications from the study area ages were uncalibrated. Recent literature, however, employ calibrates ages (calendar years) (cal. BP). For this thesis, the correlation between calibrated to uncalibrated are provided and is approximate. In this case, calibrated data from publications are presented between parentheses. Radiocarbon ages from Camarones 14 and Camarones Sur sites were calibrated using the program Calib Rev 6.0.0 (Stuiver, Reimer and Reimer); these data are discussed later in Chapter 5.

Permissions for this research were obtained from the Consejo de Monumentos Nacionales (CMN) and the Subsecretaría de Pesca, Chile. License was issued to excavate Camarones 14 but not included Camarones Sur. For Huaca Prieta, Dillehay had all the necessary permissions obtained from Peruvian institutions.

In summary, this thesis proceeds from a general view of sedentism and cultural complexity, as well as the analysis of the archaeological remains of the site of Camarones 14, to a specific analysis of the shell growth rings of *Concholepas concholepas* remains from this site and from the site of Camarones Sur. Seasonality studies are complemented with the analysis of shell growth rings of *Semele* sp. from the site of Huaca Prieta.

In order to investigate the seasonality of occupation at the sites of Camarones 14 and Camarones Sur, a new methodology based on the morphology of the growth lines in shells of *Concholepas concholepas* was developed here. This is an initial attempt to correlates the morphology of the angles observed in the formation of the growth lines with the seasons of the year in this highly complex mollusk's species. In this way, more studies are required to tests its viability. However, the positive results found here show its potential use as a seasonal indicator.

CHAPTER II

THE NATURAL CONTEXT

The rich aquatic marine life along the Andean coast provided abundant and varied resources for post-Pleistocene prehistoric populations. By contrast the arid desert that stretches from the southern coast of Ecuador to Chile's northern coast made for a harsh environment that seemed unfit for human occupation. Nonetheless, human populations learned how to exploit the surrounding environment in a way that made semi-permanent or permanent settlements possible. They explored oasis areas and how they connected to the desert coast and the river deltas (Núñez 1983; Llagostera 1989; Sandweiss et al. 1998; Dillehay 2000; Lavallée 2000; Contreras 2010; Dillehay et al. 2012a; Lavallée et al. 2011). In fact, the arid Andean coast forms a mosaic of microenvironments that ancient peoples, since at least 12,000 years ago exploited. Over time they worked out different strategies to survive and used this as a basis to create flourishing societies (Dillehay 2000; Lavallée 2000; Moseley 2001; Dillehay et al. 2004; Núñez et al. 2010; Osorio et al. 2011).

This chapter describes the region's geographic ecology including both biotic and abiotic factors. It looks at latitudinal strips from the coast to the highlands, but with an emphasis on the coastal zones. It compares the paleo-climate during the early-middle Holocene to the region's climate at present. After that, the oceanographic conditions are introduced followed by a description of the land systems that extend down from the cordillera to the desert coast. Biotic aspects of the study concentrate on the Camarones River mouth, where botanical and faunal data were compiled. As reported by

Schiappacasse, Niemeyer (1984) and Rivera (mimeograph s/d.) for both Camarones 14 and Camarones Sur, some modern and archaeological data are available. Thus, much of the data described here, including the archaeological information, comes from the available literature.

The research sites are located along the desert coast that lies between the Pacific Ocean and the Andean cordillera. This narrow strip stretches from the north coast of Peru south to the Atacama Desert in northern Chile (Figure 2.1).

Figure 2.1: Schematic representation of the Peruvian and Atacama deserts that runs from Piura in northern Peru to Copiapó in Chile (source: National Geographic Society, 2009).

Human social patterns respond to environmental changes in different ways (Moreno et al. 2008). During the period under study, significant climatic changes occurred (Sandweiss et al. 1999). To understand mobility patterns and cultural complexity under such conditions, it is first necessary to describe the paleoenvironmental settings in which human foragers lived and the changes that took place through time.

Paleoclimate

During the glacial phases of the Pleistocene,[1] ice descended down the slopes of the Cordillera some few hundred meters lower than at present. The ice sheets, however, never covered the whole Cordillera as occurred in much of North America. Only in the far south (about 30° S), near Tierra del Fuego, did glaciers cover the entire mountain chain (Lavallée 2000; Dillehay 2000). During the Late Glacial Era[2], in the Central Andes, (from 8° to 15° S) ice sheets formed above 4,000 meters. By contrast, northern Chile below 4,500 meters was ice-free. The climate, was drier than today (Lavallée 2000; Dillehay 2000). The de-glaciation began 14,000 years ago and ended around 11,000-10,000 years ago. Temperatures rose and ocean waters flooded the lowland coast (Lavallée 2000). At the end of the Pleistocene and the beginning of the Holocene, roughly 18,000 to 11,000 years ago, palaeohydrological evidence from lake level fluctuations indicates high levels of precipitation: "Central Andean Pluvial Event."

Despite many studies of the paleoclimate in the central Atacama region (21-25° S), the precise character of the Middle Holocene climate (8,000 to 3,500 C^{14} BP) is still under debate, divided in two competing interpretations: a relatively humid or an arid period (Grosjean 2001; Grosjean et al. 2003). Data from rodent middens collected from the pre-puna at the Cordillera de Domeyko suggest a rainier period (Latorre et al. 2003).

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[1] That ranges from 1.9 million to 11,000 BP. (Dillehay 2000).

[2] It ranges from 19,000 and 14,000 BP., and ending between 11,000 and 10,000 BP.

On the other hand, data from ice cores, lake sediments, and other paleoclimatic data indicate a dry period (Grosjean et al. 2003; 2007).

Studies suggest that the early Holocene in the Central Andes was a more humid period than at present, with summer precipitation intensified in the altiplano area. This phase of warm, moist conditions extended from between 8,400 to 7,300 years ago (Grosjean et al. 1997). By contrast, the middle Holocene, between 6,000 and 3,800 B.P, was marked by severe, prolonged aridity (Grosjean et al. 1997). Many altiplano lakes dried out. Lake Titicaca, for example, shows a sharp reduction in its water levels (Vargas and Ortlieb 1998). Lake sediments, however, show a short shift to more humid conditions between 5,500-5,600 B.P (Grosjean et al. 2003). In fact, sporadic episodes of intense rainfall may have occurred in a setting still marked by intense aridity, between 7,800-7,550 and 6,700-5000 years ago (Marquet et al. 2012; Ortega 2012).

For the northern Chilean coast, during the transition between the Pleistocene and the Holocene, geomorphologic and stratigraphic studies at Quebrada Las Conchas (Chimba-13), a coastal archaeological site located north of Antofagasta, points to a period of abundant rainfall and high winds (SW and W winds) (Vargas and Ortlieb 2001). The change to the arid conditions of the middle Holocene occurred after 9,400 years ago when the site was unoccupied (Vargas and Ortlieb 1998).

For the period between 6,200 and 4,200 cal yr BP, pollen records for the semiarid central coast of Chile attest to relatively arid conditions during the Middle Holocene. This followed a wetter phase (~8,700-7,600 years ago) (or ~9,900-8,700 cal yr BP) (Maldonado and Villagrán 2002; 2006). Alternating fluctuations of drought and rainfall marked subsequent periods with an increase in rainfall at 3,700 years ago (4,200 cal yr

BP) and a drought period from about ~2,600 BP (~3,000 cal yr BP) and to around 1,930 years ago (2,200 cal yr BP) (Maldonado and Villagrán 2006).

For the coast of the Atacama Desert, there is no sequential paleoclimatic data (Sandweiss 2003; Arriaza 2008). Specifically, for the Camarones delta, there is little past climatic data. The exception is indirect, based on fauna and flora recovered from the site. This is discussed later in the chapter. As Ivan Muñoz observed, there are no paleoenvironmental studies for this area (personal communication, July 1. 2006).

Overall, however, in its general aspects, the early and middle Holocene was marked by a shift from humid to dry conditions. Modern climatic conditions prevailed from about 3,500 years ago to the present.

Present-Day Time Climate and Sea Surface Temperature

Current climatic data on rainfall and sea surface temperatures (SST) is presented for the Camarones sites. This is done to highlight the changes that occurred in the past. Also, for the shell analyses, it is essential to know the ecological conditions in which modern shells of *Concholepas concholepas* grow.

The present climate is characterized by extreme aridity throughout the year (rainfall is minimal, just 3 to 4 mm/yr). This is due to the Pacific subtropical anticyclone (SPA) associated with the cold Humboldt current and other ocean-atmosphere interactions (Vargas and Ortlieb 1998). The hyper-arid desert conditions are extreme in northern Chile. The mean precipitation in Arica (18.5^{o} S) is negligible, just 1 mm/yr. (Vargas and Ortlieb 2001).

The fog ("*camanchaca*") created by humidity from the ocean is a persistent source of climatic variability. It occurs from late March to December,[3] with little or no fog formed from January to mid-March (Rundel et al 1991). This thick cloud of fog covers the coastal slopes lower then 1,000 meters. Coverage decreases in intensity as it moves inland (Pinto et al. 2006). Therefore, along the northern coast, the annual average relative humidity can reach 80 percent (Di Castri and Hajek 1976). Summer along the coast is the dry season. In the altiplano, by contrast, it is this period locally known as "*invierno boliviano*" (Bolivian winter) characterized by strong rainfall. The strong rainfalls in the altiplano have almost no affect on the coast. However rainfall fills the dry or almost dry rivers in the altiplano, whose waters then run down hill, reaching the deltas on the coast.

The average temperature along the coast of the Atacama Desert is a uniform 18° C throughout the entire year. This is mild for northern Chile (Schiappacasse and Niemeyer 1984). Using Köppen-Geiger's classification system (Peel et al. 2007), the climate in the coastal area of Arica and Iquique, including the Camarones delta is an arid, hot desert. Arica's average temperature stays between 16° C (60° F) in the winter and 22° C (71° F) during the summer (Figure 2.2). In the Camarones delta, temperature variations are greater. There is a cold winter with an average temperature of 13° C (55° F) and a warm summer with an average temperature of 27° C (80° F) (Schiappacasse and Niemeyer 1984).

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[3] Coastal fog in Peru is from May to October (Rundel et al. 1991).

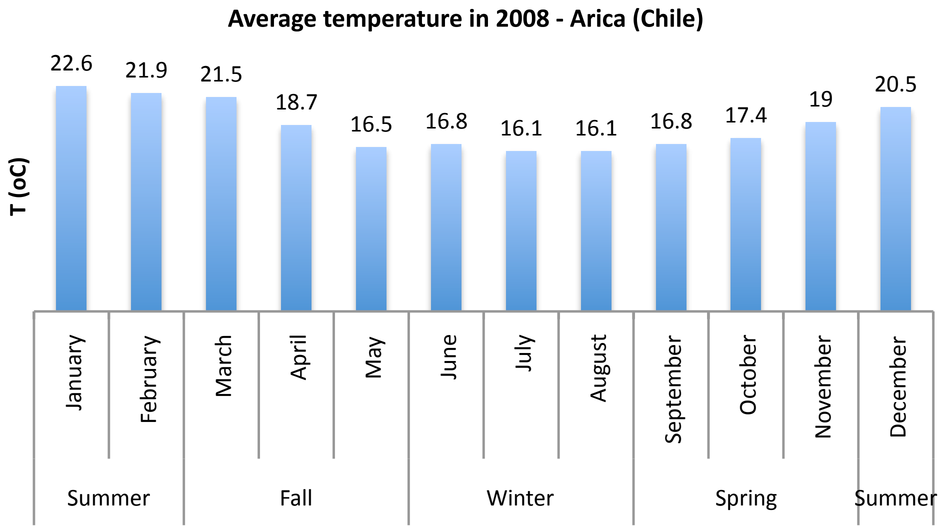

Figure 2.2: Average Air Temperature (Arica, Chile)
(Adapted from: TuTiempo.net. Data from meteorological station: 854060 (SCAR)
http: www.tutiempo.net/clima/Aric/854060.htm)

Below are the charts with data from the Arica and Camarones coast. The first set shows the sea surface temperature from Arica (Figure 2.3). The graphic with SST temperature is a historical series from 1980 to 2000, integrated with the monthly difference between maximum and minimum temperature values. The second set is from Camarones. It shows sea surface temperatures (Figure 2.4), salinity (Figure 2.5) and oxygen (Figure 2.6) data from October 2005 to September 2006.

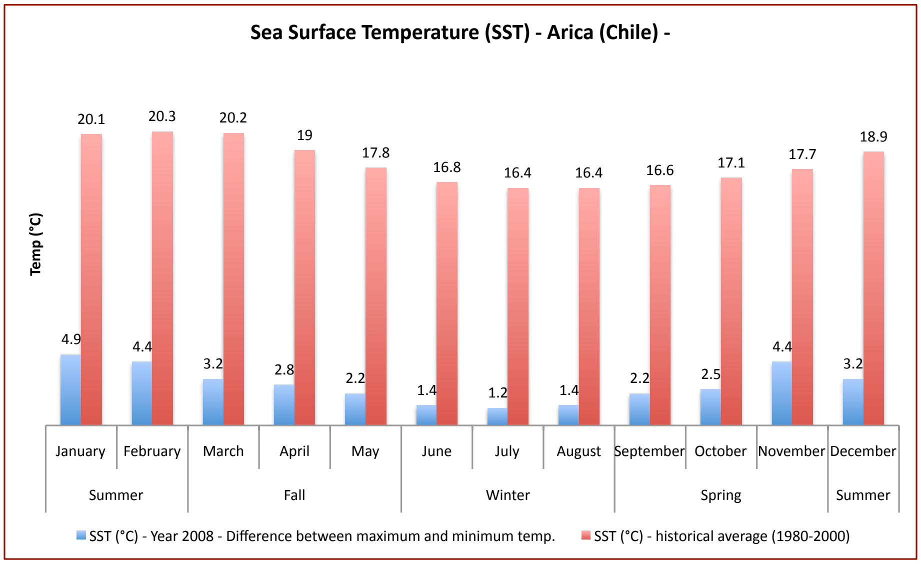

Figure 2.3: Sea Surface Temperature (Arica, Chile)
(Adapted from: Armada de Chile. Serviço Hidrográfico y Oceanográfico
http://www.shoa.cl/servicios/TSM/regiones/arica.htm)

In Arica, for the year 2008 (Figure 2.3), the minimal values in water temperature (SST) variation (the difference between maximum and minimum each month) occurred in late fall, winter and early spring, with a maximum variation of 2.2° C (May and September) and minimum of 1.2° C (July). The greatest temperature changes occurred during late spring, summer and early fall, with a maximum variation of 4.9 C in January and a minimum variation of 2.5° C in October. April is a transitional month. It shows a temperature variation of 2.8° C, which is midway between the two seasonal periods of maximum and minimal variations in water temperature. During the same year, the sea surface temperature along the Camarones coast varied from about 14° C (57° F) to 19° C (66° F) (Figure 2.4), a difference of about 5° C.

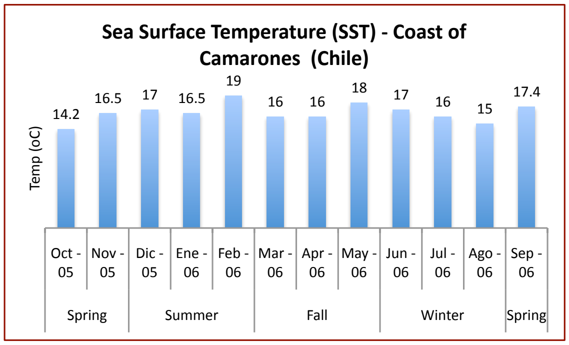

Figure 2.4: Sea Surface Temperature for the Coast of Camarones (Chile).
(Source: Sernapesca Sector Camarones, Estación 1)

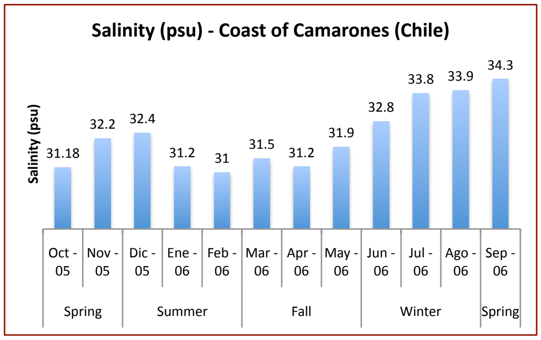

Figure 2.5: Sea Salinity Indices for the Coast of Camarones (Chile).
(Source: Sernapesca Sector Camarones, Estación 1)

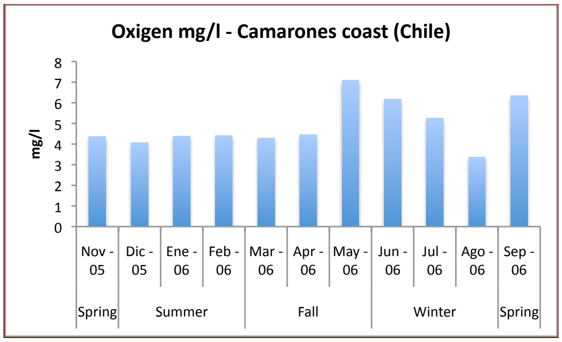

Figure 2.6: Oxygen diluted indices for the Coast of Camarones (Chile).
(Source: Sernapesca Sector Camarones, Estación 1)

Sea surface temperature plus, oxygen and salinity levels give information about ocean productivity and the stability of the sea currents. High temperatures and low levels of oxygen indicate the entrance of equatorial waters and the onset of El Niño conditions (Schiappacasse and Niemeyer 1984). This leads to a decrease in the production of marine plankton and, consequently, high mortality and displacement of marine life. High levels of salinity along with other nutrient indices correlate with ocean productivity and its seasonal variation. In the Camarones area for 2005-6, for example, periods of higher plankton productivity occurred during winter and spring (Figure 2.5).

In summary, at present, sea temperature variations are minimal in the study area. Fog from the ocean helps bring moisture to the river valleys. Runoff from the rainy season in the altiplano is channeled to the coast through mountain rivers. The altiplano rainy season is during the summer, from December to March, and the dry season extends from April to August. Along the coast, the fog gathers regularly from fall to spring, that is, from late March to early December.

In the desert biome, the tipping point between a habitable environment and an absolute desert are delicate. In such a fragile ecology, any climatic shift would have impacted the subsistence strategies of forager-hunter-gatherers, changing patterns of exploitation and settlement.

El Niño

Along the Central Andean coast, the El Niño-Southern Oscillation (ENSO) activity is a major source of climatic variation. It can bring strong rainfall to the desert coast from Peru to the Atacama Desert, as far south Antofagasta in Chile. These conditions vary in intensity. El Niño impacts do not normally extend beyond northern Peru (Rundel et al 1991). Occasionally, however, irregular El Niño events may also impact the coast of northern Chile (Rundel et al. 2007). These impacts are not limited to strong rainfall, but include a complete disruption of marine and land species, in both number and distribution. The impact can take years to reverse (Thiel et al. 2007; Rundel et al. 2007).

El Niño can change the trophic relationship in the Humboldt Current, generating a shift in species composition[4] that affects the food chain hierarchy (Thiel et al. 2007). The opposite situation, La Niña (cold phase) is characterized by drop in sea-surface temperatures and a strong coastal flow northwards toward the equator (Thiel et al. 2007). El Niño (warm phase) is marked by a decrease in or even an episodic reversal in the Peruvian coastal current that flows southward. Such changes are caused by a series of complex climatic phenomenon that occurs across the Pacific Ocean.

The El Niño period is also characterized by a rise in sea-surface temperatures. Better oxygenated conditions prevail, favoring the proliferation of some species, while others do not adapt to these changes and die or migrate south following the cold currents (Montecino and Lange 2009; Mann and Lazier 1991). During El Niño, strong rains hit the coast of Ecuador, Peru and eventually north Chile, provoking mudslides floods, and other disasters. Affected by changes in the marine environment, small-scale fisheries have to migrate to other areas less affected by the events.

Those El Niño induced changes strongly affect the fish and marine stock, with shifts in species dominance. For example, the anchovy population declines and migrates south, following the Humboldt Current. On the other hand, the sardine stock (*Sardinops sargax*) increases. Other species affected include the jack mackerel (*Trachurus picturatus*), which also has to change its migration pattern (Thiel et al. 2007). Birds are also displaced from their original habitats. During the 1997 El Niño, for example, hungry pelicans invaded Arica increasing from a normal population of 200 to some 4,000 (CNN International, August 31, 1997 – World News).

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[4] do not provoke the decline in plankton production (Thiel et al. 2007)

For the past, the periodicity of these climatic events is not yet well understood. For the late Pleistocene, and the early and middle Holocene, their manifestation in the past is still under consideration (Rein et al. 2005; Cobb et al. 2013). Analyzing the marine sediment record for Peru, Reins and collaborators (2005) argue for the onset of strong El Niño activity around 15,000 years ago (17,000 cal BP), as well as the occurrence of strong El Niño floods during the early Holocene. They found two short dry periods from between ~10,100 to 9,900 years ago (11,500 to 11,250 cal BP) and ~9,700 to 9,600 years ago (11,050 to 10,950 cal BP). They show that El Niño activity was much reduced during the middle Holocene from ~7,000 to 5,000 years ago (8,000 to 5,600 cal BP). Subsequently, during the middle-late Holocene period from between 4,900 to 4,500 years ago (5,600 to 5,200 cal BP), El Niño activity increased. It reached maximum activity between 2,600 to 1,700 years ago (3,000 to 2,000 cal BP).

Archaeological and paleoclimatic data suggest that the El Niño phenomenon was weak or inactive at least 3,000 years prior to ~5,200 – 4,400 BP (6,000 - 5,000 cal BP) (Sandweiss et al. 1996; Anderson et al 2007). Archaeological evidence from southern Peruvian sites like the Ring Site (17°40'S), Quebrada Tacahuay (17°48'S), and Quebrada de Los Burros (18°00'S) point to cool sea surface temperatures and to no El Niño floods from about 8,000 to 5,100 years ago (9,000 to 5,800 cal BP) (data compiled by Sandweiss et al 2007). Studies at sites in northern Peru suggest that El Niño events began about 4,400 years ago (5,000 cal BP) and slowly gained strength (Sandweiss et al. 1996; 2007; Anderson et al. 2007). By about 2,600 years ago (3,000 cal BP) El Niño activity was comparable to present day conditions (Sandweiss et al. 1996; 2007; Anderson et al. 2007). Debris flow sequences from the coastal areas of southern Peru and northern Chile indicate that modern El Niño climate anomalies started around 4,800 years ago (5,500 cal BP), during the mid Holocene (Vargas et al. 2006).

In fact, different sets of data show a reduction in El Niño activities beginning around ~7,000-7,400 BP (8,000-8,400 cal BP) but not inactivity (Reins et al. 2005; Rademake et al. 2013). On the other hand, coral records taken from the mid-Pacific Line Island chain from 7,500 BP to the present do not show a reduction in El Niño activity for the middle Holocene (Cobb et al. 2013).

It is interesting to note that data from Cobb and collaborators (2013) shows active El Niño in the millennium between 7,500 to 6,000 years ago that corresponds to the initial occupation of the Camarones 14 site. There was also strong activity about 6,000 years ago close to a period when the site was abandon.

The Humboldt Current and the Upwelling System

The Humboldt Current System[5] propelled by the West Wind Drift, carries cool water from southern Chile (~45°) to Ecuador (~4°). There, the cool, upwelled, Humboldt Current encounters the warm waters of the Equatorial Current System (Montecino and Langue 2009; Thiel et al. 2007). The Humboldt Current is a northward flow of fresh, cool nutrient-rich waters of subarctic origin. It brings an upwelling of cool subsurface waters to the coasts of northern Chile, Peru and Ecuador (Thiel et al. 2007). The denser, cooler artic water displaces the less denser, warmer, equatorial waters. In southern Peru (~18°), the Humboldt Current divides. One stream turns offshore (the Chile-Peru Oceanic Current), while a weaker current continues northward close to the coast (Peru Coastal

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[5] The HCS is also named Peru-Chile Current.

Current). Between these two streams, about 100 – 300 km offshore, the Peruvian Oceanic Countercurrent flows south. The effect of trade winds blowing across the Andes deflects surface water to the west (Coriolis effect). The deep nutrient-enriched ocean water then moves up to replace the displaced surface water.

The Humboldt Current is one of the most productive upwelling ecosystems in the world (Brochier et al. 2011; Montecino and Langue 2009). Upwelled water contains high concentrations of nutrients like nitrate and phosphate. Together with salinity, they are key indicators of highly productive on surface waters (Mann and Lazier 1991). The current carries a vast population of small pelagic fish, mainly anchovies (*Engraulis ringens*) and sardines (*Sardinops sagax*) that support colonies of sea lions (*Otaria flavescens*), pelicans (*Pelecanus thagus*), and an assortment of other marine birds and fishes. Three upwelling subsystems are recognized. There is one in south-central Chile, one in northern Chile and southern Peru (Montecino and Langue 2009)[6], and a third in central-north Peru. This last one is the most productive with year-round upwelling.

Although upwelling is continuous in Peru, its maximum peak occurs in winter[7] (Mann and Lazier 1991; Thiel et al. 2007; Montecino and Lange 2009). In coastal areas of southern and central Chile, upwelling produces a maximum of phytoplankton biomass in spring with a minimum in winter (Thiel et al. 2007). Upwelling off the coast of northern Chile tends to be more constant (Thiel et al. 2007), but it peaks during late spring-summer and it is weak in winter (Blanco et al. 2001). The frequency and intensity of the upwelling varies, do the periods of warm or cool anomalies in coastal waters. The

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[6] In northern Chile, discrete upwelling centers close to the research area were observed off Iquique (20° S), and Loa River (21° S), among other areas (Thiel et al. 2007).

[7] Paradoxically, it shows low biological productivity during this season (Montecino and Lange 2009).

result is a coastal environment that is rich in nutrients and attracts a great variety of marine species. This is in sharp contrast to the arid, desolate landscape on shore. In northern Chile, upwelling brings marine to the coast. One can observe this at Chinchorro beach (Arica) during the summer. Green turtles arrive in great numbers and stay very close to the shoreline, which makes them easy prey for humans. Upwelling also brings sea lions, dolphins, and migratory birds (see Table 2.3 for birds species). Such peak periods attracted forager hunter-gatherers for the summer if not for the entire year.

Between 8,000 and 5,000 years ago, warm-tropical water predominated along the Central Andean coast (until 10^0 S, south Peru) (Sandweiss et al. 1996). For the period 10.000 to 5.000 years ago, zooarchaeological studies (Reitz 2001) from site in Peru and Ecuador documented changes in marine species. Apparently, warm-temperate species replaced warm-tropical species in response to the gradual cooling of the coastal waters in the region (Reitz 2001). For northern Chile, Llagostera (1979) at the Abtao-1 site showed that about 5,350 years ago seawater temperatures gradually increased. This is documented by a species shift from *Choromytilus* (cold water indicator) to the *Trachurus* (warm temperate waters).

The Cordillera

The Andean Cordillera extends almost 8,500 kilometers from the Caribbean Coast of Venezuela/Colombia in the north to the extreme south of the continent, at Tierra del Fuego. It is marked by a succession of high peaks, volcanoes, and plateaus that extend in parallel and transverse chains from north to south of the South American Continent. The cordillera emerged during the Cenozoic Era (Tertiary Period). It was the result of the oceanic Nazca Plate subduction under the continental South America Plate and was fully formed during the Miocene-Pliocene period (Moncayo, et al. 1995). This uplifting created towering summits higher than 6,000 meters. Tectonic movements still occur in the Andes, especially on its western chains (Barrientos 2007; Cebrano et al. 2007). Active volcanic zones extended along the cordillera, especially in the Central Andes from 14^o S to 28^o S (Stern et al. 2007). This is a very active area in which volcanoes and earthquakes can have devastating impacts on both local communities and natural resources.

The Andean cordillera runs north to south through the entire South American continent. Paralleling the coast, it creates a barrier between both sides of the continent, with distinctive physical and biotic conditions on each side. Smaller east-west chains transverse the main cordillera, forming a complex mosaic of different and ecosystems. Dense forested areas and high rainfall characterize the Andean cordilleras of Colombia and Ecuador. Further south, the cordillera broadens out into high plateaus called altiplano or *puna*.

In northern Peru, the Cordillera splits into two parallel ranges, the Western Cordillera or "Occidental Cordillera" that runs parallel to the coast, and the Eastern Cordillera or "Cordillera Oriental" on the opposite side. The narrow pre-Andean coastal plains are between 20 and 100 kilometers in width with a desert climate and elevations of between 20 to 1500 meters. As a result of plate tectonics, multiple, marine terraces are staggered along the coasts from Northern Chile into Peru. This suggests that the coastal plains were submerged during the Pleistocene.

Between the Western Cordillera and the Eastern Cordillera, ranging from 1,200 and 3,500 meters high are the Inter-Andean valleys. These fertile areas with marked seasonality allow for the cultivation of crops planted at different elevations. For example, quinoa, oca, and potatoes at high zones and corn, manioc and sweet potatoes at the lower ones. The high plateaus of the altiplano (or puna) encompass parts of southern Peru, western Bolivia around Lake Titicaca, plus northern Chile and Argentina. At Lake Titicaca, in the northern altiplano of Bolivia, the altitude is 3,811 meters above sea level. Around this lake, the flatlands are agriculturally fertile. By contrast, the puna of the Chilean Altiplano is salty and the land is not fertile enough for plant cultivation (Moseley 2001).

The cordillera of northern Chile has four main segments: Cordillera de la Costa (Coastal Cordillera), Depresión Intermedia (Intermediary Depression), Precordillera (Western Escarpment), and Cordillera Occidental (Western Andean Cordillera) (Figure 2.7).

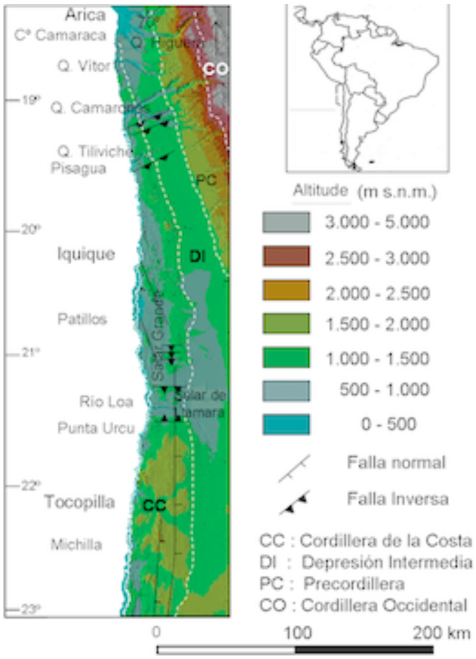

Figure 2.7: Northern Chile. Map of the Andean Cordillera and tectonic fault areas between Camarones and Pisagua (Source: Quezada et al. 2010).

The Coastal Cordillera borders the western edge of the Atacama Desert. The range is 20-40 kilometers wide with an average height of 1,500-2,000 meters (Quezada et al. 2010). From Arica (18.5^{0} S) to Iquique (20.3^{0} S) the cliffs abut the sea, which exposes them to marine abrasion. Small bays and deposits of alluvial fan can be found along the coastal range. North of Iquique up to Antofagasta (23.5^{0} S), narrow platforms of marine abrasion can be found along the cliffs (Quezada et al. 2010). The Western Escarpment (Cordillera Domeyko) borders the eastern side of the Atacama Desert. In between coastal and western mountain chains is the Central Depression where Tamarugal Plain lies. It consists of a raised depression at an elevation of more than 900 meters (Gayo et al. 2012). The Salar de Atacama (Atacama Salt Desert) lies between the Western Escarpment and the Western Andean Cordillera. It is lined with active volcanoes.

The Desert Coast

The desert coast forms a continuous 3,500 kilometers strip that extends from Piura (4^{o} S) in northern Peru to La Serena (29^{o} S) in central Chile (Rundel et al 2007). This area is framed on the east by the Andean foothills and on the west by the waters of the Pacific Ocean. It is formed by sedimentary flat lands, slopes, and lower hills that become higher further inland towards the east. The desert conditions intensify from north to south reaching its hyper-arid conditions in the Atacama area, where the region becomes an absolute desert (Rundel et al. 2007; Sandweiss et al. 2008). The rain frequency decreases and toward Peru and Chile rainfall ranges from about 15 to 2 mm (Veblen et al. 2007).

The desert extends inland for 20 to 100 km (Rundel et al. 2007). It is crossed by river valleys separated by barren and desolated areas (Parsons 1970). More than 40 rivers descend the Andes and run between 15 and 50 km through the desert lands to the coast. Although they are shallow and some dry out in winter, they are fed by highland summer rains. Some rivers have perennial lagoons and wetlands attractive to wildlife and migratory birds. A dense fog covers the coastal flat plains during the winter. In areas with tall coastal mountains, a thick fog extends inland following the river valleys. In such points along the coast[8], the fog and wetlands created conditions favorable to human occupation.

For the purpose here, the coastal desert begins with the Santa Elena Peninsula in the extreme south of Ecuador. It continues south along the entire coast of South America down to Copiapó in Chile (Figure 2.8 and Figure 2.9).

Coastal Ecuador is a transition zone between the strong rainfalls of Colombia to the north and the desert coast of Peru to the south. Both flora and fauna reflect this change. The ecology varies markedly from rainforests with 700 mm of precipitation to savannas, semi-arid zones and finally arid zones (Stothert 1988). Rainfall at the Santa Elena Peninsula is reduced to 100 mm annually, making it the driest portion of the Ecuadorian coast (Raymond 2008).

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[8] Basically near the rivers and lomas – humidity areas created by the fog.

Figure 2.8: Map of Peru showing the Andean Cordillera and the main cities and valleys discussed here (Source: public domain).

Along the north coast of Peru, the arid sandy plains and dunes extend inland as far as 100 kilometers to the Andean foothills. At its northern extreme, the Peruvian desert is crossed by small, dry valleys that eventually connect with the Lambayeque valley to the south. Isolated mountains appear on the flat plain, as well as seasonally dry river valleys and large alluvial fans (e.g. Zaña, Jequetepeque, Chacama, and Moche valleys). Between Chiclayo and Trujillo, irrigated agricultural lands mark the landscape (Veblen et al. 2007). This fertile coast, with its deep soil deposits creates rich agricultural zone (Rundel et al. 2007).

The Huaca Prieta site is located, in the Chicama River valley on the north coast. The site consists of a large earthen mound that lies about 2 km north of the Chicama River. There, the narrow coastal plain is crosscut by several small drainages that come from the Andes to the ocean. In periods of heavy rain, these drainages overflow and flood the local landscape. Narrow estuaries appear on the north side of the site along the coast. Today the area around the site is irrigated for agriculture (Dillehay et al. 2012a).

Near Lima the arid coastal plains diminish and the foothills of the Western Cordillera (Cordillera Occidental) run down to the sea. From Ocoña in southern Peru (16°24'S), to Arica (18°25'S) in northern Chile steep ridges with wide plains interspersed characterize the dry coastal landscape (Veblen et al. 2007). The Atacama Desert extends for about 1,500 km between Ilo[9] (17° S) in southern Peru to Copiapó[10] in Chile. From there, the coast tappers into a narrow shelf that extends about 150 km to the south; it is hemmed in by the coastal mountain chain (Figure 2.9). The region's hyper-aridity made it an absolute desert. South of Antofagasta, this barren landscape changes, giving rise to perennial plants and some coastal *lomas*. Further inland, at the Pampa de Tamarugal *Prosopis* woodlands are found.

To the east, the Cordillera de la Costa borders the desert coastal plains. Only sparse and very specialized vegetation can survive on what little moister that comes from the seasonal fog belts ("*camanchacas*") (Di Castri and Hajek 1976; Rundel et al. 2007). The arid Atacama coast is divided into four ecological sub-areas: the fertile coast that corresponds to the river deltas; the desert coast between the rivers; the transverse valleys

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[9] The northern limit of the desert is diffuse and in general the political boundaries are used (Rundel et al. 2007). For this research the limit in Ilo is preferred since it includes the area of the Chinchorro sites.

[10] The south limit of the Atacama Desert is also diffuse and its delimitations vary (Luebert 2011).

with vast salt flats left behind by Pleistocene lakes; and the Andean highlands above 2,000 meters (Núñez 1983; Núñez 2000). The desert stretches between rivers can be more than 900 kilometers.

Figure 2.9: Map of the Atacama Desert with the location of the Caleta Camarones. (Source: National Geographic Society).

The main water sources are the rivers that flow down from the mountains. Many are not reliably perennial as they can run dry if the altiplano rainy season is short lived due severe drought. Fortunately, the fog from the ocean counteracts the aridity bringing moisture and solar protection to the fragile life forms adapted to this peculiar environment (Llagostera 1979). The deltas of the Lluta, Azapa, Vítor, Camarones, Camiña, and Loa rivers create fertile “oasis conditions” (Núñez, 1983; 2000). The most dependable are the Lluta and Azapa; only the Loa River is perennial.

The sites of Camarones 14 (Schiappacasse and Niemeyer 1984) and Camarones Sur (Rivera 1984) are located on the south side of the delta of the Camarones river valley. This is where the fieldwork for this research was carried out.

The Camarones River Delta

The Camarones valley is about 100 km south of Arica and 150 km north from Iquique. Between Arica and Camarones is the Victor Valley. This valley is the only site that has conditions suitable for agriculture. The Quebrada Camarones, Quebrada Chiza and Quebrada Suca shape the Camarones river valley (Figure 2.11). These deep valleys cut through the highlands between the desert pampas and the coastal cordillera. Near the Bolivian border, the highlands reach over 4,000 meters in height (Pohlmann and Reiche 1980; Schiappacasse and Niemeyer 1984).

At the coast the cliffs are 400 to 900 meters high. These high cliffs frame the Camarones River delta (Schiappacasse and Niemeyer 1984) (Figure 2.10). On the north side of the valley, there are the remains of preHispanic sites (Punta Norte) from the Archaic period (Schiappacasse and Niemeyer 1984) (Appendix K).

An ample fluvial-marine terrace about 35 meters above the sea level characterizes the south side of the delta where Camarones 14 is located. With a somewhat triangular shape, it measures 350 meters along the base facing the sea and 1,500 meters along its east-west longitudinal axis from its base to its apex. The terrace merges with the slopes on the south side of the valley delta (Schiappacasse and Niemeyer 1984).

The Camarones River cuts through the valley and discharges its water into the ocean. This river has a high concentration of arsenic (1000 µg L-1) and sediment (500 mg kg-1), contaminating living organisms not only in the river stream but also near the mouth of the Camarones delta[11] (Cornejo et al. 2009; Arriaza et al. 2010). Today, during most of the year, a low sandbank in the river's delta blocks the water flowing down to the sea forming a lagoon. Occasionally, a storm opens a passageway. During the summer, when the river's waters rise this blockage is also displaced.

Figure 2.10: Camarones Delta valley showing the north portion of the mouth valley with the open beach and the area of the lagoon and river mouth in the background close to the hills (Punta Norte); Camarones 14 is located on the south side, not showing on the photo.

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[11] Its water is not fitted to drink and the local community of Caleta Camarones avoids drinking it.

The sites of Camarones 14 and Camarones Sur are located on the south side of the Camarones River's outfall. These sites are near the tiny fishing village of Caleta Camarones, 11 kilometers (road A-376) west of the city of Cuya. Cuya is 110 kilometers south of Arica and is located next to the Panamerican Highway, a coastal road (R-5) that connects the north of the country with regions further south. Camarones 14 is located on the south side of the marine terrace about 1 kilometer from the Camarones River's delta. It is just a short walk to the beach and the open ocean. The other site, Camarones Sur is less than a kilometer from Camarones 14. It sits on top of a cliff that drops abruptly 100 meters down to the sea. Below the rock seabed is accessible during low tides. This site is near a local road (A-376) that cuts through the cliffs and ends at a small harbor where fishermen keep their boats. From this point local divers forage for octopus, sea urchins, shells and other marine life hidden or attached to the bottom rocks. This large site covers an area of 72,670 m^2 (square meters) (Billings 2001). Since ancient times, this region has been intensively occupied. The archaeological sites located there attest to this (Appendix K).

Many archaeological sites are found in the river's delta area and along the nearby coast (Appendix K). Others are found along the river canyons of the Quebradas Suca, mainly associated with the Late Intermediate Period (1,000 to 1,350 AD) (Sepulveda et al. 2005) (Figure 2.11). An example is the rock art site of Chiza (Geoglifos de Chiza) about 30 km from Camarones 14. About 40 km east is the important site of Tiliviche. All this evidence points to the delta of the Camarones River as an important center of cultural convergence in prehistoric times.

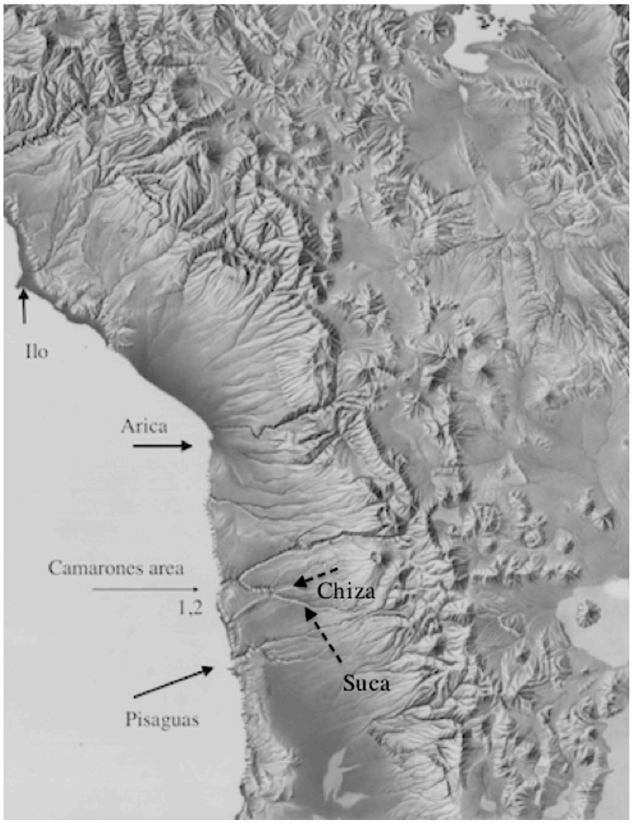

Figure 2.11: Area of the Atacama showing the coastal cordillera, the Andean foothills and the Pre-cordillera. On the coast, the location of Camarones area where the sites of Camarones14 (1) and Camarones Sur (2) are situated. (Source: public domain).

Climatic conditions along the coast of Camarones are stable. The Humboldt Current influences it. The southwest trade winds predominate. During the night the wind is calm and generates waves of small scale. Seasons do not strongly affect ocean conditions, but generally, the sea is calmer during the spring and the summer, with waves of 1 to 2 meters. Isolated waves up to 3.5 meters can occur, as big waves can be generated in distant areas on the ocean. During the fall months, the waves are generally between 1 and 1.5 meters, although waves as high 4.5 meters can occur. In the winter the average wave height is about 2 meters and sometimes they can reach 5 meters (Godoy 2009).

Coastal Vegetation

The study of floral assemblages is an important element in environmental reconstruction. By comparing modern and past vegetation in the research area, it is possible to observe any change in floral composition and climatic conditions that took place when human groups occupied the site. For example, by knowing when a plant flowers, and seeds shed, well-preserved plant remains can contribute to our understanding of what was growing, planted or collected and why.

Today, at the Camarones delta valley, the vegetation is dominated by plants adapted to marshy wetlands *Juncus* sp. and *Typha angustifolia* (totora), for example, are found close to the lagoon and the river's course. Schiappacasse and Niemeyer (1984) also reported *Equisetum gigantea* (horse tail), a shrub about 3 meters tall. Some plants are also well adapted to saline soils. Thus, salt grasses like *Tessaria absinthioides, Cortaderia* sp. are well represented. Belmont (1998) reports that today the vegetation near Camarones river delta is constituted by eight species: five dicotyledonous and three monocotyledonous. In past times, the local flora undoubtedly experienced changes due to climatic conditions. Below (Table 2.1) is a list of the plants currently found along the main river deltas in the north Chile, specifically the Lluta and Azapa in the Arica area and the Camarones delta. More information can also be found in Garcia's report (Appendix E).

Table 2.1: Wild plants from the mouth of the rivers Lluta, Azapa and Camarones. Adapted from (Belmonte et al. 1999) and (Muñoz Ovalle 2001), after (Belmonte 1998).

Specie	Common name	Family	Type
Equisetum giganteum	*Cola de Caballo* /	Equisetaceae	Shrub

	Horse tail		
Alternanthera halimifolia	*Ñahuara / Hierba Blanca*	Amaranthaceae	
Tecoma fulva	*Chuvé*	Bignoniaceae	
Schinus molle	*Pimiento, molle*	Anacardiaceae	Tree
Trixis cacalioides	*Chilca*	Asteraceae	
Baccharis petiolata	*Chilca*		
Grindelia glutinosa	*Chiñi/Chilca*		
Pluchea chingoyo	*Chilca*		Shrub (in Camarones Jan/Feb)*
Pluchea absinthioides	*Brea*		
Heliotropium curassavicum	—	Boraginaceae	
Scirpus americanus	*Totorilla*	Cyperaceae	Aquatic plant/ perennial herb - coastal, salt-marsh, freshwater-marsh
Cyperus articulatus	—	Cyperaceae	
Atriplex atacamensis	*Tola blanca*	Chenopodiaceae	
Salix humboldtiana	*Sauce*	Salicaceae	
Acacia macrocantha	*Yaro*	Mimosaceae	
Prosopis tamarugo	*Tamarugo*		
Prosopis chilensis	*Algarobo*		
Caesalpinia pulcherrima	*Tara*	Caesalpiniaceae	
Phyla canescens	*Tiquil, tiqui*	Verbanaceae	
Geoffroea decorticans	*Chañar*	Papiloonaceae	
Gossypium barbadense	*Algodón*	Malvaceae	

Adenanthera sp.	*Vilca (introd.)*	Gabaceae	
Adenanthera sp.	*Vilca (nativa)*	Fabaceae	
Distichlis spicata	*Grama salada*	Poaceae	
Cortadería speciosa	*Cola de Zorro*	Poaceae	
Sporobolus indicus	*Pasto*	Poaceae	

* Reiche, 1905.

Botanical remains from an occupied site tell us about peoples' diets, environmental conditions, and the artifacts in use (see Appendix E). Plants played an important role in Chinchorro material culture, ritual and funerary ceremonies (Arriaza et al. 2001). In artificial mummification, plants replaced eviscerated body organs and bones (Schiappacasse and Niemeyer 1984: 84 quoting Uhle 1922; Arriaza et al 1995; Arriaza 2003). In the form of mat shrouds, plants were also part of Chinchorro funerary patterns and were found with mummified bodies at Camarones 14 (Schiappacasse and Niemeyer 1984). As Cassman and colleagues (2008) note, mortuary mat shrouds made of vegetal fiber were characteristic of Chinchorro mummies, a tradition that persisted for more than 5,000 years.

Paleobotanical data from Mario Rivera's excavations at Camarones Sur are not available, yet. For Camarones 14, although Schiappacasse and Niemeyer (1984) do not present flotation analyses, other botanical remains, essentially macrobotanical remains, were identified[12] for the site's two occupational layers[13].

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[12] Macrobotanical material was identified at that time by prof. Hugo Gunckel L. (Schiappacasse and Niemeyer 1984:84).

[13] Schiappacasse and Niemeyer (1984) recognize three occupational layers for Camarones 14 divided in strata: the initial occupation, a preceramic strata (d) related with the Chinchorro culture dated there in between 7,420 ± 225 and 6,615 ± 339 BP., a mixed layer (strata c) with material from the ceramic and preceramic occupation, and the third occupation strata (b) correlated with the Saxamar culture, agro-ceramist. Chapter 3 has the description of these strata.

A) The first layers (strata b)[14] are contemporary to the Inca domination of the valley and are related to the Saxamar culture. The plant species identified include: *Prosopis* sp. (*yaro*) (pag. 64), *Zea mays* (maize), *Tripsacum* sp., *Heliconia* sp., poroto, calabash, and cotton (Schiappacasse and Niemeyer 1984).

B) The preceramic layers in the Chinchorro context (strata d) dates to between 7,400 and 6,600 years ago (Schiappacasse and Niemeyer 1984). The plants found include: cactus spines of *Trichocereus cuzcoensis* (synonym: *Echinopsis cuzcoensis*)[15] (cactus fishhooks), flowers and other parts of *Tripsacum sp.* (possible *T. dactyloides*), *Scirpus californicus*, and *Typha angustifolia*. Also found were two algae (kelp): *Lessonia nigrescens* ("*chascón*") and *Macrocystis integrifolia* ("*huíro*"). Although fragments of *Zea mays* were found on some of the preceramic layers, it could be the result of mixed layers (Schiappacasse and Niemeyer, 1984).

At Camarones 14, as well as at other Chinchorro sites, plants were also used for funerary purposes (e.g. *Scirpus, Typha*) in the inhumation technique itself, or as an external element, with bodies wrapped or laying on *totora*'s mats (Schiappacasse and Niemeyer, 1984; Arriaza 2008). Also, the wood of *Schinus molle* (Anarcadiaceae) was probably used to reinforce the skeleton in an infant's mummy (Belmont et al. 2001).

Plant samples are small, but the presence of the genera *Typha* and *Scirpus* indicate a brackish wetland, probably the lagoon formed by the valley delta. The occurrences of cactus (Cactaceae) remains reveal the aridity of the surrounding areas. Unfortunately, at present, there are no pollen data available to compare with other paleoclimate data for the Atacama.

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[14] No date was given for this stratum, but Inca period was about 1,000 to 1,400 AD.

[15] Brako and Zarucchi, 1993.

Faunal Resources

This section presents modern and archaeological data on faunal resources. By comparing the present with the past distribution of animal species found at the archaeological sites, it is possible to identify environmental changes that had occurred. These remains shed light on the seasonality of a site's occupation and the mobility patterns of its forager hunter-gatherers. Below are data for birds, fishes, mollusks and mammals from the delta of Camarones river area, including the sea. Crustaceous are presented along with mollusks. Although some insects were recovered from the site during this research, they remain unclassified. The birds and mammals listed are mainly compiled from Schiappacasse and Niemeyer's (1984) data for the local contemporary faunal composition. The list of fishes was compiled from Medina F. et al. (2004). The archaeological remains presented regarding Camarones 14 were reproduced from Schiappacasse and Niemeyer's (1984). The available information for faunal remains from Camarones Sur is for the entire context of the site and not for occupational layers; the list of species related to this site was compiled from Rivera (mimeograph s/d.)[16]; the mollusks are compiled from Billings (2001), including modern species from the Camarones seashore area.

Birds

Many marine birds are migratory and highly seasonal. Their remains at an archaeological site are clues to the period of the year they were captured, and when the

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[16] Mimeographed report from the expedition realized to the area by the Instituto de Antropología de la Universidad de Tarapacá and the Grupo Aves y Mamíferos Marinos del Instituto de Investigaciones Oceanologicas de la Universidad de Antofagasta; Mario A Rivera y George Portflit (directors, 1984).

site was occupied. During the summer, flocks of migratory birds gather around the river deltas. The bird population can increase from hundreds to thousands. This is the case for the wetland area formed by the delta of the Camarones River, which attracts a diversity of aquatic birds. A 2005 study concluded at Caleta Camarones in July (winter) counted a total of 501 birds and 15 species (Espinosa Galleguillos 2006). During the summer (February) the population jumped to 3,031 birds and 14 species (Table 2.2). Long distance migrant gulls from Family Laridae were the prevalent species.

Table 2.2: Seasonal distribution of aquatic birds at some of the rivers deltas of northern Chile

	February	July
Caleta Camarones	3,031 (14 species)	501 (15 species)
Caleta Victor	249 (9 species)	294 (12 species)
Rio Lluta (delta)	8,392 (13 species)	1,237 (13 species)

Source: Espinosa Galleguillos 2006.

The prey potential is very high during the summer months when migratory birds congregate at the river's deltas (Table 2.2). The diversity of species and the high number of birds found in these areas make them an attractive spot for hunting attracting not only humans, but other natural predators as well. During winter (July 2006), as observed at the Camarones delta, the number of birds drop from three thousands to some hundreds. Marine birds are easy to observe along the Camarones beach and adjacent rocks. They flock there when shoals of anchovies appear near the Camarones coast. The most prominent bird species are *Sula variegata*, *Pelecanus occidentalis*, *Phalacrocorax* *bougainvillii*, and *Phalacrocorax gaimardi*. The Humboldt penguins[17] flock to specific sites along the rock littoral. The birds that seek out anchovies, like *Sula variegata*, *Phalacrocorax bougainvillii*, and *Oceanites gracilis*, follow the Humboldt Current. Bellow is a list of the actual avian fauna from the Camarones area (Table 2.3). The raw data were rechecked and re-categorized by the author, including updating scientific, taxonomic nomenclature.

Table 2.3: Modern migratory and other birds from the Camarones area

Species [*]	Common name: Spanish / English	Observations**
Larus dominicanus	*Gaviota dominicana* / Kelp Gull	Largely sedentary. Breed season: late September and January
Larus belcheri,	*Gaviota peruana*	Local (Peru/Chile)[2]
Leucophaeus pipixcan (*Larus pipixcan*)	*Gaviota de Franklin* / Franklin's Gull	Winter
Leucophaeus modestus (*Larus modestus*)	*Garuma* / Grey Gull	Local (Peru/Chile). Breed season: November to January***. They do not reproduce during El Niño Southern Oscillation (ENSO) events.
Haematopus ater	*Pilpilén* / Blackish Oystercatcher	Local (Peru/Chile)
Sula variegata	*Piquetero* / Peruvian Booby	Local (Peru/Chile). Migratory: from Peru to the south in March-April returning in September-October. Follow the Humboldt Current***.
Pelecanus occidentalis (also possible *Pelecanus thagus*)	*Guajache*, *Pelícano* / Brown Pelican. Peruvian Pelican.	Local (Peru/Chile). Follow the Humboldt Current***
Phalacrocorax bougainvillii	*Pato guanay* / Guanay Cormorant	It is found along the Pacific coast of Peru and northern Chile. Follow the Humboldt Current. It is affected by El Niño Southern Oscillation (ENSO) events; feeds on peruvian anchoveta (*Engraulis ringens*). In Chilean coast

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[17] In 2008, the author of this research saw from the sea, a very small colony of the Humboldt penguins living in a cave located on the rocks between Arica and Caleta Victor. In the same occasion, a colony of Ottaridae was also observed on the offshore rocks as well as Dolphins and a great variety of marine birds. From an anthropological perspective, a group of about 10 people were also observed foraging close to the rocks in which two were diving and the others were assisting them or doing other activities.

		mainly from March to December.***
Phalacrocorax gaimardi	*Pato lili* / Red-legged Cormorant	Affected by El Niño Southern Oscillation (ENSO) events. Common during the whole year; in small groups.
Spheniscus humboldti	*Pingüino de Humboldt*, *pajaro niño* /Humboldt Penguin	Coastal Peru and Chile. Affected by El Niño Southern Oscillation (ENSO) events. A possible migration route between Peru and north Chile of c. 700 km. Rock littoral.
Oceanites gracilis	*Golondrina de mar chica* / White-vented Storm Petrel	Eastern Pacific Ocean; occurs in Chile. Follow the Humboldt Current***.
Nycticorax nycticorax	*Huairavo* / Black-crowned Night-heron	A large range species, also native from Chile and Peru. Northern populations are migratory: southward movements occur from September to October and return northward movements occur from March to May.
Pandion haliaetus	*Águila pescadora* / Osprey	A large range species. Summer visitor in Chile, from Tarapacá to Valdívia***.
Polyborus plancus (Synonym: *Caracara plancus* ?)	*Traro*, *carcará* / Southern Caracara	A large range species.
Falco peregrinus	*Halcón peregrinus* / Peregrine Falcon	A large range species. Occurs in Peru/ Chile. Some sub species are migratory, mainly populations that breeds in Artic climes migrate during the northern winter.
Arenaria interpres	*Playero vuelve piedras* / Ruddy Turnstone	A large range species. Migratory; in Chile during summer***.
Aphriza virgata	*Playero de las rompientes* / Surfbird	A large range species. Migratory; in Chile during Summer***
Calidris alba	*Playero blanco* / Sanderling	A large range species, from Arica to Estrecho de Magallanes. Migratory; in Chile during summer. In September they start appearing on the coast***.
Numenius phaeopus	*Zarapito* / Whimbrel	A large range species; from Arica to Tierra del Fuego. Migratory. In Chile during Spring.***
Sterna elegans (Synonym: *Thalasseus elegans*)	*Gaviotín elegante* / Elegant Tern	Migratory. In Chile during Spring***. Affected by El Niño Southern Oscillation (ENSO) events.
Larosterna inca	*Gaviotín monja* / Inca Tern	It is found along the Pacific coast from northern Peru to central Chile.
Rynchops nigra (Synonym: Rhynchops niger ?)	*Rayador* / Black Skimmer	Migratory; in Chile during summer. Occurrence in Chile: from Arica to Estrecho de Magallanes ***.
Cinclodes nigrofumosus	*Churrete costero* / Seaside Cinclodes	Large range species. In Chile from Arica to Valdivia***

Macronectes sp. (*Larus* sp.)	*Petrel gigante* / Southern Giant-petrel	In Chile from Arica to Antartic. Related with the Humboldt Current. *** In the north and central-south coast, they are more abundant during winter.****
Corasyps atratus [?]. Possibly *Coragyps atratus*	*Jote de cabeza negra* / Black Vulture	Large range species.
Cathartes aura	*Jote de cabeza colorada* / Turkey Vulture	
Casmerodius albus	*Garza Blanca* / Great White Egret	Large range species. Found in inland and coastal wetlands.
Buteo polyosoma	*Aguilucho* / Red-backed Hawk	Large range species.
Florida thula (*Egretta thula* – it was on Leucophoyx genus - or *Egretta caerulea* – this one was on Florida genus)[18]	*Garza chica* / Snowy Egret or Little Blue Heron	Large range species.
Geranoaetus melanoleucus	*Águila* / Black-chested Buzzard-eagle	Large range species.
Vultur gryphus	*Cóndor* /Andean Condor	Occurrence: through the Andes.

Source: *Schiappacasse and Niemeyer (1984)
**IUCN 2011.
*** http://www.avesdechile.cl (Remsen Version [oct. 21. 2011])
****Arata, J. and Hucke-Gaethe, R. 2005.

As noted in Table 2.2, more then thirty species of migratory and local birds are currently found at the Camarones delta. This suggests the site's importance, not only as a source of food, but also as source of raw materials for artifacts that used bones, skin, feathers, and plumages. Avian remains were also used in funerary rituals and in bodies' mummification.

At Camarones Sur, Rivera's excavation identified penguins (Spheniscidae) and vultures (Cathartidae), which are numerous in the area (Rivera, mimeograph s/d). At Camarones 14, Schiappacasse and Niemeyer (1984) excavation, recovered one hundred

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[18] The classification follows the South American Classification Committee from the American Ornithologists' Union and/or the IUCN Red List of Threatened Species.

and seventy avian remains. From these, five species were identified that accounted for 72% of the total sampled (Table 2.4):

Table 2.4: Avian remains from Schiappacasse and Niemeyer (1984) excavation at Camarones 14

Specie / stratum*	b	c	d
Spheniscus humboldti (*pájaro niño*)	3	12	32
Phalacrocorax sp. (*cormorán*)	6	15	25
Phalacrocorax bouganvillii (*pato guanay*)	5	1	4
Pelecanus occidentalis (*pelícano*)	8	0	8
Macronectes giganteus (*petrel gigante*)	0	0	1
Cinclodes nigrofumosus (*churrete costero*)	0	0	2
Totals:	22	28	72

*Bone fragments per excavation stratum

About eleven bone fragments show incisions done during the manipulation of the bones to make artifacts or other instruments; the ones related to strata d are: *Spheniscus humboldti*, *Pelecanus occidentalis*, and *Phalacrocorax bouganvillii*. The range of exploited species in the site was small denoting selectivity. This supports the view that birds were an important component in the forager system providing food as well as raw materials for artifacts.

Due to their migratory habits and diet, marine birds provide a good indicator for seasonal studies as well as for El Niño events. Such birds are directly affected by changes in the Humboldt Current and consequently in the food chain. All the species identified at the Camarones 14 site depend on the Humboldt Current, as do the species that flock there today. This is a good indicator of the stability of the system. Concerning seasonality, *Macronectes giganteus* is found in much greater numbers during the winter. Besides

Macronectes, *Phalacrocorax bougainvillii* remains (four occurrences) are more common during the summer, from December to March. The remains of both species go back to the preceramic period, at the time of the Chinchorro occupation.

To conclude, based on the archaeological remains found at Camarones 14 the presence of *Phalacrocorax bouganvillii,* and the *Macronectes giganteus* (giant petrel) are good seasonal indicators.

Fishes

A warm-temperate group of fishes of tropical and sub-tropical origin thrive along the coast of northern Chile [19] (Ojeda et al 2000). The coastal area of the Camarones Valley is favorable for fishing, both the beach and the seashore rocks. The seashore's natural configuration provides good spots for line fish and diving. Although the climate is mild with no rain, the summer is less favorable for fishing. This is due to the water runoff from the altiplano that brings sediment to the ocean, darkening the water close to the river's delta. It is during this time that many local fishermen move from Caleta Camarones to Arica. However, during the rest of the year, fishing and diving for mollusks gathering is a regular activity, as long as ocean conditions are favorable. During the summer, migratory fishes like *Trachurus symmetricus* (*jurel*) and *Coryphaena hippurus* (*palometa*) frequent the coastal littoral near Camarones. Shciappacasse and Niemeyer (1984) found the remains of at least one of these, *Trachurus symmetricus* (*jurel*). In Camarones Sur, four different species were recognized, but not identified

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[19] This group of littoral fish fauna belongs to the Peruvian province. A second group belongs to the Magellanic province (40-56° S) with cold-temperate fish fauna of subantartic origin. The transition zone occurs from 30 to 42° S with the mixed of both faunas (Ojeda et al. 2000).

(Rivera, mimeograph s/d). A list of the marine fishes that occur on the north zone of Chile is presented bellow in Table 2.5. The raw data show below were rechecked and re-categorized by the author, including updating scientific, taxonomic nomenclature.

Table 2.5: Marine fishes from the Camarones area. Following Medina F. et al. (2004) systematization for the North Coast of Chile.

Species	Common name: Spanish/English	Cam14 (1984)	Habitat	Observations
Ophichthus pacifici	*Anguila común* /Common snake-eel		Demersal (found at 24 to 454 m deep)	Eatable fish.
Sardinops sagax	*Sardina española* /Pacific sardine		Seasonal, Humbodt Current (HC). Abundance increase with El Niño. Spawning at the North HC: Winter[1]	Eatable fish. School.
Engraulis ringens	*Anchoveta*/Anchovy		Seasonal, Pelagic, neritic zone. Spawning at the North HC: Winter[1] Abundance decay with El Niño.	Eatable fish. School. Negative correlation with *S. sagax*
Galeichthys peruvians	*Bagre con faja* / Peruvian sea catfish		In association with El Niño.	
Genipterus maculatus	*Congrio negro* / Black cusk eel		Demersal; rock littoral up to 100 m deep. HC.	Eatable fish.
Genipterus chilensis	*Congrio colorado* / King ling		Bottom rock	Eatable fish
Merluccius gayi gayi	*Pescada, Merluza común* / Chilean hake			Migratory; eatable fish
Aphos porosus	*Bagre* / Banded toafish		Seasonal; Bentonic	
Sicyases sanguineus	*Peje sapo común* / Common clingfish		Intermareal; adhered to the rooks.	With hook; eatable fish
Gobiesox marmoratus	*Peje sapo veteado* /Marbled clingfish		Intermareal zone	
Odontesthes regia	*Pejerrey* / Sea silverside		In association with sardine and anchovies	Net. Eatable fish
Scomberexos	*Agujilla* / South		In association with	Net. Eatable as

saurus scombroides	Pacific saury		sardine and anchovies	fish flour
Hippocampus ingens	*Caballito de mar* / Pacific seahorse		Rock littoral	Found during El Niño 1982-1983
Scorpaena hystrio	*Diablito* / Player scorpionfish		Bottom rocks	
Sebastes capensis	*Cabrilla española* / False jacopever		Rock littoral	Eatable fish
Congiopodus peruvianus	*Chanchito* / Cacique pigfish		Rock littoral	
Normanichthys crockeri	*Bacaladillo, Mote* / Mote sculpin		Occasional fish***; pelagic. Close to sardine and anchovy schools.	Net. Eatable as fish flour
Paralabrax humeralis	*Cabrilla común* / Peruvian rock seabass		Occasional fish***, bottom rocks	Eatable fish
Acanthistius pictus	*Vieja colorada* / Brick seabass		Seasonal***, bottom rocks	Eatable fish
Hemilutjanus macropthalmos	*Apañado* /Grape-eye seabass		Rock sub littoral; found at 10 m deep	Eatable fish
Trachurus murphyi (Synonym: *Trachurus symmetricus*)	*Jurel* /Jack mackerel	X	Pelagic, can be found close to the beach or in brackish water. Seasonal, warm temperate waters**	Migratory. Eatable fish
Seriola lalandi	*Dorado* /Yellowtail amberjack		Pelagic	School. Eatable fish
Coryphaena hippurus	*Palometa, Dorado* /Mahi mahi		Pelagic. Close to the coast with warm temp.	Migratory. Eatable fish
Brama australis (Synonym: *Lepidotus australis* ?)	*Reineta* / Pacific pomfrets		Pelagic, near the rocks	Eatable fish
Anisotremus scapularis	*Sargo*/Peruvian grunt		Resident fish***	Eatable fish
Isacia conceptionis	*Cabinza, Roncador* /Cabinza grunt		Sand beach (0-50 m deep). Resident fish***	Line fishing. Eatable fish
Cynoscion analis (*Sciaena gilberti* ?)	*Ayanque* / Common Peruvian weakfish	X	Pelagic	Eatable fish
Paralonchurus peruanus	*Rococo* / Coco croaker		Demersal	Eatable fish
Sciaena deliciosa	*Roncacho* / Lorna drum		Resident fish***	Eatable fish

Sciaena fasciata	*Sargo de peña* / Arnillo drum		Occasional fish***	Eatable fish
Stellifer minor	*Mojarrilla, corvinilla* / Lined drum		Sand beach.	Eatable fish
Cilus gilberti (Synonym: *Cilus montti*; *Sciaena gilberti*)	*Corvina* / Corvina drum	X	Sand beach. Resident fish***	Demersal. HC. Eatable fish
Girella laevifrons	*Baunco* / Black seachub			
Graus nigra	*Vieja* / Black wrasse		Rock littoral	Line/ Harpoon
Medialuna ancietae	*Acha* / Peruvian halfmoon		Rock littoral	Harpoon Eatable fish
Oplegnathus insignis	*San Pedro* /Pacific beackfish			Eatable fish
Chromis crusma	*Burrito* / Pacific chromis		Rock littoral, intermareal zone	
Nexilosus latifrons	*Castañeta* / Coquito sergeant		Rock littoral, intermareal zone	
Aplodactylus punctatus	*Jerquilla* / Zamba marblefish		Sand beach	
Cheilodactylus variegatus	*Pintacha, blagay* /Peruvian morwong		Sand beach	School Eatable fish
Mugil cephalus	*Liza* / Striped mullet	X	Juveniles in freshwaters /estuaries.	Eatable fish Migratory (spawning)
Semicossyphus darwini (Synonym: *Pimelometopon darwini* and *P. maculatus*)	*Pejeperro* / Common sheephead	X	Rock littoral	Eatable fish
Halichoeres dispulus	*Doncella* / Chameleon wrasse		Rock littoral (2-76 m deep).	
Pinguipes chilensis [Synonym: *Mugiloides chilensis* ?]	*Rollizo* / Chilean sandperch		Rock littoral	Line fishing Eatable fish
Prolatilus jugularis	*Blanquillo* / Pacific sandperch			Line fishing Eatable fish
Caulolatilus princeps	*Peje fino* / Ocean whitefish		demersal (10-91 m deep)	
Auchenioncchus [Aunquenionchus] variolosus	*Chasque* / Tomoyo clinid		Rock intermareal	
Auchenioncchus microcirrhis	*Chalaco*			

Labrisomus philippii	*Tomollo* / Chalapo clinid		Rock submareal	Eatable fish
Scartichthys gigas	*Borrachilla* / Giant blenny		Rock littoral, benthonic	
Scartichthys viridis	*Borracho verde* / Green blenny		Rock intermareal	
Hypsoblennius sordidus	*Trombollo robusto* / Bullblenny		Rock littoral	
Tripterygion chilensis	*Trombollo tres aletas* / Threefin blennies			
Sarda chilensis	*Bonito* / Eastern pacific bonito	X	Pelagic	HC
Scomber japonicus peruanus	*Caballa* / Chub mackerel	X	Seasonal***; coastal pelagic	
Calamus brachyosomus	*Sargo del Norte* / Pacific porgy		Sand bottom	
Seriolella violacea	*Cojinova* / Palm ruff		Pelagic. Sand beach.	
Seriolella porosa	*Cojinova* /Choicy ruff			HC
Psenes sio	Errante/Driftfish			HC
Paralichthys microps	*Lenguado de ojos chicos* / Smalleye flounder	X	Sand bottom; beach	
Hippoglossina macrops	*Lenguado de ojos grandes* / Bigeye flounder		Sand bottom	
Balistes polylepis rubicundus	*Pez ballista* / Triggerfishes			
Xiphias gladius	*Albacora, Espada*/Swordfish		Pelagic oceanic. Sometimes in coastal waters.	
Stromateus stellatus	*Palometa*		Pelagic	
Scartichthys viridis	*Roncacho*		Sand beach	
Menticirrhus ophicephalus	*Pichigüén* / Snakehead kingcroaker		Sand beach	
Myliobatis peruvianus	Raya águila	X		

Obs.: HC = Humboldt Current

* Identified at Camarones 14 site (Shiappacasse F. and Niemeyer F. 1984).

** Llagostera, 1979, *** Sielfeld et al. 2002. [1] Brochier et al 2011.

Other sources: Medina F. et. al. 2004; Schiappacasse and Niemeyer 1984; Saez and Pequeno 2009; Bailly 2010; Froese 2011; Fishbase.org (http://www.fishbase.org)

As the data show (Table 2.5), the area offers a high diversity of fish. Of these, the research of Schiappacasse and Niemeyer (1984) identified at least 9 species that were exploited at the Camarones 14 site (see Table 2.4). As they observe, all the fishes identified, that is, *jurel*, *corvina*, *ayanque*, *liza*, *pejeperro*, *bonito*, *caballa*, *lenguado*, and *raya* can be caught from the coast without any kind of boat. Most of these are sedentary but some are migratory. *Trachurus symmetricus* (jurel or jack mackerel) and *Scomber japonicus peruanus* (caballa) have migratory patterns related to the coastal food supply. *Trachurus murphyi* (jack mackerel) migrates to the shoreline during the summer and returns offshore in early spring. During fall and in winter, migratory fishes disperse away from the coast. In summer, or during warm years they move into coastal waters. The migration pattern is also affected by El Niño events (Núñez E. et al. 2004; Thiel et al. 2007). For the study of sites in northern Chile, the jack mackerel was used as a biomarker for temperate warm water (Llagostera 1979). *Scomber japonicus peruanus* (chub mackerel/*caballa*) also has a migratory behavior, approaching the coast during summer months and El Niño events and going offshore in winter. This is shown by the high catch rates of "*caballa*" in Chilean waters between November and May (summer and fall) with a peak in January, which had three times the catch of any of the other month ("Chile, Desembarque Artezanal Año 2008 por Especie y Mes"). The water, of course, is warmest in January. Like the jack mackerel, the *caballa* head out into ocean waters to spawn and then returns back to the coast.

Table 2.6: Fish remains from Schiappacasse and Niemeyer (1984) excavation at Camarones 14

Specie / stratum*	b	c	d
Trachurus murphyi (jurel)	21	3	17
Cilus montti (corvina)	5	2	16
Sciaena gilberti ? (ayanque)	3	0	0
Pimelometopon (pejeperro)	21	4	3
Mugil cephalus peruanus (liza)	4	0	9
Sarda chilensis chilensis (bonito)	5	0	15
Scomber japonicus peruanus (caballa)	0	0	2
Paralichthys (lenguado)	0	0	5
Myliobatis peruvianus (raya águila)	2	0	0
Totals:	61	9	67

*Bone fragments per excavation stratum

From among the fishes identified by Schiappacasse and Niemeyer (1984) at the Camarones 14 excavation, the species that best give indicate seasonal movements are *Trachurus murphyi* (jack mackerel) and *Scomber japonicus peruanus* (chub mackerel/ *caballa*); both migrate to the coast in great numbers during the summer.

Mollusks, Sea Urchins and Shrimps

The Camarones shoreline with its beach and rocky seabed favors a variety of mollusk species easily collected by human foragers during the low tides when the rocks are exposed. Some species can also be collected on the beach. For others outside the tidal zone, it is necessary to dive in order to reach them. Extraction, however, depends on ocean conditions like waves, thunderstorms, and the clearness of the seawater. Below is a list of the modern shells from the surrounding area of Camarones delta seashore [20].

Table 2.7: Modern marine shells from Camarones area (Chile). Data compliled from Billings (2001: 61).

Species	Common name	Habitat
Agropecten purpuratus	Purplish Scallop	Sandy
Aulacomya ater	Black-ribbed Mussel	Rock
Choromytilus chorus	Chorus Mussel/*Chorus*	Rock
Concholepas concholepas	Rock Barnacle/*Loco*	Rock
Crepidula dilatata	Dilated Slipper	Rock
Fissurella crassa	Keyhole Limpet/*Lapa*	Rock
Fissurella latimarginata	Keyhole Limpet	Rock
Fissurella maxima	Keyhole Limpet	Rock
Glycemeris ovata		Sandy
Hiatella solida		Sandy
Littorina peruviana		Rock
Oliva peruviana	Peruvian Olive	Sandy
Perumytilus purpuratus	*Chorito maico*	Rock
Priene ruda		Rock
Protothaca thaca	Thaca Venus Clam	Sandy
Scurria viridula	Green Chilean Limpet	Rock
Semele solida	Solid Semele Clam	Sandy
Tegula atra	*Caracole negro*	Rock
Thais chocolata	Chocolata Rock Shell/*Locate*	Rock
Turritella cingulata	Banded Turritella	Rock/sandy

Sampled places for modern shells were Alacrán, Arenillas Negras, El Onda, and La Capilla, located in Arica and its surroundings. Samples from El Onda, and La Capilla are from shells of living species collected by underwater divers. Samples from the remaining locations were composed of shells found on the beach. Therefore, modern samples from Camarones area consists, basically, of non-living species of shells collected from the shoreline area of Camarones. From a total of twenty-six species identified, twenty are listed for this area as they were found by Billings (2001). A complete list with all shells collected from other points of the littoral around Arica can be found in Billings (2001).

Table 2.8 relates the archaeological shells collected at the Camarones Sur site by Billings (2001), to the strata in which they were found. The shells were collected from column samples 20 centimeters wide and 20 centimeters in depth taken at three different points of the exposed profiles, one from the east profile, and two from the west profile. It covers the period between 3,600 to 4,500 years ago.

Table 2.8: Archaeological shells from Camarones Sur compiled from Billings (2001)

Species	Strata				
	3	4	5	14	15
Choromytilus chorus	*	*	*	*	*
Concholepas concholepas	*	*	*	*	*
Fissurella crassa	*	*	*		
Fissurella latimarginata		*	*	*	
Fissuralla sp.			*	*	
Crepidula dilatata	*	*	*	*	
Protothaca thaca			*	*	
Thais sp.	*		*		
Scurria sp.	*	*	*		
Scurria viridula			*		
Perumytilus purpuratus	*		*	*	
Chiton	*	*	*	*	*
Tegula luctuosa		*		*	
Tegula sp.		*	*	*	*
Thais chocolata		*			
Tegula atra			*	*	
Crassilabrum crassilabrum			*		

Below is the archaeological data on shells collected at Camarones 14 by Shiappacasse and Niemeyer. The nine shells listed first were the most abundant species recovered. For the Preceramic occupation, the most numerous were *Concholepas concholepas*, *Fissurela crassa*, and *Crepipatela dilatata*. These species were found in the intermareal and submareal zones. Of economic importance, they can be collected from the seashore during the low tides or by diving. The most abundant shell was *Concholepas concholepas* followed by *Fissurela crassa*. Both species were found in ceramic and Preceramic contexts. The other species appeared less frequently, mainly in the Preceramic occupation period.

Table 2.9: Archaeological shells from Camarones 14, data compiled from Schiappacasse and Niemeyer (1984)

Presence/absence per strata		
Species (common name)	Ceramic	Pre-ceramic
Concholepas concholepas	*	*
Fissurela crassa (*Lapas*)	*	*
Fissurela limbata	*	-
Fissurela maxima	*	-
Fissurela latimarginata	*	-
Tegula atra (*Caracole negro*)	*	+
Prisogaster niger	*	+
Thais chocolata (*Locate*)	*	+
Crepipatella dilatata	*	*
Choromytilus choro	*	-
Perumytilus purpuratus (*Chorito maico*)	*	+
Mesodesma donacium (*Macha*)	-	+
Mulinia sp. (*Almeja*)	+	+
Enoplochiton niger (*Apretador*)	*	+
Crucibulum quiriquinae	not infomed	
Oliva peruviana	not infomed	
Turritela cingulata	not infomed	
Scurria viridula	not infomed	

Obs.: * present in more quantity; + present in less quantity; - absent.

From the data presented, notice that *Mesodesma donacium* is not an abundant species. This species was not in the data presented by Billings (2001) for Camarones, although it was represented in samples from Alacrán, Arenillas Negras, and El Onda. Of these, only the last one also had samples live. This taxon, *Mesodesma donacium*, does not show up in the ceramic occupation. In the Preceramic context, it is restricted to two or three concentrations. By contrast, in the 2007 excavation executed for this research, *Mesodesma donacium* remains were abundant and formed a thick layer about 20 centimeters deep (conf. in chapter 2 in this thesis). Also, the layers below appear to have been dug intentionally and filled with some of the *Mesodesma* remains[21]. As show by Billings' (2001) research for modern shells, this species, today, is no longer common in the Camarones delta area.

The mollusks listed for Camarones Sur and Camarones 14 sites are essentially marine species. The class Cepahlopoda is represented in the Camarones area by two species: *Octopus vulgaris* and *Dosidicus gigas* (Shiappacasse and Niemeyer 1984). Locally know as "*pulpo*", the first species is still harvested by local divers. The "*pulpos*" are a local delicacy and are sold to local restaurants in the nearby cities of Cuya or Arica. Since neither of these species have shell or bones, the likelihood they well be preserved at an archaeological site is slim, difficult, although under the desert conditions, this is a possibility. However, no remains of cephalopods were found at Camarones 14 or Camarones Sur.

Other local invertebrates are the sea urchin (Echinoidea) *Loxechinus albus* a marine echinoderm, and the river shrimp *Cryphiops caementarius* (Molina 1782). The sea urchin is found in the local rocky littoral. The edible parts are the gonads. Although they are available throughout the year, they are intensively harvested during the reproductive season from the end of the fall to the beginning of spring (May to

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[21]

September)[22]. They can be extracted from the rocky seabed during low tide in calm waters with a "*chope*" (Figure 2.12). This ancient artifact, made from the bones of marine mammals, was used to harvest and open shellfish and sea-urchins (Standen 2003). This artifact can also be used to collect roots and plants from the soil.

Figure 2.12: Artifact made from a sea-lion rib used to harvest shellfish and sea-urchins (*chope*). Artifact found at Chinchorro burial site. (Source: Standen 2003).

River shrimp migrate down to the river mouths to spawn, a cycle that peaks between January and March (Viacava et al 1978; Meruane et al. 2006). As observed by this author, in April 2008 shrimps were still harvest at the Camarones mouth. The harvesting is done passing by a small net along the river bottom near the shore (Figure 2.13). Between March and May, the juveniles migrate back up stream where they develop into adults (Meruane et al. 2006). During the Schiappacasse and Niemeyer excavation (1984) remains of sea urchins and shrimps were not found at either at Camarones 14 or at Camarones Sur site (Rivera s/d).

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[22] Based on the SERNAPESCA data from sea urchin landing for the Caleta Camarones, year 2012.

Figure 2.13: Net used to harvest shrimp at the Camarones river delta (April 2008) (Author's photo).

Mammals and Reptiles

The area's fauna can be divided into marine and terrestrial. Marine mammals constitute a diverse group; each species require distinctive hunting strategy. Marine carnivore mammals often congregate on coastal rocks and along the seashore. At such times, humans can hunt them without the use of boats. Table 2.10 lists the most common marine mammals that occur in the area and near the seashore. It also lists the animals that inhabit the valley close to the coast. Some other species found at Camarones 14 site during Schiappacasse and Niemeyer (1984) excavation, that is highland animals and marine reptiles, are in Table 2.11 and 2.12, respectively.

Two species of turtles were found at the site. These turtles are an easy prey during the summer months when they approach the coast. The author had the opportunity to observe this at Chinchorro beach during the 2007-2008 summer. Although turtles do not spawn at the Chinchorro beach, it is possible that summer currents bring them close to the shoreline.

The raw data show below were grouped, rechecked and re-categorized by the author into readable tables. This included updating scientific, taxonomic nomenclature.

Table 2.10: Marine and terrestrial mammals from the Camarones coast

Species [*]	Common name: Spanish / English	System	Camarones 14- pre-ceramic (SchNy)**	Observations
Otaria flavescens	*León marino* / Sea lion	Marine	X (juvenile)	El Niño impact on population: decline
Lontra felina Synonym: *Lutra felina*	*Chugungo, Nutria de mar* / Marine otter	Terrestrial/ Marine/ Freshwater	X	Coastline
Globicephala melaena	*Calderón negro, ballena pilot* / Long-finned pilot whale	Marine		
Delphinus delphis	*Delfín común* / Common dolphin, Pacific dolphin	Marine		Warm temperate and tropical waters/equatorial and subtropical waters
Cephalorhynchus	*Tunina* (possible, *Cephalorhynchus eutropia*)	Marine	X	Two species for Chile; Pacific – southeast, from about 30°S to Cape Horn, at the southern tip of South America restricted to cold shallow coastal waters***
Physeter macrocephalus	*Cachalote común*	Marine		
Canis culpaeus (Synonim: *Lycalopex culpaeus*) *	*Zorro colorado* / Red Zorro	Land		Solitary. Furbearer. From the Andes to northern Chile shoreline (0 to

				5,000 m ****
Canis griseus (Synonim: *Lycalopex griseus*) *	*Chilla* / South America grey Fox	Land		Sea level to 3,000 m. ****
Conepatus sp. (probably *Conepatus chinga*)	*Chingue* / Molina's Hog-nosed Skunk	Land		Nocturnal. Furbearer. Both sides of the Andes, more common in north Chile, from northern Chile to Tierra del Fuego*. Sea level to 2,500 m.****
Felis jacobita	*Gato montés*	Land		

Table 2.11: Non local Mammals from Camarones 14 site (Schiappacasse F. and Niemeyer F. 1984)

Species *	Common name: Spanish/English	System	Camarones14- pre-ceramic (SchNy)**	Observations
Vicugna vicugna	*Vicuña*	Land	X	Puna. Restricted to altitudes of 3,200 to 4,800 m*
Lama guanicoe	*Guanaco*	Land	X	Puna. Migratory and no migratory population (forage seasonal for food - fruits, leaves and flowers)*
Lagidium viscacia	*Vizcacha*	Land	X	Puna. Between 2,500 m to 5,100 m.*
Chinchilla chinchilla	*Chinchilla*		X	Puna. Furbearer. Between 3,000-5,000 m. Nocturnal.****

Table 2.12: Marine reptiles

Species *	Common name: Spanish/English	System	Camarones14, pre-ceramic (SchNy)**	Observations
Dermochelys coriacea	*Laúd del Pacífico* / leatherback sea turtle	Sea	X	The largest sea turtle. Occurs in the Chilean central coast line.*****
Chelonia mydas	Green turtle	Sea	X	Occurs in northern Chile*****

*Source: IUCN 2011.
(SchNy) ** - Material identified at Camarones 14 site during Schiappacasse and Niemeyer field season (Schiappacasse and Niemeyer 1984).
*** Reeves et al. 2008; **** Chester, Sharon R. 2008; ***** Chandler 1991.
X – taxon identified in the archaeological record of the site.

Along the Atacama coast, sea lion (*Otaria flavescens*) is the predominant species. Sea lions often come close to the seashore in search for food. They congregate in breading colonies that can have thousand of animals. Pups are born in the summer (mid-December, to early February) and weaned at 8-10 months old (Campagna 2008; Acevedo R. et al. 2003). Young sea lions can be found alone on the beach and over the rocks where they become easy prey. During the winter (August, 2007) the author saw young sea lions at the Chinchorro beach in Arica. Currently, sea lions have a colony on the sea rocks close to Arica, which is accessible by boat. In ancient times, bone harpoons were probably used to hunt both, sea lions and various species of fish.

The marine otter (*Lontra felina*) is a small mammal that lives along the rocks littoral of Chile, Peru, and parts of Argentina. Remains of both species were found at hunter-gather sites in Chile, like Abtao-1 and Curaumilla-1 (Llagostera, 1979; Jerardino, 1992), and also in Camarones 14 site. The presence of this species at the Camarones 14 site is discussed later in this section.

Other marine mammals include *Globicephala melaena* ("*calderón negro*"), the *Delphinus delphis ("delfín común*"), and *Physeter macrocephalus* ("*cachalote común*") (Schiappacasse and Niemeyer 1984). Boats and harpoons are used to hunt these mammals as they are found offshore, although, on occasion, they come close to the coast. No remains of these species were found at Camarones 14.

Land animals are few along the desert coast. Those found in the Camarones valley, as noted by Schiappacasse and Niemeyer (1984) include, *Canis culpaeus* ("*zorro colorad*o"), *Canis griseus* ("*la chilla*"), *Conepatus* sp. ("*chingue*"), and possibly, *Felis jacobita* ("*gato montés*"). Different species of bat (Order Chiroptera) also inhabit the area. None of these taxa were found among Camarones 14 faunal remains.

Archaeological data from Camarones Sur, although limited, indicated the remains of the Felidae family. Marine mammals were represented by *Otaria flavescens* and some other cetaceous species distributed between the Mysticeti and Odontoceti families (Rivera, mimeograph s/d).

Table 2.13: Camarones 14: mammal remains distribution. Data compiled from Schiappacasse and Niemeyer (1984)

Specie / stratum*	b	c	d
Otaria flavescens (sea lion)	*	*	*
Lama guanicoe (*guanaco*)	*	*	*
Llama lama (*llama*)	*		
Vicugna vicugna (*vicuña*)	*	*	*
Chinchilla chinchilla (*chinchilla*)		*	
Lagidium viscacia (*vizcacha)*			*
Lutra felina (*chungungo*)	*		
Cephalorhynchus (*tunina*)	*	*	*
Cetacea (others)	*	*	*

Presence/absence per stratum

During the Schiappacasse and Niemeyer (1984) excavations, the following taxa were registered at Camarones 14 (Table 2.13): From the first layers (stratum b), associated with agro-ceramists, the post-Chinchorro Saxamar culture, they found *Lutra felina*[23] ("*chungungo*"), *Otaria flavescens*, *Cephalorhynchus* (Cetacea, "*tunina*"), *Vicugna vicugna* and *Lama lama* (Camelidos). From the pre-ceramic layers (strata d and c) associated with Chinchorro came *Otaria flavescens*, *Vicugna vicugna*, *Lama guanicoe* ("guanaco"), *Cephalorhynchus* (Cetacean) *Lagidium viscacia* ("*vizcacha*", at stratum d), and *Chinchilla chinchilla* ("*chinchilla*", at stratum c).

The presence of *Cephalorhynchus* is important because the two species currently found in Chilean waters rarely stray so far north. They prefer the colder waters further south. Nowadays, the northern limit of *Cephalorhynchus eutropia,* or "*tunina*", is around Coquimbo (Reeves et al. 2008). The presence in the past of this species as far north as the Atacama coast suggests that cold currents circulated further north in the early period, at the time the site was occupied. Another point to detach are the remains of immature specimens of *Otaria flavescens* and camelids, although the remains from young camelids are from the ceramist occupation (Table 2.14).

Table 2.14: Remains of young animals from Schiappacasse and Niemeyer (1984) excavation at Camarones 14

	%		
Specie / stratum	b	c	d
Otaria flavescens	37.8	40.7	44.6
Camelidae	17.4	0	0

Obs.: Percentile of bone fragments per stratum

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[23] A synonym for *Lontra felina.*

Concerning the sea lion, a vertebra from an immature animal with a lithic project point jabbed in it was found in macro strata d, that is, at the base of the site occupation. Since pups of *Otaria flavescens* are born in the summer (January-February) (Acevedo R. *et al.* 2003), it is reasonable to infer that the young sea lion was captured around winter/spring. This also applies to the remains of other young sea lions. The remains of animals from the *altiplano* ("*vicuña*" – stratum c and d, guanaco – c and d, chinchilla - c, and "*vizcacha*" - d) are good indicators of contacts with the highlands. Finding "*viscacha*" remains in the Preceramic layer associated with Chinchorro suggests that such contacts date back to the early period of the site's occupation, from between 7,400 and 6,600 BP (Schiappacasse and Niemeyer 1984).

As mentioned previously, the only difference between past and present mammalian species is with respect to *Cephalorhynchus* ("*tunina*"), which is not found in the area today. The *altiplano* fauna found at this site, such as *vicuña*, *guanaco*, *chinchilla*, *viscacha*, and *llama*,[24] are still found in the highlands. Their presence is due to human activity rather than to environmental changes.

Summary

A desert environment marks the Central Andean coast. This present-day hyper-aridity, however, was not prevalent during the early Holocene, when conditions were wetter. The change to drier conditions intensified during the middle Holocene (Grosjean et al. 1997; Grosjean et al. 2007; Maldonado and Villagrán 2002, 2006). Also, some studies indicate that El Niño oscillations were not as frequent or intense during the Early-

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[24] *Llama lama* is only related with the ceramic occupation.

Middle Holocene as they are today (Sandweiss et al. 1996; Sandweiss et al. 2007; Anderson et. al. 2007, Rademake et al. 2013). Numerous river valleys traverse the northern coast of Peru, which makes agricultural possible. By contrast, the northern coast of Chile is a vast, absolute desert only broken by a few intermittent river deltas. Of these, only the Loa River has permanent water today.

This chapter examined the regions biotic and abiotic features. Seasonal cycles include the blooming period of plants, the formation of *lomas* during the winter, and the migratory birds that arrive during the summer. Other cycles reflect when a resource is harvested intensely for human use, like the sea urchins, collected when their gonads are mature and ready to consume, or the river shrimps that spawn in the river delta during the summer and early to middle fall. A similar cycle is noted for the sea lion when, during the winter months, isolated young animals became easy prey for hunters. Seasonal abiotic factors include periods of calm seawaters that favor fishing and harvesting.[25] This is in contrast to river runoff that carries sediment from the highlands and darks the seawater by the river deltas in mid summer.

Harpoons, *chope* hooks, fishhooks, and project points, and possibly reed boats, were part of the tool kit used in the exploitation of land and sea resources. Such artifacts are associated with the Chinchorro and some were found in funerary contexts (e.g. Schiappacasse and Niemeyer, 1984; Standen 2003).

The point is to study whether local ecological conditions and the seasonal cycles they generated encouraged early maritime foragers to live in permanent settlements along

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[25] Ocean currents were not highlighted in this work, but they will in part regulate/favor sea travelling in certain periods of the year.

the coast of the Atacama Desert. If so, at what point and how did a favorable environment foster cultural complexity in the way the Chinchorro people developed it.

Regarding seasonality, the excavation data currently available, although still fragmentary, points to a Preceramic occupation of the Camarones 14 site. Such a settlement, however, may well have been seasonal. People lived there during the summer and winter and possibly into the spring. Data from birds, fishes, and marine mammals suggest this.

In the next chapter (Chapter 4), the main aspects of the methodology developed in this thesis for the analysis of the shells growth lines in *Concholepas concholepas* are explained. Data from isotopic analysis and *Semele* shells from Huaca Prieta is also introduced, along with the fieldwork activities at Camarones 14 and Camarones Sur and site's stratigraphy.

CHAPTER III

METHODOLOGY

This research examines early cultural complexity and its relationship to sedentism in coastal hunter-gatherer societies in northern Chile and northern Peru. To document seasonality, it analyses shell growth lines from three archaeological sites that go back to the early-middle Holocene. The sites are located on the north coast of the Atacama desert (Camarones 14 and Camarones Sur sites) and the north coast of the Peruvian desert (Huaca Prieta site). The evidence for a sedentary life style is based on the seasonality of mollusk collections at occupied sites; this evidence can verify the role sedentism played in the rise of early cultural complexity.

Following Bar-Yosef's (1998) observations on biological indicators for establishing settlement seasonality, the study's methodology takes a paleoenvironmental approach focused on site seasonality. It combines archaeology, botany, physicochemical, and parasitological analysis. These markers are employed to investigate sedentism, for this study. Sedentism means the presence of the group or part of it in the same area during the whole year. From this base, a group can explore the surrounding environment throughout the yearly seasonal cycle. This cycle is reflected in the subsistence remains of animals, plants, birds, mollusks, fishes and other living species used for food, tools, artifacts or ritual activities.

Camarones 14 was first excavated by Schiappacasse and Niemeyer (1984). For this research, the site was examined through the excavation of two (2) sectors of 1x1 square meters (m^2), and it was also the object of paleoenvironmental analysis (e.g. pollen and phytolith). Camarones Sur has been studied by Mario Rivera (1984); it was also a focus of a more recent and parallel study realized by Billings (2001)[1]. The investigation related to this site concentrates on the main core of this research, that is, the analysis of shell growth lines from the selected mollusk species *Concholepas concholepas*.

The site located on the Peruvian coast, the Huaca Prieta mound, was first studied by Junius Bird in 1944-1945 (Bird at al 1985) and it was recently re-investigated by Dillehay and collaborators (2012b). As a secondary focus, the analysis concentrated only on the study of the shell growth rings[2]. The shell collection analyzed here was generously provided by Tom Dillehay.

Central to the study is the analysis of shell growth rings. This method was used to study the shells from the three selected sites. For Camarones 14 and Camarones Sur, the gastropod *Concholepas concholepas* was chosen, while for the Huaca Prieta site the choice was the bivalve from the genus *Semele*. Oxygen isotope analysis on *Concholepas concholepas* was performed on the shells from Camarones 14 site[3].

Sedentism and seasonality are investigated and measured through the analysis of the shell growth rings. This kind of analysis can indicate the season of the year in which the mollusks were captured, giving indirect confirmation of the human presence in the area during a specific period of the year (e.g. Jones 1980; Claassen 1998; Richardson 2001). To do this, shell growth rings from the target species, *Concholepas concholepas*,

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[1] Billings (2001) topic was to verify sedentism in this site and some others in the Arica area (Quiani complex), through isotopic analyses on marine shells.

[2] The author of this thesis did not excavate this site.

[3] Although planned to be done in the future (Dillehay's personal information, 2012), isotope analyzes on the shells from Huaca Prieta is not part of this thesis.

and *Semele* sp. were studied. The principle is that patterns on the growth of the shell correspond to seasonal growth cycles.

For comparison, modern shells for each season were collected from the Camarones area and from near the Huaca Prieta site. Data on the formation of the collection and preparation of shells for *Concholepas concholepas* are presented later in this chapter. In addition to isotopic analyses on shells, other paleoenvironmental indicators, such as botanical and faunal remains are used to test and reinforce shell data. In this way we can understand the ecological framework in which coastal forager societies took shape and the implications this ecology had for their mobility patterns and cultural complexity.

The shell data collected and the methodology applied, sheds light on the rhythms of seasonality, mobility patterns, and site occupation. This enriches our understanding of cultural complexity within early maritime societies of the Pacific coast and the relationship this had to the mobility-sedentism continuum.

This chapter describes the archaeological investigations carried out at Camarones 14 and Camarones Sur. It then describes field procedures and laboratory analyses in sedimentology, paleobotany, parasitology, radiocarbon date, artifacts, and shell analysis. The Huaca Prieta site was not a primary object of excavation for this research. Consequently, the archaeological context and stratigraphic profiles are not presented here but in Chapter 4, integrated with the shell growth ring analysis.

Field Procedures

The excavation aimed at understanding mobility patterns and occupational characteristics of early coastal hunter-gatherers of the Camarones Valley. Both sites, when combined, Camarones 14 and Camarones Sur, have a time span of about 4,500 years, ~7,500 to 3,000 BP. This factor, as well as their location near the coast and in a well-defined fertile valley, indicates their potential for the studies proposed here. Prior work by Schiappacasse and Niemeyer (1984) at Camarones 14 uncovered signs of ritual and funerary practices that incorporated some of the earliest evidence of artificial mummification. Such findings suggest a complex culture, and make this site important for examining cultural complexity and hunter-gatherer mobility patterns. Below is a summary of archaeological excavations carried out at both sites during the field seasons of 2007 at Camarones 14 and 2008 at Camarones Sur.

Camarones 14 Field Season 2007

Camarones 14 sits on the north side of a terrace about 35 meters above sea level. The terrace itself is desert-like. It ends abruptly to the north, where the modern sanitaire deposit is located that receives the garbage from the nearby village of Caleta Camarones. Vegetation is concentrated in the valley below. To the south are the slopes of the Coastal Cordillera covered by sand dunes. The ocean is about 500 meters to the west. Due to the accumulation of sediments from the alluvial fans formed in nearby small canyons, the surface inclines slightly from east to west. Schiappacasse and Niemeyer (1984) observed that mudflows from the south slopes resulted in compact soils hardened by the marine salts from the air. These compact soils were also observed in the subsurface of the site.

The actual surface of the site is covered by fine sand and coarse sediment. Artifacts, mainly lithic, can be found dispersed at different points on the terrace. This suggests an intensive occupation of the area by past societies.

Schiappacasse and Niemeyer (1984) used a 50 by 50 meter grid system to prospect and mark the limits of the site. They identified two occupational units: a pre-ceramic occupation from the archaic period associated with the Chinchorro culture, and a second one related to an agro-ceramic occupation from the Formative period. The twenty-two skeletal remains from adults and children were found in the Preceramic occupation. All the children were artificially mummified while the others were naturally mummified. The base of the site is date of 7,420 ± 225 BP (Schiappacasse and Niemeyer 1984).

For the excavation, Schiappacasse and Niemeyer (1984) gridded the site area with a square set[4] of 2 X 2 meters in which 14 sectors (from A to M, and sector LL)[5] were worked (Figure 3.2). All human burials were found in its southwest portion (sectors G, M, L and LL), marking this space as a sacred one in which mummified bodies were buried, apparently under a residential unit[6] (Figure 3.1). In the opposite direction (sectors I and K), no burials were found, but they uncovered a hearth of about 1.5 meters in diameter, suggesting an area of domestic activity. Today, all these excavated areas remain open, but filled with modern trash and sand. The profiles are eroded or covered by a hard mixture of sand and salt patina.

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[4] The exception is for two sectors of 1,8 by 2 m (E and F).

[5] They also opened two pit tests (number 12 and 13) nearby the demarcated area.

[6] Although there were found signs of a hut, they were not enough to calculate its size and structure conclusive (Schiappacasse and Niemeyer, 1984: 18).

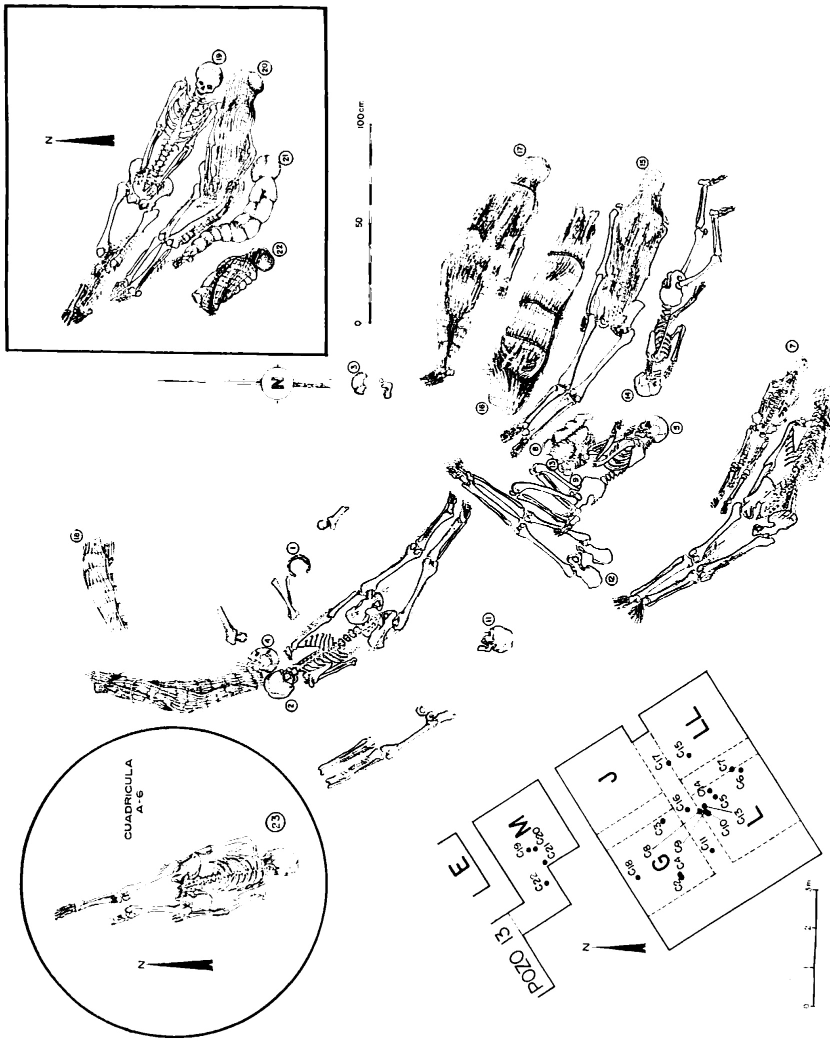

Figure 3.1: Scheme of burials distribution at the site of Camarones 14 as presented by Schiappacasse and Niemeyer (1984).

Given the objective of studying sedentism and seasonality, the primary goal here was: a) to collect stratified samples of botanical and faunal remains, mainly *Concholepas concholepas* shells; b) to collect fishing and other types of artifacts; and c) to have a more detailed site stratigraphy and chronology.

The former area worked by Schiappacasse and Niemeyer guided the author's selection of the space to be worked at the Camarones 14 site. The author's excavation program developed focused mainly on shells and other paleoecological remains, rather than on burial remains. Consequently, the target area selected was on the east portion of the site near sectors A and I, which are more related to domestic occupation. This avoided sections where burials were found, that is, on its southwest portion. An area of 8 m^2 was gridded with a square set of 1 x 1 m with 8 sectors from A to D (Figure 3.2 and Plan of the excavation in Appendix - Figure “plantilla Cam 14”).

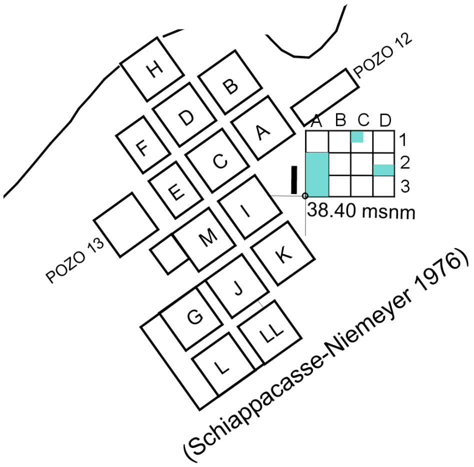

Figure 3.2: Plan of the excavation’s sectors at Camarones 14 site showing the 2007 demarcated area in relation to Schiappacasse and Niemeyer’s 1976 excavation. Schiappacasse and Niemeyer excavation area are on the left, and the area worked for this thesis is the square with letters and numbers at the right. Sectors A2 and A3 are marked in color, including pit tests (after Schiappacasse and Niemeyer 1984, adapted for this research by R. Rocha).

Two contiguous sectors of 1 x 1 m, each designated here as A2 and A3, were excavated, generating a 2 m^2 of excavated area 1.20 m deep. To give more precision to the findings, the sectors were subdivided into four sub-quadrants of 0.50 m each (SQ A, B, C and D). Coordinates were not taken for the artifacts' location, but only their relative position in the square (Figure 3.3). Four pit tests of 0.50 x 0.50 m were also tentatively opened. Three were close to the excavated sectors and one in the south portion of the site that was cut by a small local road. These pit tests were contaminated with modern trash mixed in the layers and were not studied here[7].

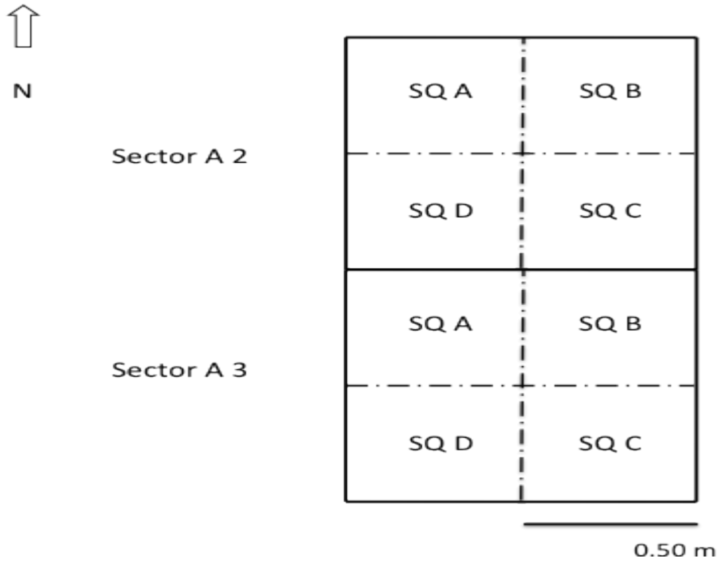

Figure 3.3: Sectors and sub-squares of the excavated area at Camarones 14

The site was excavated in natural levels intercalated by arbitrary levels of 10 cm for thicker layers. Levels that showed small variations were also divided into smaller categories and letters were added to the level numbers on their tags. Carbon samples for radiocarbon date, plus artifacts, botanical and faunal remains were collected during the excavation. Bucket samples (10 liters) for quantitative analysis, flotation, and

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[7] Around twenty years ago existed a house near the site and more recently a dump that was closed by local administration about nine years ago.

sedimentology were collected from each layer from arbitrary 0.2 X 0.2 m quadrates arranged inside both sectors. All sediments were sieved through a ¼ cm screen, but the samples for flotation and sedimentological studies were brought to the laboratory for study. At the end of the excavation, samples for pollen, phytolith, and arsenic analyses were taken directly from selected layers of the exposed profile. Dr. Bernardo Arriaza performed the last one for his studies regarding arsenic contamination in the Camarones Valley and its impact on the local Chinchorro population. All material and samples were brought to the Museo Arqueológico de San Miguel (Universidad de Tarapacá, Chile) where they were sorted and sent to different specialists for specific analyses as explained bellow.

Regarding the shell sampling strategy, shells of *Concholepas concholepas* were not the predominant species, as they were in Schiappacasse and Niemeyer's (1984) research at the site. As a result, shell fragments were also collected, but with attention to avoid double sampling by collecting different fragments of the same shell. Nevertheless, the sampling size was reduced from the planned 50 per layer to a total of 125 shells, fragmented and entire[8]. Shells of *Concholepas concholepas* were later removed from the sampling because they were deteriorated by parasites, or they broke during sample preparation. The final number of shells submitted for growth line's analysis is composed of 70 shells.

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[8] To amplify the number of shells of *Concholepas* to be analyzed, an attempt was made to examine the material from the former excavation at Camarones 14 conserved at the Museo de Santiago. However, due an internal reorganization of the collections, this was not allowed.

Camarones 14 Stratigraphy

This section describes the stratigraphic profiles of Camarones 14 as defined by Schiappacasse and Niemeyer (1984) and the profiles defined here, after the excavation had been carried out for this research. At the end of this section is described the macro strata for the site occupation as proposed here in the light of the excavation data from 2007.

Schiappacasse and Niemeyer's Macro Strata

Schiappacasse and Niemeyer (1984) recognized a total of six macro strata (Figure 3.4). They classified them from the surface to the bottom of the occupation by the letters "a" to "f". The site's early occupation (the Archaic occupation), which is related to the Chinchorro, corresponds to stratum "d" and was dated from between 7,420 ± 225 to 6,615 ± 390 (Schiappacasse and Niemeyer 1984: 26). There is no radiocarbon data available for the other strata at the Schiappacasse and Niemeyer (1984) excavation. Radiocarbon dating obtained for this thesis places strata "c" and "d" between ~ 6,000 and 7,700 BP respectively. A more detailed chronology is presented later in Chapter 5 in this thesis.

The descriptions of the strata are general for the entire area and there is not much information regarding the intermediate layers that constitute each stratum. The macro-strata are summarized below[9]:

Stratum a: sand of aeolian origin accumulated on the surface depressions of the next stratum. It corresponds to the terrain surface. Thickness: about 0 to 10 cm.

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[9] The descriptions available in their publication (Schiappacasse and Niemeyer 1984) does not detail the depth and thickness of each stratum, therefore, the information presented below was took from the sketches provided on the referred publication.

Stratum b: sand mixed with shells with plenty of remains from the agro-ceramist occupation. This macro-layer is deepening and interrupts the lower stratum. At certain points, it can reach the natural floor of the site. Some have a conic shape and can be about 75 cm thick. Also, observed in certain areas on this stratum were compact layers considered as a kind of occupational floor. Thickness: less then 10 to 50 cm.

Stratum c: sand mixed with cultural remains from the agro-ceramic occupation and the Preceramic deposit. Thickness: about 20 to 45 cm.

Stratum d: sand mixed with thin residues of plant origin, constituted by abundant leaves and shredded branches. Compact substrata or layers defined as occupational floors also occur in limited areas on this stratum. This is where the artifacts were concentrated; they are interrupted in some parts by intrusions from the superior strata. Thickness: about 10 to 35 cm.

Stratum e: a localized sterile layer with no cultural elements; formed by compact sand and shredded shells and restricted to the excavation sectors H and D[10] (Figure 3.2).

Stratum f: this is the natural layer of the site, composed of a compacted stratum of angular sand and gravel, and without archaeological material. This layer extends from 0.70 to 1.10 m.

Strata “c” and “d” are separated in certain parts by a compact saline crust that thickens in certain sectors. Pieces of this crust were found in stratum “c,” indicating a secondary deposition. Also observed were thick ash lens, some about twenty centimeters

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[10] Those are sectors from Schiappacasse and Niemeyer excavation (1984). Sector H is the north most sector open and sector D is the sector localized right behind it. They are in the opposite direction in relation to the sectors where the mummies found were concentrated, mainly in sectors G, J, L and LL in the south portion of the site (see Figure 3.2).

thick (Schiappacasse and Niemeyer, 1984). Fragmented "*morteros*" were found at the base of the site.

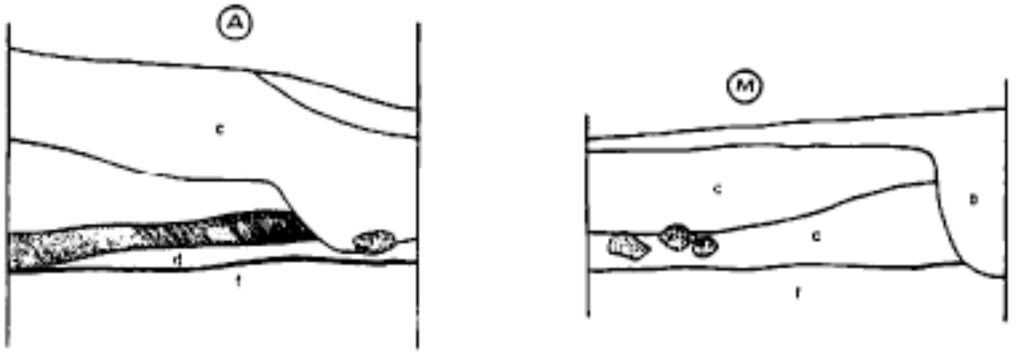

Figure 3.4: Profiles in south Section A and in section E from Schiappacasse and Niemeyer (1984).

Layers Correspondence

As previously stated, an area in the east portion of Camarones 14 was selected for the author's excavation; it was divided into two sectors, A2 and A3, of 1 x 1 m (Appendix - lámina plano 1976 cam). The excavation is close to sectors worked by Schiappacasse and Niemeyer (1984). The surface of the area has a natural inclination from east to west; this results in a difference of about 20 cm from one end to the other. Each sector was subdivided into sub-squares A, B, C, and D (Figure 3.3) of 0.50 x 0.50 cm each.

In this way, letters and numbers indicate the initial classification. On the table below (Table 3.1), these levels are under the label "Levels–dig". At the end of the excavation, 18 layers were defined and codified by numbers as represented in the East Profile (see Figure 3.6). In the above mentioned table, they are under the label "Final Layer (profile)". Another code using only letters was assigned to samples sent for laboratorial analysis, for instance, pollens, phytolith, radiocarbon data, and coprolites; these are under the label “Letter codes”. Also described in the table are the natural and archaeological contexts of the layers. The label “Macro-strata” refers to cultural divisions proposed here, based on chronology and cultural context of the respective strata.

Table 3.1: Camarones 14 excavation context correlation between Schiappacasse and Niemeyer (1984) layers and the ones defined during 2007 fieldwork.

Macro strata	SchNy[1]	Letter codes	Final Layer-profile	Sectors	Levels - dig	Soil description	Organic composition
				A3; A2	Surface	Sand grey	Shell fragments
V	a	M	1	A3; A2	1,1A; 1A	Light yellowish sand	Small shell/ fish fragments
	Fill	L	4/5	A2	1D	Brown soil and yellowish sand, stones, pieces of concretion.	Fill (“Relleno”)
	Fill	-	2	A2	1 C	Sand, stones, blocks of concretions.	Fill (“Relleno”)
	Fill	-	4	A3	1B, 1C, 1E	Sand, stones, blocks of concretions.	Fill (“Relleno”)
	Fill	-	4/5	A3;	1D	Sand, stones, blocks of concretions.	Fill (“Relleno”)
	Fill	-	5	A3	1F, 1G, 3, 3A, 3B	Sand, stones, blocks of concretions.	Plants/mollusk shells
IV – Post-Chinch.	b	K	3	A2	1B	Semi-compact brown sand	Shell fragments
	b	J	6	A2	2	Sand, light brown, friable.	Plants/fish bones/flakes
III – Transitional Terminal Chinchorro	b	I	7	A2	3, 3B	Sand, dark brown. Compacted.	Charcoal/plants/fish bones/mollusk shells/flakes
	b	H	8	A2	4, 4 dp 2	Sand, compacted, light brown/yellowish.	Small shells and fish bones /flakes. Low amount of organic material
	Mixed	-	10 A	A3	11	Sand, dark brown.	Mixed sediment. A hole open on the SE corner of the SQ B in A3
orro (~6700 – 6000 BP or	b	-	9	A2	6, Rasgo 1	Sand, reddish brown, friable.	Structure (sac); plants/ shells (mainly Choromytilus)/bipolar flake (1)

	c?	G	10	A3; A2	5, 5B, 5C; 5	Basically shells with very low sand.	Shells (Mesodesma)/projectil points, flakes, Hammerstone, Q. coco, fishhooks
	c	F	11	A3; A2	7,7B, 8, 8B, 8C; 8	Reddish brown	Plants/fish bones/shells/lithic point, flakes, scrapper, fishhooks. No Mesodesma shells.
	c	E	12	A2; A3	9, 9A 9B, 9C	Laminar - grey/ reddish brown	Plants/fish bones/crustaceous /shells/flakes
	Concretion	D	13	A3; A2	10	Bedrock	Projectile point /Almost sterile
I - Early Chinchorro (~7600 – 7000 BP)	d	-	14	A3; A2	12; 12, 12B	Sand and ashes, with charcoal, friable. Dark grey.	Shells/ crustaceous/fish bones/flakes
	d	C	15	A3; A2	13; 12C, 12C dp2, 13	Light brown and sand with silt	Plants/fish bones /crustaceous/ feathers/leather/ flakes, hammerstone
	d	B	16	A3; A2	13B, 13B	Light grey with ashes and some dark brown sediment, friable and thin sediment. Compact in some parts	Shells/ crustaceous /flakes
	d	A	17	A3; A2	13C, 14; 13C, 13D	Light brown/ashes	Plants/avian/fish bones/shells/ coprolites/projectile point, scraper, flakes/*Lagenaria* (squash)
	f	Base	18	A3; A2	15; 14	Light grey/brown; compact sand; bedrock	Sterile layer
	[1] SchNy – Schiappacasse and Niemeyer's (1984) macro strata						

The profiles from the north and east walls were cleaned, photographed, and sketched. Due to the instability of the walls, which were mixed with loose sediments and the shell layer, the south and west profiles were not sketched (Figure 3.5)[11].

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[11] The instability of the walls reduced the level of excavation that could be taken inside the sectors to clean and adjust the walls, since any strong movement to transpose the hard sediment from the excavated levels collapse the walls.

Figure 3.5: Profile of south wall in sector A3. The south and west profiles were unstable, with a risk of collapsing.

Below is the east profile of the site at the end of the excavation. The numbers refer to the final layers (profile) as described in Table 3.1. Small letters on the left, from "a" to "d," represent divisions envisioned by Schiappacasse and Niemeyer's macro strata[12]. This is based on their 1984 publication, as well as a correspondence with the occupational level divisions here presented. Roman numerals from I to V, also on the left side of the drawing, are indicative of the macro-strata that represent the different occupational contexts, as proposed in this thesis[13]. Thus, the macro-strata are composed of a combination of excavated layers. The base of the occupation, layer 18, was archaeologically sterile and was not labeled. Also, the concretion on the middle of the occupation, layer 13, was not labeled. This layer 13, although it had a few signs of

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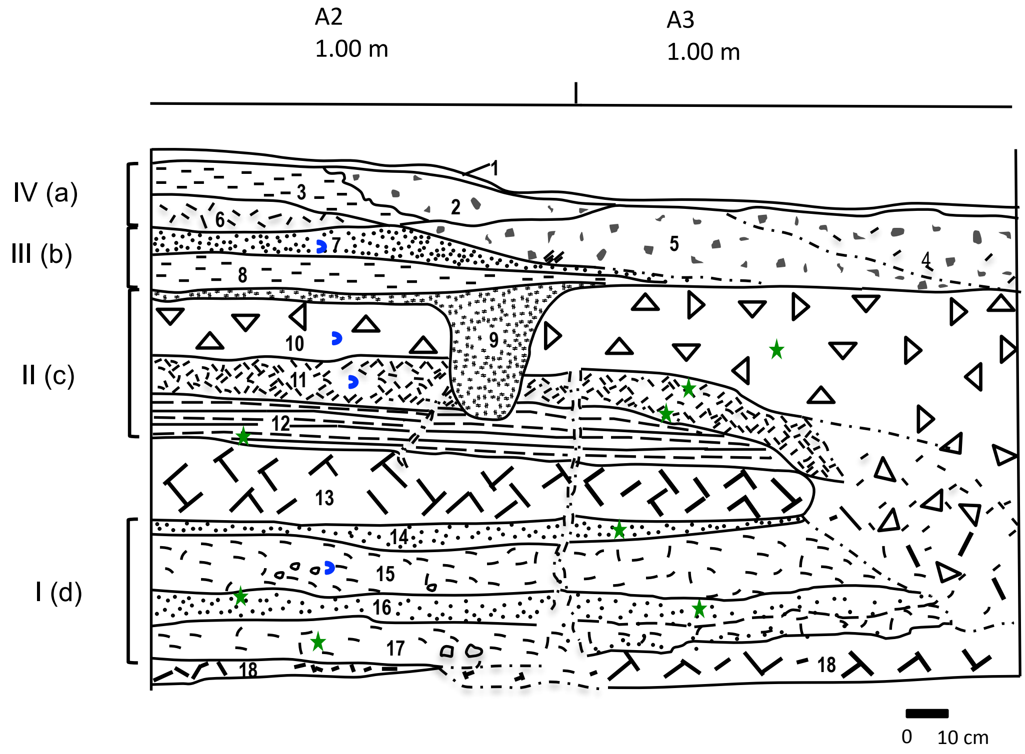
[12] The subdivisions of the strata are not described for Camarones 14 in Schiappacasse and Niemeyer (1984) publication for this site.

[13] The macro-strata are described later in this chapter.

occupation, it did not offer enough data for a direct association with any occupational layer. All macro divisions are explained after the layer description that follows the profile sketch (Figure 3.14).



Legends:

Figure 3.6: Camarones 14, east profile stratigraphy. Roman numerals refer to the macro strata proposed for this thesis. Letters from a to d are Schiappacasse and Niemeyer (1984) macro strata. Layers numbered from 1 to 18 are describe on Table 3.1.

Sand with plants, shells and small fish remains

Sand, friable, with plants, fish and shells.

◆	Small stones and small pieces of conglomerates in sand matrix	≠	Plant remains
⁘	Sand with charcoal, small plants, fish and shell fragments.	◁ ⧗	Shelly (mainly *Mesodesma*)
☰	Lens of sand intercalated with organic material	⟋	Bedrock
⊃	Fishhook	★	Radiocarbon sample

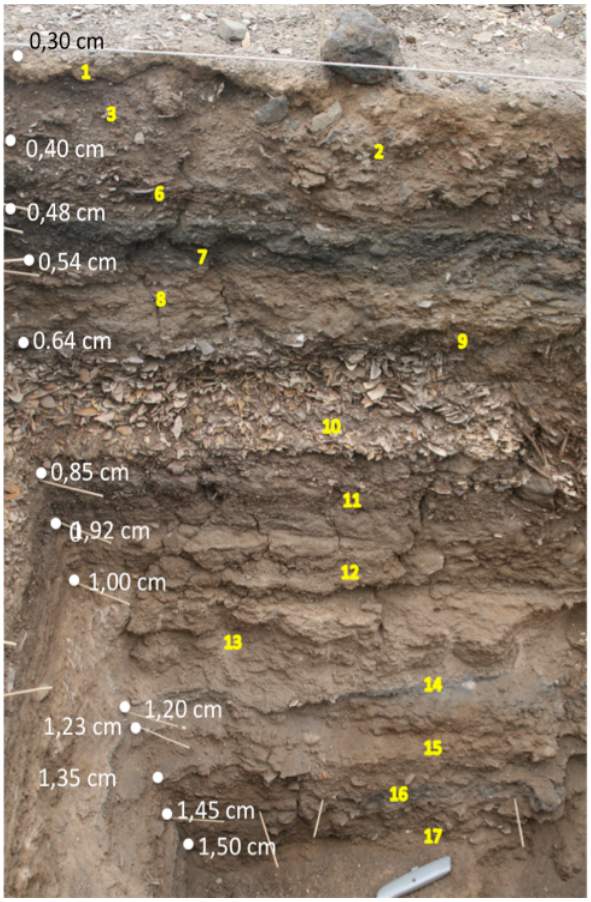


Figure 3.7: East Profile. Section of the sector A2, sub-square B: layers and depths. Layers 4 and 5 are restricted to the sector A3 and are not showing here.

Layer Descriptions

The terrace where the site is located is in a desert environment with high dunes in its south portion. Plants are concentrated down in the valley to the north. The terrace is covered by sand and coarse sediment. Certain parts of the terrace are also covered by compact sediment that originated from mudflows hardened by the marine salt. These compact soils are also found in the subsurface of the site. The surface of the site has a slight inclination from south to north, the result of an alluvial fan deposition.

For chronological sequencing, the occupational layers are described from the bottom to the surface of the site, as follow:

Layer 18: the lowest level is constituted by bedrock of very compact sediment composed of sand and gravel, which forms the natural bases of the site. On its surface, the deepest part the layer was a semicircular depression about 12 cm diameter. It was found on sector A3 (Figure 3.8) and was filled with sediment and other organic remains from the upper level. Two stones surrounded and framed the hole. It was at 120 cm from the actual surface level, on the corner of sector A2. At the intersection of sectors A2 and A3, a fissure that begins in layer 11 crosses the surface bringing sediments from the upper levels to this area. A 70 cm area of this section, in between sectors, was excavated more deeply to verify the base of the site. Material from this area was mixed with material from the upper levels. This layer is about 1.20-1.25 meters from the actual surface of the excavated area, while the intersection is about 1.40 meters deep.

Figure 3.8: Base of the excavation of Camarones 14. A hole framed by stones can be seen in the intersection of sectors A2 and A3.

Layer 17: is rich in organic material. In a friable light brown sand matrix, it contains plant remains, fish and avian bones (probably pelican), as well as shells (mainly *Choromytilus*), plus coprolites and charcoal. A lent of hearth with ashes and charcoal covers parts of the base of this layer in sector A3. At the base of this layer, five semicircular holes about 12 to 15 cm in diameter were found in sector A3 (Figure 3.9). They were filled with sediment and other organic remains including plants, fish bones, and crustacean fragments deposited in this layer. One of the depressions was opened when working on layer 18. The cultural remains had a projectile point, a scraper, and flakes of different sizes, in addition to shells with signs of manufacture. In the intersection between sectors A2 with A3, the sediment was mixed with material from the upper layers due to a crack in the sediment, as explained above for layer 18. This layer was dated to between 6,980 ± 50 BP (Lab. Number: AA85504 2) and 7,125 ± 37 BP (Lab. Number: AA99972) (uncalibrated dates), which is more recent than expected, since the layer above has an older date. Layer 17 is between 10 and 5 cm thick.

Figure 3.9: Depressions or holes in the base of layer 17 (surface of layer 18).

Layer 16: was characterized as a hearth. It contained ashes mixed with silt and sand sediment, compact in some parts of the sector, mainly in SQ B and D in sector A3, with charcoal, medium and small plant fragments, some shells (e.g. *Choromytilus chorus*), and bone remains from small fishes; also, some lithic flakes and shell artifacts. Some very thin sediment composed of ashes in SQ A (sector A3) continued in to the subsequent level 13 C. This layer was dated to 7,669 ± 54 BP (Lab. Number: AA85503 1). It is between 5 and 10 cm thick.

Layer 15: is light brown sediment of silt and sand, with fragments of medium and small fishes, crustaceans, and some shells (e.g. *Choromytilus chorus*). Cultural material included lithic flakes, hammerstone, and shell artifacts, besides shell and thorn fishhooks. It is about 15 cm thick.

Layer 14: is ashy sediment; had successive thin sheets of ashes and brown sand, with charcoal and burned shells, small fishes and crustacean remains, as well as some few botanical fragments. It also contains lithic flakes, a thorn fishhook and some shell material with signals of manufacture. This is friable sediment with light compact sections at the base. This layer was radiocarbon dated to 7,015 ± 50 BP (Lab. Number: AA85505 3). It is between 5 and 2 cm thick.

Layer 13: was a solid conglomerate of sand and gravel, similar to layer 18 found at the base of the occupation. A large stone 50 cm long and 15 cm thick was removed from the portion north (sub-square A and B) of sector A2; the layer was almost sterile archaeologically. The only artifact found was a lithic projectile point broken at both extremities. It was found inside this compact sediment in its upper portion. The layer is between 15 and 20 cm thick.

Layer 12: had a laminar structure of micro-layers. This layer is composed of friable sand deposits about 2 cm thick, mixed with organic material – plants, fish bones, small fragments of crustaceous, and shell fragments, mainly *Choromytilus choros.* These were intercalated with compacted flat soil, in a laminar deposit, suggesting a “floor” or periods of abandonment. Also uncovered were lithic flakes and a pebble with tie marks. No fishhooks were found, only a shell disk that was part of a fishhook manufacture was found. These occupational floors were cut in the east portion of sector A3, and filled with shells from layer 10. This layer was dated to 6,641 ± 49 BP (Lab. Number: AA85506 4). A thick layer, that is layer 13, already described, forms its base. It is about 10 cm thick.

Layer 11: was composed of friable reddish brown sand sediment with fish bones, tiny shell fragments, and plant remains. Lithic flakes and a projectile point were part of the cultural remains found, as well as shell fishhooks and other shell fragments with signs of manufacture. This layer was cut in sector A3 in its southeast (part of SQ C) and west portions (SQ A and D). It meets the concretion (Layer 13) that covers the area and lies below this layer. A *Zea mays* fragment associated with this feature contained coprolites radiocarbon and dated to 785 ± 35 BP (Lab. Number: AA84945)[14]. The upper section of this layer (7B) was radiocarbon dated to 6.088 ± 55 BP (Lab. Number: AA85508 6), while the deepest section (8C) was dated to 6,522 ± 54 BP (Lab. Number: AA85507 5). The thickness is between 5 and 10 cm.

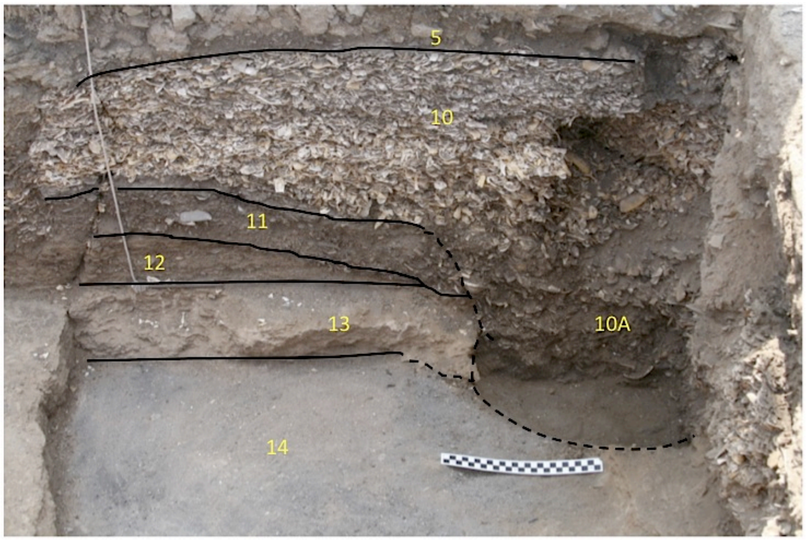


Figure 3.10. A portion of the east profile showing layers 5, 10, 11, 12, 13, 14, and layer 10 A characterized by a hole or cut that reaches the base of the site.

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[14] Material sent to date by T. Franco and M.A.Rivera

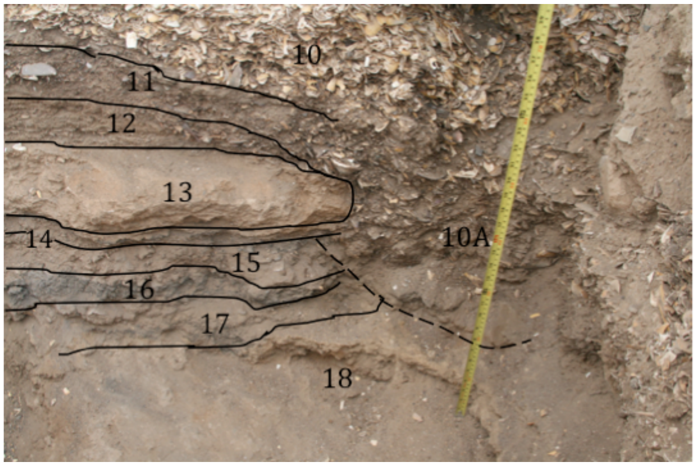

Figure 3.11: The base of the site, showing the terminal portion of layer 10 A, characterized as a cut that initiates in layer 10.

Layer 10: had a predominance of *Mesodesma donacium* (Lamarck, 1818) shells in its composition with very low amounts of sand (Figure 3.10). This layer also contained fragments of *Choromytilus chorus* (Molina, 1782), *Chiton* sp., and plant remains as well as a long Ottaridae bone (marine mammal). Also recovered were string of textiles fragments, shell fishhooks, and other pieces of shells with signs of manufacture, as well as hammerstones, lithic projectile points, scrapers, and flakes. It is about 20 cm thick.

This layer suggests a different use of the space in which shells have been accumulated in certain areas of the site. This conclusion is reinforced by Schiappacasse and Niemeyer (1984), who noted that *Mesodesma donacium* shells were concentrated in two or three deposits[15]. In fact, this species was not the dominant one among shell

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[15] The authors do not offer more information regarding the concentration of *Mesodesma* its context in the site and disposition of the site stratum (see page 81 in Schiappacasse and Niemeyer 1984).

fragments[16] found at the site during its excavation. *Mesodesma donacium* and the components of layer 10 are mixed with the subsequent layer, a thin sheet of vegetation (layer 9) in a sack shape that vertically crosses the shell layer (see figure 3.12).

Layer 10A: was created by a cut in the base of layer 11 that reaches down to the bottom of layer 18 (Figure 3.11). It was filled with dark brown color sand mixed with plants, fish bones, and shell remains from layer 10. It had a concave base and compact walls that could be close to or associated with a funerary area, although no human bones were found (Figure 3.10 and 3.11). It is about 50 cm deep.

Layer 9: is a thin stratum with sack shape features that cut layers 10, 11 and the surface of layer 12. It had botanical fragments, mainly straws, concentrated inside the structure itself. The base of this feature is mixed with material from layer 10. Layer 9, was cut in its south portion (sub-square C in sector A3) by the disturbance of layers 5 and 4. Almost no artifacts were found in layer 9; only a single bipolar flake, and few small flakes from bucket samples. Apparently, it was used to cover the shelly layer of *Mesodesma* shells right bellow it. It is about 2 cm thick, reaching around 30 cm deep in the feature associated with this layer (Figure 3.12).

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[16] Unlikely, *Concholepas concholepas* and *Perumytilus purpuratus* were reported by the authors as the main species present on the site.

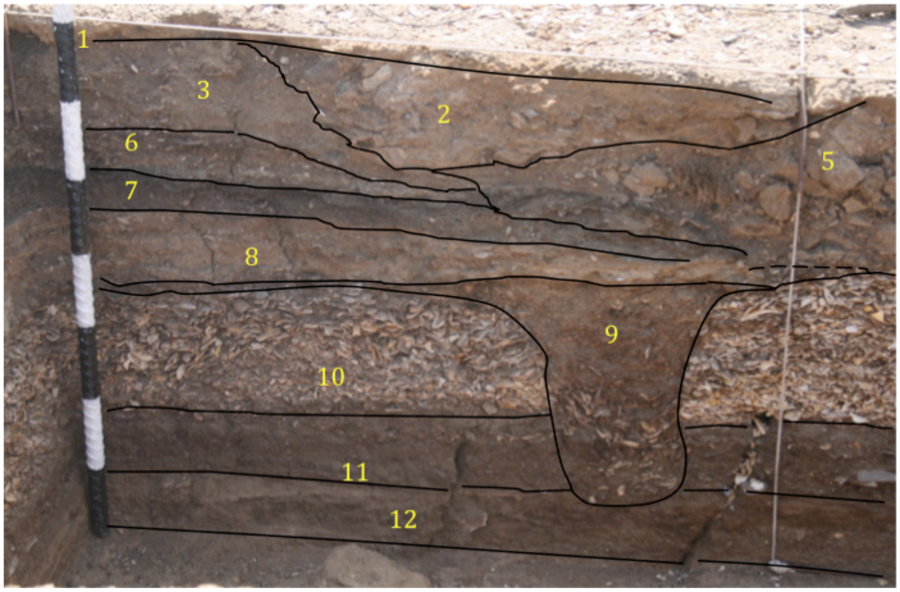

Figure 3.12: East profile, Camarones 14: upper section of sector A2, showing a sack-shaped hole in layer 9, cuting layer 10. Also, two fissures were cutting layers 11 and 12.

Layer 8: had light brown sand, compacted and mixed with small shell fragments. This layer was removed in parts of the sectors in A2 and A3, areas filled with mixed sediment. Small flakes were found in this layer. The thickness is about 10 cm.

Layer 7: composed of compacted sand with burned, dark brown to gray soil, mixed with charcoal; there were small plant fragments, fish bones, and mollusk fragments[17]. A shell fishhook and some flakes were also found in this layer. Parts of sectors A2 and A3 were filled by mixed sediment. It is about to 5 to 10 cm thick.

Layer 6: had loose, light brown sand, along with by plant remains and small fish bone fragments, plus some shells. Lithic flakes and a core were found in this layer. This layer, disturbed by layer 2, is restricted to sector A2 sub-square B. It is about 5 to 10 cm thick.

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[17] Some materials from level 3A in sector A3 were kept apart from analyzes because this section was very disturbed with mixed sediment.

Layer 5: was an altered layer partially covered by secondary deposits from layers 2, 4 and 1 that develops in sector A3. It is filled with soil mixed with large pieces of broken conglomerate, stones, and sand. It cut parts of layers 7, 8 and 9. It has botanical and fish remains, shells, and lithic flakes. This layer is between 5 and 20 cm thick.

Layer 4: was similar to layer 5. Restricted to sector A3, it had secondary deposits filled with mixed soil composed of sand, small stones, and pieces of conglomerate. It has plants, fishes and shell fragments, lithic flakes, and a curved thorn fragment that resembles a fishhook. This layer is between 5 and 20 cm thick.

Layer 3: was composed of semi-compact sand mixed with charcoal, plant fragments, fish bones and shell remains. Layer 3 is restricted to sub-square B of sector A2[18]. The thickness is approximately 10 cm.

Layer 2: had secondary deposits similar to layers 5 and 4, concentrated in sector A2. It was filled with sand, blocks of conglomerate soil, stones, some fish and botanical remains, including fragments of *Zea mays*. It is between 5 and 15 cm thick.

Layer 1: was composed of friable sand with small gravels, shell fragments, and small fish bones. It is about 1 to 2 cm thick.

Of the two sectors worked here, sectors A2 and A3, the first was a better preserved layer with less interruptions and mixed layers as was found in sector A3. However, in both sectors, the top layers corresponding to post-Chinchorro occupation were partially removed and samples were restricted to small sections of the excavation, as was the case for layers 3, 6 and 7, and possibly, layers 8 and 9. All these layers were restricted to Sector A2. These layers were apparently removed in recent times possibly

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[18] In the rest of the excavated area, this layer was removed and only fractions of it was registered as layers 3A and 3B in portions of the sector A3. They were combined in layer 5 (sub-square A and D, respectively).

due to looting or other activity, as explained later in this sequence. Consequently, these layers should be interpreted with caution, since samples were limited to a smaller area of the site.

Although the excavation was done in a small area of 2 X 1 m some of the layers suffered post-depositional alteration due to anthropogenic activities or natural phenomena. Below is a description of the disturbances observed in the excavated area.

Two fissures with possible natural origin are visible on the east profile (e.g. Figure 3.12). These cracks could be the result of an earthquake, since Niemeyer and collaborators found evidence of tectonic movement at the area prior to 7,000 BP (in Schiappacasse and Niemeyer 1984: 21). The fissures begin in layer 11. One disappears at layer 13 in a compact sediment matrix, while the other crosses this very hard layer (Figure 3.10) and runs to the base of the site mixing materials from the upper levels inside the fissure. This crack develops in the middle of the dig area, splitting both excavated sectors, A2 and A3. The fact that it cuts layer 13, a layer worked during the excavation with chisel and hammer, suggests its tectonic origins.

Among the disturbances of anthropogenic origin was a depression registered on the south portion of layers 1 D, 1 E, 1 F and 1 G, in sector A3 (sub-squares C and D) (see Figure 3.2). This disturbance cut through layer 3 and its subdivisions (3A and 3B)[19], reaching the first level of layer 5 (shell layer of *Mesodesma donacium*). Measuring about 80 cm in length and 30 to 20 cm in height, this channel shaped cut was filled with mixed sediment.

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[19] For sub-squares within the excavated area see Figure 3.2

A sack-shaped feature similar to the one described for layer 9 for the east profile was also noted; it began at the base of layer 8 and cut layer 10, the one with *Mesodesma donacium* shells. This feature is graphically represented in the north profile (Figure 3).

In the division between both sectors and cutting layer 10 is an intrusive accumulation of coprolites, probably human, together with pieces of concretion and maize remains found close to this feature. This area formed a depression with secondary deposits of mixed material that started in level 1C. Maize remains were collected from different levels but were later related to this mixed zone. Materials from these areas are mixed with different levels and could not be analyzed. Levels with mixed sediment or fill levels include 1, 1A, 1D, 1C, 1B, 1E, 1F, 1G, 3, 3A, and 3B, as well as level 11. These disturbances related to the mixed layers are difficult to categorize. They could be the result of human occupation during the post-Chinchorro period, the result of more recent looting, or consequence of the activities of the local municipality to transform the area. On the east side, close to the site, was a sanitary deposit recently removed and covered by the municipality. Also, in the 1970s, there was a house close to the site on its west side (Figure 3.13).

Figure 3.13: The person in the photo is standing in the area where a former house was close to Camarones 14 site.

The Macro Strata and Chronology Sequence

This author defined four main strata for the Camarones 14 site in a chronological sequence for the Chinchorro and post-Chinchorro occupations. These are: early Chinchorro (~7,700 to 6,700 BP), middle Chinchorro (~6,700 to 4,000[20] BP), transitional Chinchorro (~4,000 to 3,500 BP) and post-Chinchorro (after 3,500). These are shown in the north profile bellow (Figure 3.14). This sequence partially follows Schiappacasse and Niemeyer's strata division, mainly regarding strata "d" and "c". Stratum "b", however, was sub-divided into three different strata here[21]. The upper layers show post depositional

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[20] Although there are no radiocarbon date marking the upper limit for this period of the site occupation in Camarones 14, some changes in Chinchorro cultural practices are observed in other sites for the period between 4,500 to 4,000 BP; good graves became more common in Chinchorro burials in other sites, as well as head deformation (Arriaza et al. 2008). Also, Red mummies, another change in Chinchorro cultural practices, date between 4,500 to 4,090 BP (Arriaza 1995)

[21] The east profile (Figure 3.6) has the layer descriptions, as well as the strata correspondence between Schiappacasse and Niemeyer divisions and the ones presented here.

alterations with mixing sediments including stones and blocks of compact sediment broken to trespass the layers. These alterations were concentrated in the left portion of the profile that corresponds to SQ-A and advanced to layer 12. The deepest layers in this part of the excavation were preserved by the thickness of layer 13 underneath.

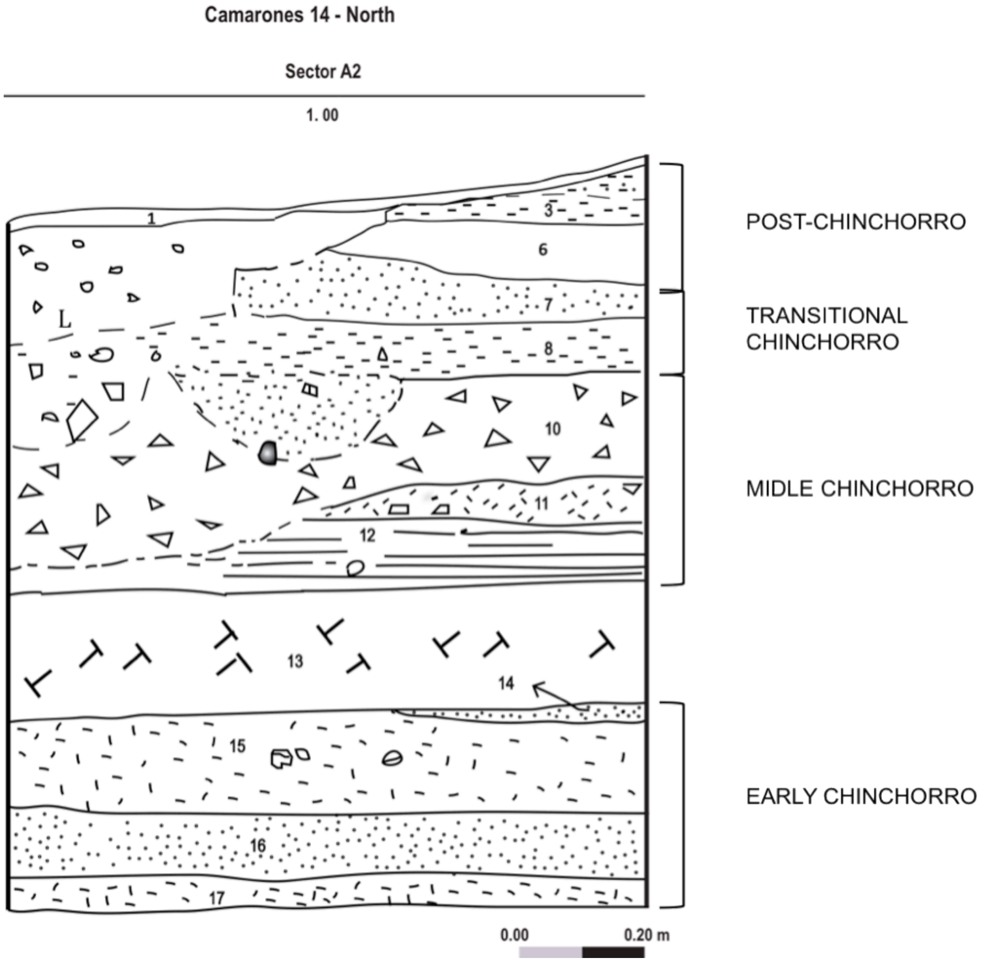

Figure 3.14: North profile showing upper layers disruptions in the southwest portion that cut various layers. Layer 8 has a characteristic feature in the shape of a sac that crosses layer 10. The down portion of the profile shows the subsequent layers with no visible disruption. A large stone (~40 x 45 cm and ~10 cm thick) was removed from the southwest corner (sub-square A) possible connected to layer 14 that is restricted to the northeast section of the profile.

Below the surface layer of fine sand with recent material, four macro-strata were defined; from these, three correspond to Chinchorro periods at the Camarones 14 site. They were defined based on position, chronological sequence, and fishhooks occurrence. The main strata are described chronologically, as follow:

The Early Chinchorro Period (~7,700 to 6,700 BP)

It is represented by stratum I (layers 14 to 17) dated to between 7,015+-50 and 7,669+-54 BP. Its layers show the use of shells and thorn fishhooks, plus the exploitation of plants and faunal resources. Projectile points, scrapers, flakes, and hammerstones were part of the local toolkit. Layer 14 had sediment associated with hearths and successive thin layers of ashes and sand. *Lagenaria* (squash) appeared in the site at this time. Overall, the remains suggest a fish-gathering and hunting culture that exploited coastal and inland resources during a cooler and more humid period.

The layer 13 represents a period of site abandonment between the Early and Middle Chinchorro strata. As already described, it is composed of thick, compact sediment practically sterile in an archaeological sense. It has a time span of about 400 years and it is chronologically situated between ~7,000 and ~6,600 BP. It corresponds to stratum d in Schiappacasse and Niemeyer's (1984) division.

The Middle Chinchorro Period (~6,700 to 4,000 BP)

It is represented by stratum II (layers 12, 11, 10 and 9) dated back to between 6,600 BP and 6,000 BP, and maybe later. There is no available radiocarbon date marking Middle Chinchorro upper limit. Its initial section is characterized by successive thin layers[22] of hard and very compact sediment within which are thin occupational layers of friable sediment mixed with plants, fish bones, shells, shrimp and crab fragments, all in a laminar disposition. Artifacts are similar to the ones from the previous strata, except for the absence of thorn fishhooks. The presence of freshwater shrimp (*Cryphiops caementarius*) remains in considerable quantity indicates summer and maybe early fall activity, which is the time when shrimp congregate close to the river delta for reproduction. This is the period, in modern days, when people come to capture shrimps using small hand nets. This stratum is marked, in its upper portion, by layer 10 and/or layer 9, already described, composed of *Mesodesma donacium* shells (layer 10) and by a thin sheet (layer 9) of plant remains. In Schiappacasse and Niemeyer's (1984) divisions, this stratum corresponds in part to stratum "c", with the exception of layers 9 and 10, which are stratum "b" in their classification.

The Transitional Chinchorro Period (~4,000 to 3,500 BP)

It is represented by Stratum III (layers 8 and 7). Although these layers have shell fishhooks, their manufacture is poor, if compared with the oldest artifacts of this type found in the deepest layers of the site[23]. Stratum III corresponds in part to stratum "b" in Schiappacasse and Niemeyer 's (1984) division.

The Post-Chinchorro Period (after 3,500 BP)

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[22] Although these compact sub-layers may represent periods of abandonment, this is not clear, and instead, they could be occupational layers. In this regard, a refined excavation is recommended to better understand this superposition.

[23] However, this is just a speculation, since it was not possible to study the artifacts from the anterior excavation (Shiappacasse and Niemeyer 1984), and there is no detailed information available on their publication regarding their temporal context in relation to each other.

It is represented by stratum IV (layers 6 and 3). Following Schiappacasse and Niemeyer's classification, this is a period of ceramic agriculturalists, although no pottery was found during the present excavation. Also, there are no fishhooks in this stratum. It partially corresponds to stratum "b" in Schiappacasse and Niemeyer's (1984) division.

As a final observation, the fishhooks were distributed as following: stratum III with 1 piece; stratum II with 11 pieces, and stratum I with 3 pieces; from these, two were made of cactus spine and found in layers 14 and 15 (stratum I). Fishhooks are discussed in more detail in Chapter 4.

Camarones Sur

This site has several different names in the literature. The designation here is "Camarones Sur", which follows one of the first published monographs. The term indicated a shell mound located in the sector Camarones-Sur. Names for the Camarones Sur site, include Camarones Conchal Sur with the following variations: Conchal-Sur (CAM-S) or Camarones Sur (Rivera, 2002; Rivera and Aufderheide, 1998), CAM-S (Rivera and Aufderheide, 1998), and Camarones (Rivera, 1984), Camarones West or Camarones (Billings, 2001). To complement data on seasonality for maritime foragers, work at this site focused on sampling shells from *C. concholepas* from the different stratigraphic layers.

As described in Chapter 1, previous archaeological excavations at Camarones Sur exposed a stratigraphic profile about 5 m deep with abundant shells. Rivera (1984, 2002) identified three cultural units: I) a more recent one, with ceramic dates to ~3,000 BP (1,050 ± 110 a. C) in the top meter of the deposit; II) a transitional unit with ceramics and other elements from the later Chinchorro context; III) a Preceramic unit about 5 meters deep dated to 5,640 ± 160 BP, (Rivera 1984; 2002).

As mention above, the work at Camarones Sur was to sample shells of *C. concholepas.* Hence, the approach taken was to collect shells from the profile, complemented with samples recovered during Rivera's 2008 excavation at the site.

Although the sampling strategy was to collect about 50 shells of *C. concholepas* from each layer, this was not possible. The totality of shells retrieved from this site was just 160. Shells from some layers, mainly the deepest ones, were very fragile; they were disintegrating due to the weathering process and the pressure of the soil matrix above them. This problem was also reported by Billings (2001), who wanted to use shells from this site for demographic analysis, as her samples were collected from columns open in the exposed profiles. The collection strategy here was not been limited to a small profile column. Instead, it focused on the whole area of the exposed profile. This was done to allow the recollection of more shells.

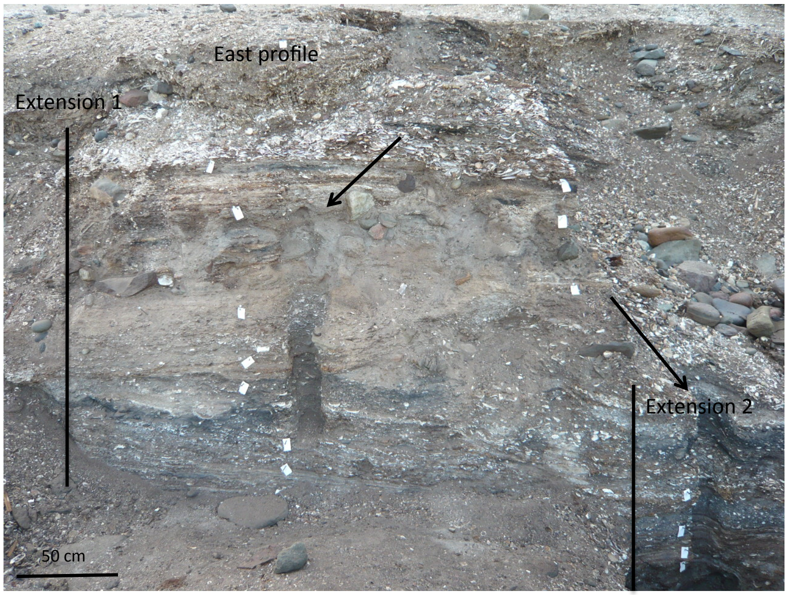

Figure 3.15: Profile of Camarones Sur site showing Extension 1, east Profile, and Extension 2. Arrows point to columns worked by Billings (2001). See figures 3.18 and 3.19 for layer divisions.

With this design in mind, the former area excavated by Rivera was selected for sampling for *C. concholepas*. Its exposed profile allowed collecting shells directly from it. Note that all pits and sectors described below were from the 1979 Rivera excavation. The area sampled concentrated on the east profile of Camarones Sur. This was selected because it is the most exposed and ample area of the profiles left opened from the Rivera excavation. For purposes of this research, this profile, called here the “East Profile”, was divided into three areas from north to south: Extension 1, East Profile, and Extension 2 (Figure 3.15). Extension 1 is a section cut into the edge of the East Profile (on its north or left portion); it forms a small platform not excavated at its deepest levels. The East Profile corresponds to the central portion, which was already partially collapsed on its left portion. The main section is 2.45 m deep where it reaches the base of the excavated area, called here a “platform”. Extension 2 is a pit already opened in the south portion of the former excavated area. It exposed some of the deepest layers of the site not reached in the main section of the profile. An extension of the East Profile, but below the platform level, it extends 0.80 m along its base. The maximum depth from the surface down to the exposed area is about 3.20 m.

In the first stage of work, the profile was divided into nine layers identified and marked by differences in color and composition. A central area close to Billings' stratigraphic column was chosen as a reference's guide (Figure 3.16). Another reference point was the enclosed area of Extension 2, which is the lower level on the left of the East Profile. As previously mentioned nine layers were initially defined on the East profile (Figure 3.16) and four on the lower section of Extension 2. However, no materials, shells of *C. concholepas*, or artifacts were collected from Extension 2[24].

For the second stage of work, shells were collected along a trench excavated by Rivera (about 3.20 X 0.80 m) close to the East Profile. With the excavation and exposure of the deepest layers, the final composition of the profile consisted of thirteen layers and one sub-layer (layer 8A on the Extension 2), plus the base of the site (Figure 3.17 and 3.18). As observed above, in some of the deepest layers, shells are fragile and difficult to remove. They formed lines of delicate weathered material compacted by the weight of overlapping layers. During the excavation, shells of different mollusk species (e.g. *Choromytilus chorus*, and *Fisurella spp.*) were found as well as fish bones, marine mammalian bones, botanical remains, lithic points, grinding stones, weights for nets, textiles fragments, and parts of a human burial. For this research, only *C. concholepas*

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[24] Although during the work at Camarones Sur, only shells of the gastropod *Concholepas concholepas* was collected, some artifacts that ocasionally appeared during the cleaning were also collected.

was collected during this time. The shells analyzed here came from the trench along the extension of the West profile. The base of the excavation in this area was about 3,15-3,20 m deep were two grinding stones were found (Figure 3.21).

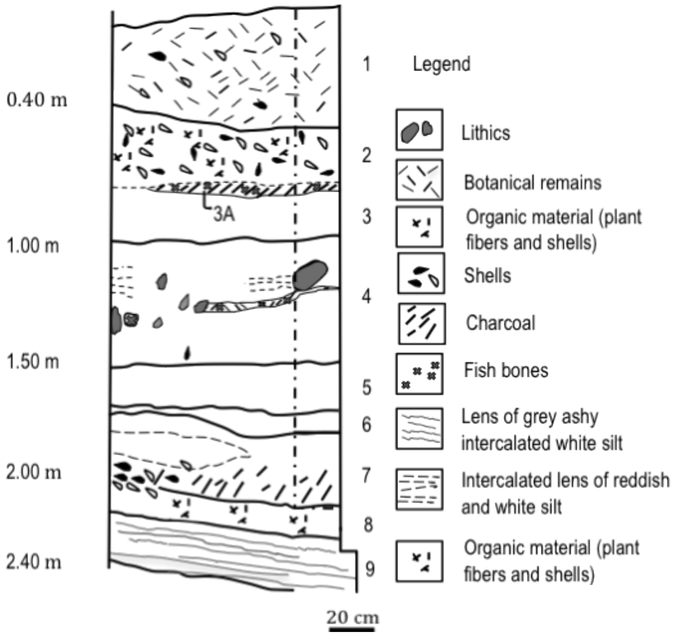

Figure 3.16: Schematic representation of an area of the East profile before Rivera's 2008 field work season. Dotted area marks Billing's column (2001).

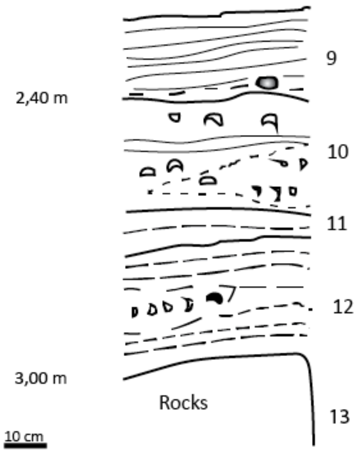

Figure 3.17: Schematic representation of an area of the East profile showing the deepest layers (from layer 9 to layer 13) after Rivera's 2008 fieldwork season.

Camarones Sur Stratigraphy

Camarones Sur has a complex matrix of sediments with many sub-layers and cultural components that include thin layers of ashes, shells, botanical remains and some other organic elements. Shells were collected from the exposed profile and later on, from the subsurface layers opened during Mario Rivera's excavation of the site in 2008. That excavation corresponds to layers 10 to 13. The division of the profile into macro-units was done to contextualize the shells sampled with respect to each layer. The division in macro-units was necessary to increase the sampling area and, consequently, the number of shells collected. For this reason, there are no sub-layer divisions[25]. The layers were defined as followed:

Figure 3.18: The stratigraphy of the East profile from Camarones Sur

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[25] To work with sub-layers, it was necessary to excavate an ample area of the site, from the surface to the bottom, in order to better define the sub-layers and to increase the chances to obtain the necessary number of shells from each sub-layer. This author did not have the authorization to excavate this site.

Layer 1 is mainly composed of botanical remains, natural fibers like "totora" reed, along with strings, marine shells, including *Concholepas concholepas*, fish bones, some marine mammalian bones, sea urchin fragments, medium and small pebbles, as well as corn cob remains, ceramic fragments, and a lithic point fragment. This layer was about 35 cm thick.

Layer 2 had concentration of shells, mainly *Choromytilus chorus,* mixed in brown sediment with small pebbles and sea urchin fragments. Some other shells observed in this stratum included *Concholepas concholepas* and shell from the genus *Fissurela*. A single stonefish weight was found associated with this layer. Maiz and ceramics were also found in this layer (Rivera's personal information 2008). This layer is about 20 to 50 cm thick (Figure 3.22).

Layer 3 is compacted with a light brown color mixed with grey and white lines produced by hearths and calcined soil with fish bones; a thin layer of shells was found plus a stonefish weight fragment (Figure 3.23). Small light brown lines of organic material crossed the layer. This layer is about 30-35 cm thick.

Layer 4 has an upper section continuous with the compact zone of fireplaces with calcined sediment and organic material from layer 3 and lines of crushed shells. A large fragment of a grinding stone (about 30 cm long) is visible and immersed in this layer. Pebbles and cobbles are dispersed, mainly in its south portion. Below this zone is a fine, light brown sediment with a sparse layer of shells. Layer 4 is about 50 cm thick.

Layer 5 is about 25 cm thick with shells in a brown sediment matrix. There was gravel, as well as some faunal remains, including marine mammals. No artifacts were found.

Layer 6 is formed by a light brown matrix of sand and brown color lines of organic material; it is between 5 and 12 cm thick. No artifacts were unearthed.

Layer 7 is of calcined dark and grey soil with ashes, lenses, and charcoal mixed with fragmented shells and faunal bones. A hearth structure about 10 cm thick was visible in the profile with incrustations of shells. Layer thickness is about 25 cm.

Layer 8 is a thick layer (10 to 15 cm) of decomposed organic material (botanical?) intercalated with small shell decaying fragments. Lines of fragile shells are visible; the shells from this layer and subsequent ones are disintegrating making it difficult to collect them from the profile.

Layer 8A has a gray layer of charcoal and ash with small shell and bone fragments. It is about 10 cm tick. This layer is observed in the southern part of the profile at Extension 2.

Layer 9 has grey/white lines of calcined sediment with ashes and crushed shells mixed with botanical material; white spots, possibly decayed shells, as well as pebbles and cobbles stones also occur. This layer is 10 to 15 cm thick and tends to disappear before it reaches Extension 2, where layer 8A develops.

Layer 10 is composed of organic material that includes botanical remains such as branches and fibers, crushed shells, and possibly animal manure. The layers are mixed with sandy clay sediment that creates dark red color lines interposed by white lines that becomes more intense in the next layer. It is about 20-25 cm thick.

Layer 11 is a laminar layer about 8 to 12 cm thick, with white lenses interspersed with sand-clay sediment that forms dark red color lenses. A smooth textured lens of brown organic material (botanical) in decomposition was visible in the profile, as well as a fragment of string.

Layer 12 was compacted layer of calcined sediment formed by ashes and shells, mixed with pebbles and cobbles that frame the layer in its south portion before it reaches the

Extension 2 area. It is about 20 cm thick. Fish bones and lithic artifacts were found, including a bifacial projectile point in a foliaceous shape (Figure 3.20).

Layer 13 had pieces of big stones, cobble, and pebble stones, including two grinding stones; one of them was close to a stone structure in the south portion of the profile (Figure 3.21). The layer also had crushed shells and other organic remains; it is cut by fire zones from the upper layer with calcined sediment. It is about 20 cm thick.

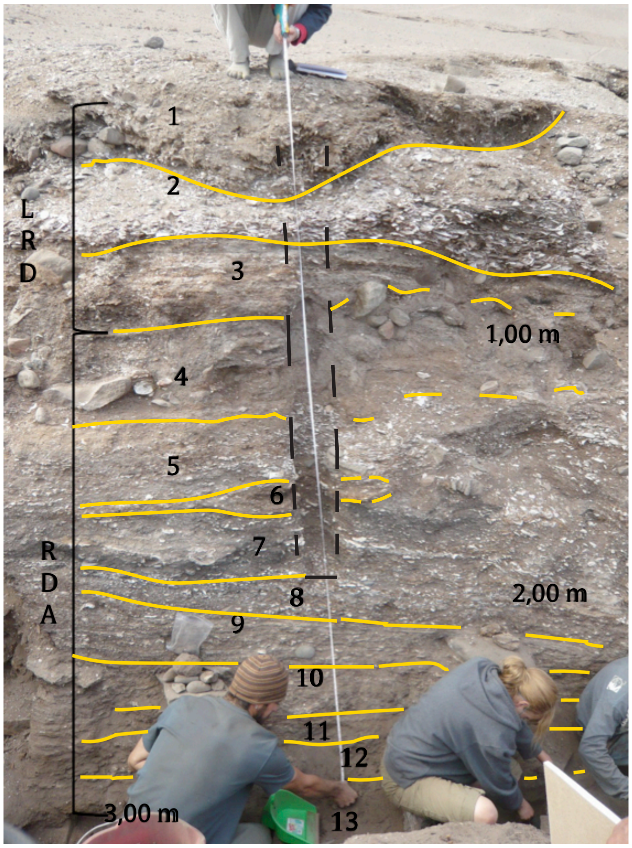

Figure 3.19: The East profile from Camarones Sur. The dashed line in the center of the figure marks Billings' stratigraphic column.

Notes: LRD - Late Regional Development; RDA – Regional Development Alto Ramirez. The Contact zone, Terminal Chinchorro/RDA, embraces layers 8, 9, and 10. Terminal Chinchorro the layers 11, 12 and 13.

As already described, Rivera (1984) identified a ceramic and a Preceramic occupation (Figure 3.19). Besides the ceramics, a weaving loom (mono and polychromatic techniques) is also characteristic of the first occupation. As to food, cultigens like maize (*Zea maiz*), potatoes (*Solanum tuberosum*) and squash (*Cucurbita sp.*)-"*calabaza*") were found, as well as fish, mainly Scianidae. This occupation is represented in the profile by layers 1 to 4 in its upper section around 1 meter deep. By inference from Rivera's publications (1984; 2002) this initial layer is linked with Unit I, and is culturally related to what he called "Late Regional Development" (LRD).

Unit II refers to the layers corresponding to Regional Development Alto Ramirez (RDA) that extends approximately from layers 5 to 10. The radiocarbon date of 3,060 ± 290 BP (RL-2055–standard uncorrected) (Rivera personal communication, 2010) was tentatively assigned, by inference, to layers 8, 9 and 10 that embrace a contact zone between the Alto Ramirez culture and the Terminal Chinchorro.

The Unit III, a Preceramic occupation, is mainly characterized by the presence of grinding stones and by conical stone mortars used for crushing and grinding activities. Layers 11 to 13 correspond tentatively to the Terminal Chinchorro, while Middle Chinchorro would be at the low section of the profile, which is at the base of the excavation that was barely touched (Figure 3.21).

Figure 3.20: Bifacial artifact from Camarones Sur (layer 12)

Figure 3.21: Stone structure with a gridding stone at the base of the excavation (layer 13)

Figure 3.22: Stone fish weight from Camarones Sur (Layer 2)

Figure 3.23: Stone fish weight fragment from Camarones Sur (Layer 3)

Camarones Sur represents a late period in the occupation of the Camarones river delta valley. It covers a chronological transition period from about 3,000 BP to 600 BP between the Alto Ramirez and the Terminal Chinchorro. Layers 11, 12 and 13 are tentatively related with the Terminal Chinchorro; for purposes of analysis, it is studied here as a separate occupation.

The initial occupation of the Camarones delta is represented by the initial strata of Camarones 14, followed by a transitional and then a post-Chinchorro period, represented at Camarones Sur by the Regional Development period of Alto Ramirez. Both sites together cover a long period of occupation from about 7,000 BP to 600 BP. Such a time spam provides the kind of sequence necessary to study seasonality at the site.

Laboratorial Analyses

Samples were collected from the stratigraphic profile of the Camarones 14 sites. Besides shells of *Concholepas conchoepas*, other samples collected included sediment for sedimentology, pollens, and phytoliths, as well as macro-botanical and coprolite remains. Sedimentology and coprolite studies are discussed in Chapter 5. This section introduces the paleobotanical analysis. Material culture is represented by shells and lithic artifacts, as well as by the oxygen isotope analysis in the shells of *Concholepas concholepas*. The main part of this section, however, covers the preparation of the shells of *Concholepas conholepas* for the growth ring analysis, and has the studies performed on the shells of *Semele* sp.

Paleobotany

The research sites lie on the dry coast of the Atacama Desert where botanical remains are typically well-preserved. Such material was incorporated into the research to provide paleoenvironmental data, to unravel the presence of domesticated plants and to identify for economic changes. If domesticated plants entered their diet, then sedentism would be a possibility. The botanical analysis embraces both macro and micro remains. It is based on flotation samples and the selective collection during the excavation. Sediment for pollen and phytolith analyses was collected from the profile at the end of the excavation.

Those materials were studied in macro- and micro-scales by different specialists. The macro-botanical remains consisted of leaves, flowers, seeds, and woody parts analyzed by Garcia B., a local research affiliate at the Museo de San Miguel de Azapa (MASMA). Flotation samples for macro-botanical studies were collected from both sectors (A2 e A3) and from quadrates of 0.20 x 0.20 m during the excavation procedures and almost all levels were sampled. Samples sizes varied, according to each layer's thickness. To avoid contamination, a flotation machine of small dimensions was constructed specifically for this research[26]. It consisted of a small bucket adapted with a hose and screen to retain heavy and light fractions; these are separated from sediments by water in different fractions following the standard procedures for this operation. The author started work with the machine flotation, a job continued by Magdalena Garcia, who also performed the analysis on the macro-botanical remains (see Appendix E for the report).

Sediment samples for pollen and the phytolith/starch analyses were taken from the exposed profile at selected layers of the Camarones 14 sites. Although some samples were collected from Camarones Sur, these were not analyzed due to various restrictions. Thus, the analysis concentrated on Camarones 14. First, the profile was cleaned, scraping selected areas to avoid contamination by modern material. Samples were taken using a trowel, cleaned with alcohol after removing each sample. Sediments were placed in separate plastic bags with individual tags. This material was later sent for analysis to different institutions. Samples for phytoliths and starch grains were processed and studied by José Iriarte, from the Laboratory of Archaeobotany and Paleoecology, Department of

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[26] Initially, flotation was done using the flotation apparatus from the Museo de San Miguel de Azapa. This equipment, however, was been used in another project at the time.

Archaeology, Universidad of Exeter (England). They were collected from layers B, C and F (levels 13 B, 13/12, 9, respectively). A lithic flake from level 9c (E) was also sent for analysis (see Appendix G for the report). Linda Scott Cummings and Melissa K. Logan analyzed pollen samples with the assistance of R. A. Varney, from the PaleoResearch Institute. Samples sent were from layers A, C and F (levels, 13c/14, 13/12c and 9) (see Appendix F for the report).

Results of these analyses are presented and discussed in Chapter 4. Such material generated information not only about the cultural and economic aspect of the plants utilized by local hunter-gatherers, but also about the paleoecology and the paleoclimate of the region. This has helped to reconstruct the coastal paeloenvironment for the north Atacama Desert, which is not well known, compared to the altiplano where climate research has been concentrated. It was also expected to acquire data concerning seasonality of site occupation and, possibly, the initial utilization of some cultigens.

General Studies

To characterize the environment exploited by at the Camarones 14 site, and to establish parameters as to changes in the economy and technology of coastal populations, quantitative studies were done to verify changes in artifacts and faunal/botanical resources. Ten-liter bucket samples were collected from almost all excavated layers from Camarones 14 site (Table 3.2). This site was chosen for quantitative analysis because it was excavated for this research. It offered a better view of the occupational layers and better control of the sampled area. In this fashion, sampling avoided mixing natural layers, as often occurs when directed trough the profile following artificial layers. Samples were collected separately from the two worked sectors, A2 and A3, following the natural levels defined during the excavation. Bucket samples were collected at random.

The bucket samples collected were sorted in the laboratory by category and each layer was weighted in separately. The categories included pebbles, flakes, and shell artifacts; mammalian, avian, and fish bones, as well as fish otoliths[27]; plant remains included seeds and inflorescences; invertebrates included sea urchins (phylum: Echinodermata), crustaceans, for example, fragments of shrimp (phylum: Crustacea), and mollusk shells (phylum: Mollusca, classes Bivalvia and Gastropoda). The shells were identified based on Guzmán's (et al. 1998) descriptions of the littoral mollusks from the Antofagasta area in northern Chile. In addition, there is a reference collection at the Museo de San Miguel de Azapa and at the Museo de Conchas in Arica. Since the approach here relies on the analysis of shell growth rings, the results were not subject to interpretative analysis.

Table 3.2: Bucket samples from Camarones 14 excavation

Sector A2		Sector A3	
Layers	Weight (gram)	Layers	Weight (gram)
Superf.	1,525	Superf.	700
1 dcp2	2,200	1	1,814
1D	2,380	1c	4910
1E	2,200	1d	2,614
2	2,316	1e	1970
3	1,450	1f	1,000
3B	0,350	1g	910
4	0,450	3a	750
4 dcpd 2	5,300	3b	920
5 dcpd 2	7,000	5 dcpd 1	5,850
5 dcpd 3	4,200	5 dcpd 2	8,200
5B	5,310	5 dcpd 3	1,900

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[27] A small calcareous body related with fishes movement and equilibrium.

6	3,700	5b	6,300
9c	1,310	5c	5,050
12	0,630	7	2,100
12 C-2	230	7b	3,900
13	638	8	2,700
13B	0,620	8b	1,100
13C	658	8c	3,870
		9a	2,290
		9b	1,870
		9c	950
		10	5,870
		11	1,350
		12	2,630
		13	770
		13c	3,200
		14	1,540

Material Culture

The artifact assemblage helps to trace eventual changes in technology and subsistence that, over time, could have happened at the Camarones 14 site. The fishhook assemblage has the potential to verify the chronology of fishhooks, a debated point in Chinchorro chronology (Llagostera 1979; Guillén 1997). For a sedentary site, it was expected to show a variety of artifacts. Pre-forms and finished artifacts were expected to be found, as well as the raw materials discarded during artifact manufacture. Such artifacts would be considered markers only if associated with a wider spectrum of different indicators. Expedite (disposable) artifacts could be present, but they are necessarily not good signs of long-term occupation.

Artifacts were tagged according to the sectors and layers where they were found. All material were brought to the Museo de San Miguel de Azapa for analysis. They were either directly collect during the excavation or were separated later from bucket samples in the laboratory. Artifacts and other cultural materials recovered during excavation were collected, recorded by level, and included in the analysis. Among these materials were lithic projectile points, flakes, thorn and shell fishhooks, shell fishhooks in stages of manufacture, other shells artifacts, and some fragmented pieces of wooden implements. Also found were twined fragments of vegetable fiber, plus animal and/or human hair. The author analyzed all these materials; the results are presented in Chapter 5.

Shell Analysis

Modern and archaeological marine shells from Camarones 14 and Camarones Sur were collected. This generated comparative samples for the study of shell ring growth and oxygen isotopes analysis. This data, in turn, can shed light on seasonality of sites. Shell studies show when mollusks, as food items, were procured by ancient peoples. Such data should reflect the seasonality of past occupation. From this evidence, indirect inferences can be made about mobility strategies and sedentism across multiple ecological zones.

A secondary focus is the overexploitation of species. A reduction in the mean shell size in samples taken from the base to the top of the two excavations could indicate such overexploitation. Over time, of course, the ecological reduction of certain species could be due to climatic change (Jerardino 1992; Jerardino 1997; Mannino and Thomas 2002). Shell measurements were controlled for size variations. So they are good indicators of overexploitation, especially when associated with indicators derived from complementary paleoenvironmental analysis. The expectation is that shell size decreases with time pointing to overexploitation. This analysis was done tentatively with one species. The species selected was *Concholepas concholepas*, a common mollusk used as food by local population.

Shell Growth Ring Analysis

Shell growth rings or shell growth-lines have been used to examine seasonality at archaeological sites around the world (e.g. Jones 1980; Claassen 1986; 1998; Quitmyer et al. 1997; Andrus 2011). Growth lines result from calcium carbonate formed when the mantle of the shell is extended outwardly during feeding periods and it is often regulated by food availability, spawning, El Niño events, and predation (Claassen 1998). Periods of increased growth leave a pattern of larger lines on the surface of shells that can be associated with a specific season of the year (Richardson 2001). With a modern shell collection retrieved during different periods of the year, it is possible to know the period or season of the year that corresponds to a specific ring pattern of the target species. Therefore, by comparative analysis with the archaeological samples, it is feasible to infer the period of the year in which the mollusk was exploited and, indirectly, to know when the site was occupied. The problem with this technique is to distinguish annual rings from disturbance rings, presuming that the shell species actually develops regular growth rings. However, this can be reduced with the analysis of patterns formed by micro-growth bands and lines present in the internal structure of the shell, instead of on its external surface (Richardson 2001). These micro-bands have a periodicity regulated by tidal cycles (Richardson 2001).

For example, in *Mesodesma donacium* (Carré 2007; Carré *et al.* 2009) the shell grows faster and shows large dark bands during the summer. For *Donax vittatus,* the growth seasons goes from spring to the end of summer, while the opposite occurs during winter and fall when the growth is significantly reduced or halts (Maia and Pimenta 2007). Such periods can vary not only from one species to another, but also between the same species, as observed on quahog clam (*Mercenaria mercenaria*). The clam's season pattern varies with the region where they are located (Clark II 1979). Growth seasons also vary with latitudes; shells from higher latitudes grow faster during the summer while shells from lower latitudes show an opposite pattern with faster growth during the winter (Jones and Quitmyer 1996). As already observed, growth is marked in the profile of the shell and can be seen through a cross section (Clark II 1979; Richardson 2001; Andrus 2011). During the period of reduced growth, the bands are formed closed to each other; during the period of intense growth the bands are larger. The angles of the growth lines in relation with seasons of the year was observed in *Donax vivatus* (Maia and Pimenta 2007), making it a potential seasonal indicator.

Shells from Camarones 14 and Camarones Sur: *Concholepas concholepas*

For this research, three species of mollusks were initially considered: *Eurhomalea rufa* (Lamarck, 1818), locally know as almejas; *Concholepas concholepas* (Bruguière, 1789), locally know as *locos*, and *Choromytilus chorus* (Molina, 1782), locally know as *chorros*. These species are dominant in archaeological context along the northern coast of Chile; they are also, the most exploited mollusks at many Chinchorro sites (Billings, 2001; Standen 2003). A preliminary analysis of shells collected in 2006 showed that *almejas* (*Eurhomalea rufa*) and locos (*Concholepas concholepas*) are the best specimens to study growth-ring stages. Growth stages are clearly visible on the external edge of bivalves and well marked on the cross-section of modern local shell species (Franco and Dillehay, personal observation, 2006). Although studies of this nature have been done with *Mesodesma donacium* (e.g. Carré 2007), this species was found sporadically at Camarones 14, and as Shciappacasse and Niemeyer (1984) observed, the shells of

Mesodesma are concentrated in two or three areas of the site. The reason for such concentration is unclear. The fact is that the shells form a cluster that is not representative for other layers. Because of that, *M. donacium,* was not selected for analysis here.

Collection of *almejas* and *choro zapato* (*Choromytilus chorus*) was initiated in 2006, but abandoned when problems arose regarding their prevalence at the site. *Almejas* were not abundant at the target site of Camarones 14. Since the beginnings of the Holocene *Choromytilus chorus* was a highly exploited mollusk and an important raw material for manufacturing various kinds of artifacts. Despite this, it was not a good choice. At the Camarones 14 site, *Choromytilus chorus* shells showed up highly fragmented due to their intensive use for making artifacts. Another complicated factor is that due to overexploitation, this mollusk has almost disappeared from certain regions of the Chilean littoral, including Arica (Romero 2002). Nowadays, it is difficult to find it in sufficient numbers to form a large enough reference collection to covers each season or month.

Hence, the research concentrated on *Concholepas concholepas* (Bruguière, 1789) (Gastropoda, Muricidae), a mollusk well represented in archaeological contexts and the dominant species found by Shiappacasse and Niemeyer (1984) at the Camarones 14 site. This species is registered in many sites along the central Andean coast covering different periods of time. Growth-line analysis study is usually performed on mollusk bivalve, but it can also be applied in gastropod shells including the statoliths (Richardson 2001). Finally, *C. concholepas* is a reliable species for the application of isotopic analysis, although it needs more samples and research to be used as seasonal markers (Falabella et al. 1991).

Each growth increment in *C. concholepas* is formed by a pair of light/dark bands with the formation of one growth band per day (Fernandéz et al. 2007; Guzmán 2004). They have a circadian cycle and light (translucent) increments are formed during the day (faster growth) while dark (opaque) develops during the night (slow growth) (Lazareth et al. 2007). Also formed on a daily basis is a succession of 40-50 micro layers (Grosselin et al. 2013). The term "growth lines" refers to the thin dark lines or laminations formed between the white bands (Jones et al. 1978 and Thompson et al. 1980) visible at the internal surface of a cross cut section of the shell (Figure 3.24).

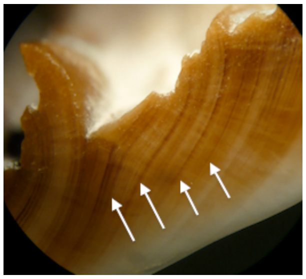

Figure 3.24: The growth lines are the dark laminations visible in a cross section of a *Concholepas* shell, as indicated by white arrows.

A baseline of modern shells of *Concholepas concholepas* was collected to examine along side archaeological samples from Camarones 14 and Camarones Sur. It applied two techniques, the analysis of shell growth rings and the analysis of shells oxygen isotopes.

Modern Samples

To create a representative collection of modern shells from the research area, a local fisherman collected live samples of *Concholepas concholepas* shells each season of the year. Given Chilean legislation samples could not be smaller then 10 cm. A total of

256 shells were collected in 2008 as follow: during the fall (March/April, 19 shells), early winter (June, 53 shells), early spring (September, 49 shells), and early summer (December, 34 shells). In 2010, during high summer (Jan/Feb), 101 shells were collected. The mollusks were removed from the shells just after capture. The modern shells were initially sorted, discarding the ones with damaged the edges. The table below has the number of shells collected in each period and the effective number of shells analyzed after preparation and trial. The reduction in the final number of the shells occurred because some shells were broken during transportation or the cutting process, while in some others the growth lines were not well defined.

Table 3.3: *Concholepas concholepas* – Modern and Archaeological Samples

Modern shells	Months					
	April/May	June	Sep.	Dec.	Jan/Feb.	Total
Total shells sampled	19	53	53	39	101	265
Total shells analyzed	19	48	47	33	79	226
Archaeological shells	Provenience					
		Camarones 14			Camarones Sur	
Total shells analyzed		70			162	

Archaeological Samples

These samples were recovered in 2007 and 2008 as part of the excavations at the site of Camarones 14 and Camarones Sur as described earlier in this chapter. Archaeological samples were prepared in the same fashion as modern ones. The shells from Camarones 14 are from Early and Middle Chinchorro covering a period of 6,088 ±

50 BP to 7,669 ± 54 BP, as well as from more recent strata not dated. Some of the late strata are from a post-Chinchorro deposition related to the Saxamar Culture, as identified by Schiappacasse and Niemeyer (1984) identification of the site occupation, but no shells were analyzed from this later context. The controlled stratigraphic excavation allowed the inclusion of selected fragments of *C. concholepas* that are not part of any other repeated fragment; a total of 70 fragments and entire shells were selected for the shell growth ring studies. Regarding Camarones Sur, samples were collected from the east profile, and during Rivera's excavation at the site in 2008; from this site a total of 162 shells were analyzed. The majority of shells come from the Terminal Chinchorro from 3,060+-290 BP (RL-2055) and the post-Chinchorro period between 594+-35 BP (AA-84944) and 1,050+-110 BP (GaK-8644) (conf. Table 4.2).

Preparation Techniques and Analysis

The process described below was applied to both collections of shells. After they were measured, a transverse section was cut across the growth axis of each shell, from the umbo to its inferior margin (Figure 3.25), using a water saw machine. Because of the different sizes and staets of preservation, the shells were cut using different types and sizes of wet tile saws, preferably diamond saw blades. (The best equipment to cut medium and small samples was a small table saw, the ND 125, Model D, of 4.800 revolutions per minute.) After shell sectioning, the most suitable side of each shell was chosen, sanded and polished either manually or using an electric machine (Ecomet 2 from Buehler). Shells were sanded using water and abrasive, waterproof sandpaper with progressively finer grain sizes of 220-b, 320-b, 600-b and water, while a metal polish liquid (Brasso) was used to highlight the internal features (growth lines). Modern shells from Jan/Feb 2010 were prepared with a wet sanding apparatus (Handimet Grinder from Buehler) using sensitive abrasive paper grit 240, 320, 400, 600, and polished on a wheel (from Buehler) using a micropolish of 1.0 micron (Alpha Albmina from Buehler) mixed in water. Some modern and archaeological shells were embedded in epoxycure resin (Buehler). This was done to etch the surface of the transverse sections in acetate peels.

Figure 3.25: Archaeological sample of *Concholepas concholepas* sectioned for analysis. Barnacle epibionts are visible in portions of the external surface of the shell (authors photo).

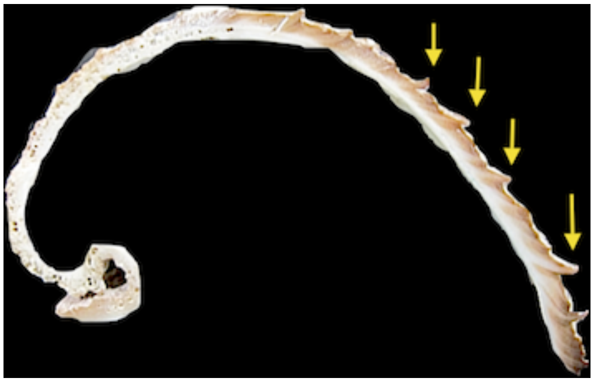

Figure 3.26: Sectioned sample of a *Concholepas concholepas* shell prepared for analysis. Arrows point to some of the lamellas or ribs. Lateral view of the shell in a cross cut section (authors photo).

Samples in the epoxy resin were tested by the acetate peels technique, etched in 10% hydrochloric acid for approximately 1 minute. This technique yielded poor results. Perhaps the etched time of 1 minute was excessive and damaged the lines, mainly on the archaeological shells. Hence, the polished surface of the shells was directly observed using a binocular microscope (Bausch and Lomb) with magnification ranging from 0.7X to 3.0X and, also, a metallurgical microscope (Leica DM 4000 M) at 25X to 50X magnification. All samples were photographed at 25X magnification.

The growth-lines of the modern samples were visually analyzed[28]. The modern samples were studied first in order to find patterns that could be related to the seasons of the year. To test some features, the first step was the direct examination of the cut surfaces of all shells from the modern collection, with attention to the edge or tip (the opposite extreme from the umbo area) (Figure 3.27).

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[28] For more information see Chapter 4.

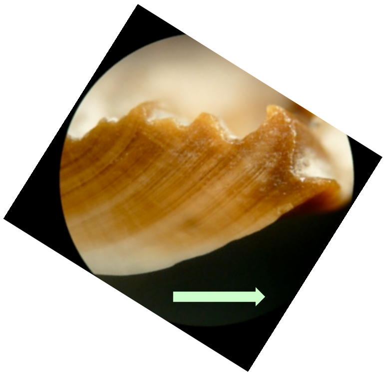

Figure 3.27: Detailed view of the extreme tip of the shell margin showing the growth lines. White arrow shows direction of growth (authors photo).

Data from each was gathered for:

a) The angles that are formed by the growth lines: if they were visually more vertical (low = downward sloping) or more horizontal (high = upward sloping) in relation to the shell surface (Figure 3.28)

b) The space between the lines at the very end of the tip: if these lines were close (compressed) to each other or more spaced (dispersed) from each other.

c) The number of lines: if there are more (high) or less (low) lines occurring at the very end of the tip.

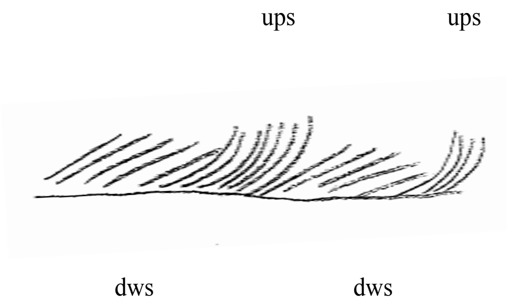

Figure 3.28: Schematic representation of shell growth lines: ups = high angles or upward sloping, and dws = low angles or downward sloping

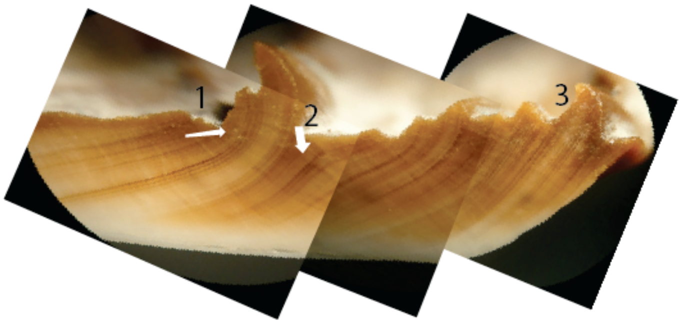

Figure 3.29: Mosaic of the area close to the tip of the shell. Arrow 1 shows the point at which the angles change direction from a downward to an upward slope. Arrow 2 shows the change is from an upward to downward slope position. In number 3, the angles returned to an upward slope position with a slight tendency to change to a downward position at the extreme edge of the tip. The number of lines is high at the edge and the lines are compressed. The yellow arrow shows the direction of shell growth.

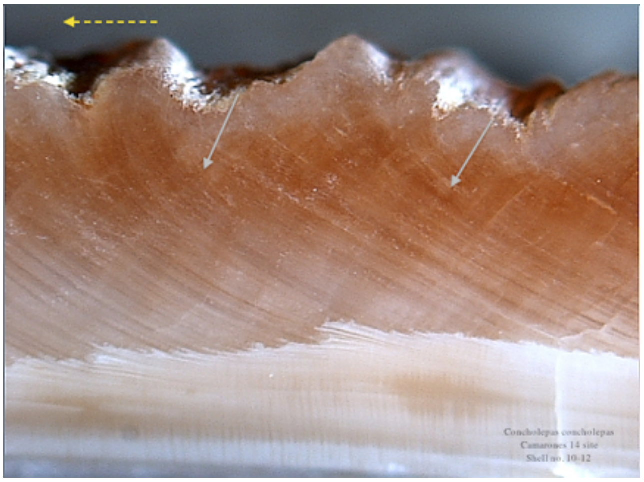

Figure 3.30: Growth lines displayed in a polished section of a transverse cut of *C. concholepas*. The two gray arrows show the points at which the angles formed by the lines changed direction from dws to ups; the yellow dash line indicates the shell's growth direction.

The working hypothesis is that the direction of the growth lines formation changed when the seasons changed and this is reflected in the angles of the lines visible on the crosscut of the shells. Thus, the direction of the line would be an indicator of the season of the year in which the growth lines were formed.

A derivative approach is that if the tendency of the angles is to turn down and growth lines formed more horizontal to the internal margin of the shell, then the shell growth is faster; if they are increasing and assuming a more vertical position, growth bands are smaller and the shell growth is slowing down. A similar approach was applied for the space between growth lines, that is, if lines are closer, shell growth is slow; if the distance between lines are increasing, then shell is growing faster. The same approach was taken for a high or a low number of lines close to the shell tip. These are patterns on observed on the crosscut section of the shells. The key here is to check if these trends are correlated or not with the seasons of the year.

To test these patterns in relation to the seasons and thus determine their applicability, several statistical tests were performed. Contingency tables and chi-square tests (Pearson and Likelihood) were used to evaluate the relationship between the seasons of the year and those specific features (angle, space between lines, and the number of lines). Parametric regression analysis checked correlations found on the chi-square tests. These were run using the STATA program. To test the relation between seasons from modern shells and the archaeological ones, the binominal test was used. The results are presented in chapter 4; the raw data is in Appendix A.

Shells from Huaca Prieta: *Semele*

Shells from modern and archaeological samples were provided by Tom Dillehay for this analysis. The species analyzed were: *Semele solida* (Gray, 1828) and *Semele corrugata* (Sowerby, 1833). During 2008*,* modern shells were collected from an area close to the site of Huaca Prieta. The archaeological samples are from the 2007-2008 excavation of this site. Shell samples come from phases II to V, covering a period from about 7,500 to 3,400 BP.

A total of 85 modern shells were studied. All these samples were sectioned by Victor Vazquez of the Universidad Nacional de Trujillo in a cut parallel to umbo of the shells, at their middle portion. The preparation of the samples followed similar procedures described for *Concholepas concholepas*, that is, using water and sandpaper to sand them and Brasso to polish the cut area. No samples were embedded in epoxycure resin, and acetate peels were not used in these analysis.

The analysis followed those steps used for *Mercenaria* shells, which is based on the formation of white and dark bands during the seasons (Quitmeyer and Jones 1997). A similar seasonal pattern was found on modern shells of *Semele*, so it was used comparatively to identify the seasons of the year in which shells were collected. More details are found on Chapter 4, with the description of the method and results. Raw data are in Appendix B.

Stable Isotopic Signatures

To determine the seasonality of a coastal site's occupation, archaeologists have been using stable isotopic analysis on shells. This method is based on the sea temperature variations determined by isotopic curves from stable isotopic of ^{18}O ($\delta^{18}O$). *Concholepas concholepas* is one of the most common mollusks found on archaeological sites in northern Chile and southern Peru. It is still a highly exploited species and one of the most important benthic mollusks in Chilean economy. Know as "*loco*" in Chile, it has been studied extensively. Nonetheless, there is little research on the *loco's* potential as paleoclimate proxy at archaeological studies.

Stable isotopic analysis of ^{18}O ($\delta^{18}O$) was performed on shells of *C. concholepas* from Camarones 14 and Camarones Sur site (north Chile). This work complements Billings' (2001) cursory isotope study of seasonality based on shell samples from Camarones Sur (synonym: Camarones West Shell Midden), which yielded inconclusive results. By comparison, Falabella and collaborators (1991) did stable isotopes on shells of this species with some positive results for environmental changes through time.

To perform the isotope analysis, archaeological samples of *Concholepas concholepas* shells were prepared and sent to Dr. Fred Andrus from the Department of Geological Sciences at the University of Alabama. The shells were cut along the axis of maximum growth, sanded and polished, as described above. Samples were taken by drilling at specific intervals along the cut axis of the shell. To get reliable data on shell seasonality and the season of death, the sample covered an entire year of growth prior for a shell's moment of death. This is a more comprehensive approach than the one followed by Billing's (2001) who examined only the external area at the extreme edge of the shell.

Billings's (2001) research on shells from Camarones Sur concluded that year-round shell harvesting was not practiced. Five different mollusks' species were analyzed by her study: *Concholepas concholepas, Fissurella crassa*, *Fissurella latimarginata*, *Choromytilus chorus*, *Crepidula dilatata*, *Protothaca thaca.* This study gave results consistent with isotopic analysis. However, some reservations are in order. Samples came from the tip of the external margin of the shell and not from an interior crosscut section. Billings' work was not based on a life series; that is, a sample sequence that covers a year's cycle of shell growth. As Billings observes, the problem with this is that there was no effective way to identify the time of death of a sampled specimen. In older shells, months or even years could be compacted on the edge of the shell. To minimize this problem, young specimens were chosen for analyses here. A more reliable approach is to take a sequence of samples from an internal section of the shell that covers the shell's full growth cycle. This generates a time series profile for each specimen (Andrus 2012). This method also provides better data on temperature variations, for a one or a two-year period. As described bellow, this technique is the one applied in this research.

For Camarones 14, shells were sampled from different archaeological layers. All samples were prepared and drilled by this author and then sent to Fred Andrus from the Department of Geological Sciences at the University of Alabama for the analysis. A life profile for a modern specimen was generated first. This was done to test the method's feasibility on selected sampled. After that, the archaeological shells were selected preferably entire shells from the deepest layers of the site.

Samples included a modern shell of *Concholepas concholepas* and two sets of archaeological shells from the Camarones 14 site. As already mention, the modern shell was sampled to test the viability of the life profile procedure for shells of *Concholepas concholepas*. Archaeological shells were divided in two sets because they came from different time periods. The second set was prepared and sent after the results of the first set proved unsatisfactory.

The first set of nine shells came from levels 14 (2 shell), 13 (2 shells), 12C (1 shell), 12B (1 shell), 12 (1 shell), 7 (1 shell), 6 (1 shell). The second set of two shells came from levels 13C and 12. All selected shells were transversally cut and polished as described before. For this site, eleven (11) samples of shell calcium carbonate were drilled and taken from the inner calcite layer of each shell[29]. The weight of each sample was between 40 and 100 microgram[30] (mcg) weighted on an analytical scale and put into 4.5 milliliter (ml) round-bottomed vials. A G9928 Flex Shaft Grinder, with the support of a binocular microscope, was used to drill and powder the samples. The interval between sample holes was first put at between in 2.0 to 4.0 mm. For a high profile sampling, this was later changed to a 1.0 mm distance between each hole (Figure 3.31).

Figure 3.31: Detail of a shell of *Concholepas* sectioned and sampled for isotopic analysis; sample interval is about 1 mm, detached in the photo by crosses.

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[29] The number of samples drilled from fragments may vary according to the size of the shells.

[30] One microgram (mcg) is equal to one thousandth (1×10^{-3}) of a milligram, and one milliliter (ml) is one thousandth of a liter.

For modern shells of *C. concholepas*, the results demonstrated that seasonal variation is recorded in their oxygen isotope profiles (see Appendix D). In the first shell set from Camarones 14, a seasonal range in $d^{18}O$ was not clear and did not generate a sinusoidal curve. Annual cycles were obscured. Perhaps the interval between samples was not reflecting monthly growths. Although the sampling strategy was refined and samples were milled in smaller intervals of 1 mm, the results remained unsatisfactory. Consequently, they were not used for the shell ring analysis. This is discussed in detail in Chapter 4.

Shells Overexploitation

Considering that *C. concholepas* is an important resource for local populations, the expectation here is that if the shell size decreases over time, as the result of overexploitation due to resource depletion, this could indicate long term occupation perhaps coupled with population growth. If no overexploitation is observed, then there is no stress on this resource that could be pushing the local population to move to other areas.

When the mean size of shells collected at the base of the excavation units is significantly greater than those sampled at the top, it can indicate either overexploitation or reduction of certain species due to climatic change (Mannino and Thomas 2002). Shell measurements are good indicators of overexploitation when associated with other complementary paleoenvironmental data. The expectation is that shell size decreases over time, as the result of overexploitation due resource depletion what could indicate long term occupation perhaps coupled with population growth.

Shells of Huaca Prieta were not object of analysis for overexploitation. All archaeological specimens came from various layers of Camarones 14 and Camarones Sur. They were directly collected from the worked areas, or separated from the sieve during the excavation procedures. From Camarones 14, they came from sectors A2 and A3. From Camarones Sur, they came from the East profile area including a trench opening close to it.

The maximum growth axes of the shells were measured (corresponding to width) using a 0.1millimeter (mm) precision digital vernier caliper. Data was recorded and quantified using Excel. Statistical tests were calculated using both Excel and STATA. Entire shells and selected fragments whose length was not compromised were measured. From Camarones 14, 94 shells were analyzed and from Camarones Sur, 140 shells. The results are presented in Chapter 4.

Summary

This chapter presented the fieldwork and the methodological approach applied to the study of shell seasonality. The study focused on the annual growth rings of archeological marine shells collected through the excavation of two sites: Camarones 14 and Camarones Sur in northern Chile. Also studied were shells from Huaca Prieta, which were derived from Tom Dillehay's excavation at the site.

The excavation at Camarones 14 revealed a series of layers that were combined into four main cultural periods: early Chinchorro, middle Chinchorro, transitional Chinchorro, and post-Chinchorro. Although they follow the stratigraphic chronological sequence represented in the site, the sequence is not intended for use beyond this context;

its is simply a methodological tool to organize the data discussed in this thesis. The fieldwork carried out at this site and Camarones Sur recovered material relevant to understanding the local paleoenvironment during the middle Holocene. In addition, shells were collected for growth ring analysis as well as for oxygen isotopic studies on shells. Taken together, such data can shed light on long-term changes in settlement mobility, sedentism, and social complexity.

As discussed here, the shell growth ring analysis performed on *Concholepas concholepas* and *Semele* sp. confirms the potential of the shells as seasonal indicators. On the other hand, oxygen isotopic analyses yielded mixed results.

In the next two chapters (4 and 5), the results of the analysis are presented and discussed, giving meaning for to all data collected. Through the analysis of these data and the methodology applied, the rhythms of seasonality and site occupation start to appear, and a pattern of mobility drawn from that help to understand the dynamics of seasonality and sedentism and the emergence of cultural complexity within these early maritime societies. These data also strengthen our understanding of the subsistence strategies, seasonality, and the diversity of adaptive strategies.

Chapter 4 has the results of the analysis of shell growth lines performed on *C. concholepas* and in *Semele*. Isotopic and overexploitation analysis are also presented.

CHAPTER IV

DATA ANALYSES

This and the subsequent chapter discuss the results of the archaeological material analyzed for this dissertation. This includes the shell analysis on *Concholepas concholepas* from Camarones 14 and Camarones Sur, as well as shells of *Semele solida* and *Semele corrugata* from the Huaca Prieta site. Samples from the Huaca Prieta site were processed under Tom Dillehay's supervision. Chapter 5 presents the artifacts recovered at the Camarones 14 site, such as fishhooks and other shell artifacts, as well as lithic and wood material. Botanical data includes macrobotanical remains, pollen, and phytoliths.

Radiocarbon dating samples from the Camarones 14 site were sent to the AMS Facility at the University of Arizona. These results are also presented in Chapter 5, along with the chronology available for the Camarones Sur site. Faunal remains, other then shells and some fish otoliths were separated by classes, but not analyzed[1] because the report from the specialist was not sent back by the time this dissertation was finished.

Ms. Magdalena García B. a researcher affiliated with the MASMA (Museo Arqueológico de San Miguel de Azapa, Chile) analyzed the macrobotanical material. Pollen analysis was done at the Paleo Research Institute (Colorado, USA), while phytoliths were analyzed by Dr. Jose Iriarte at the University of Exeter-Department of Anthropology (England). Coprolite samples were studied by Dr. Adauto de Araujo and

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[1] A few mammalian bones, as well as feathers and avian bones, were recovered at Camarones 14. Notwithstanding their potential as seasonal idicators, mainly for migratory birds, the person contacted to work with this material did not complete it. So, no results are presented.

Mônica Vieira, at the Escola Nacional de Saúde Pública - Fiocruz (Rio de Janeiro, Brazil). Dr. Mario Piño from the Universidad Austral de Chile conducted the sedimentology analysis of selected samples from Camarones 14. Jessica Peñailillo, at the Universidad Arturo Pratt (Iquique, Chile) made a preliminary identification of some fish otoliths. Statistic analysis was performed in collaboration with Dr. Isleide Zissimos, at Vanderbilt University, Economics Department.

Modern and archaeological samples of *Concholepas concholepas* were cut in different moments and at different places. Part of the shells was cut by a local marble artisan at the cemetery of the city of Arica (Chile). Another part was cut and polished using the facilities from Universidad Arturo Pratt (Iquique, Chile) in the laboratory of Prof. Miguel Araya with the assistance of Jessica Peñailillo, who also assisted with cutting and preparing fish otoliths. Another part of the shells was prepared using the facilities of the Vanderbilt University: shells were cut using the equipment from the Department of Earth and Environmental Science, polished manually in the laboratory of Tom Dillehay (Anthropology Department) and in the laboratory of the Mechanical Engineering Department (School of Engineering). Samples for isotopic analysis were weighed on a precise scale from the Medical Department. All the equipment is specified in Chapter 3 concerning the methodology.

Shell Sclerochronology

Sclerochronology studies incremental growth structures formed by the accretion of skeletal materials. This occurs in a temporal sequence that is annual, seasonal, daily, and tidal. Sclerochronology also includes geochemical analysis to generate a time-series profile based on growth structures (Andrus 2012). The shells are formed by the secretion of calcium carbonate (CaCO3) and conchiolin (a complex of proteins) by the epidermis of the mantle of the mollusk. The periodicity of the shell's growth is the object of study of sclerochronology. Therefore, through the study of their growth lines, mollusk shells are potentially informative for seasonal studies. In archaeology, shell sclerochronology can determine the season of capture and thus estimate the seasonality of a site's occupation (e.g. Jones 1980; Quitmyer et al. 1997; Claassen 1998; Carré 2007; Carré et al. 2012; Andrus 2012). Such analysis can also be performed on gastropod shells (Richardson 2001), as well as on fish otoliths and vertebrae (Andrus 2012).

Growth lines are formed with a certain periodicity by calcium carbonate. The process is influenced by many factors such as food availability, spawning, temperature, El Niño events, and predation (Claassen 1998). Periods of increased growth leave an incremental pattern (larger bands) on the shell's surface that can be associated with a specific season of the year. Using modern shells collected at different times of the year, as a reference, it is possible to know the season that corresponds to a specific ring pattern on the target species (Quitmyer and Jones 2012). Hence, by comparative analyses with the archaeological samples, it is possible to know the period of the year in which humans exploited the mollusk and, indirectly, when the archaeological site was occupied. With this in mind, the first step in this study is to determine the seasons of the year in which mollusk species were procured as food items, and then the remains deposited by maritime foragers. This is performed for Camarones 14 and Camarones Sur and for the Huaca Prieta site, all during the middle Holocene period (8,000 – 3,000 BP) (Sandweiss 2007).

This will establish the seasonality of site occupation, the time of the year in which a site was actively used by people as indicated by shell growth rings. To study seasonality, two different analytical approaches can be applied: 1) the visual inspection of growth increments on mollusk shells and 2) the geochemical analyzes based on oxygen isotopes. The second approach was done only for shells from the Camarones 14 site[2].

Although the three sites are on the desert littoral coast and share a similar environment, there are differences. Ocean currents along the northern Andean coast where Huaca Prieta is located are more sensitive to the effects of El Niño events. Consequently, the local fauna are more exposed to environmental changes during such episodes (Dillehay et al. 2012). In addition, different factors such as temperature, salinity, and spawning can influence shell growth. Periods of optimal growth can vary from one species to another, and also within the same species. To take an example from North America, *Mercenaria mercenaria*--quahog clam–-has different seasonal growth patterns, depending upon the region (Clark II 1979). As Ansell (1968 in Clark II 1979: 165) shows, winter is the growth season for *Mercenaria mercenaria,* which lives from North Carolina to Florida. Clams from Virginia north to Canada, by contrast, grow faster during the summer. Because of this variability, each species to be studied requires the study of modern local collections.

Mesodesma donacium is one of the most reliable species to study seasonality at sites along the Andean central coast (Carré et al. 2009). Another species with potential for the study is the *Choromytilus chorus* (Jones 2010; Gosselin et al. 2013). Also, the

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[2] Isotopic analyzes on shells of Huaca Prieta were not the scope of this research, but it is being performed by separate research teams: DeSantis (Vanderbilt University) and Andrus (University of Alabama). Regarding Camarones Sur, this analyses was cancelled because no positive results were obtained from the analyses done on *C. concholepas* from Camarones 14. See specific section on Isotopic Analysis later in this chapter.

subtidal species *Trachycardium procerum* presented positive results for oxygen isotope analysis (Houk Jr. 2002).

In this research, however, *Concholepas concholepas* is the taxon selected for analyses at Camarones 14 and Camarones Sur. *Semele solida* and *Semele corrugata* are the taxa selected for the Huaca Prieta site. *C. concholepas* was chosen after an initial evaluation with modern shells showed visible external and internal growth lines. This was also the most representative species recovered during the earlier excavations performed by Schiappacasse and Niemeyer (1984). Dillehay and collaborators selected Semele clams for analyses. All modern species analyzed are found in the seashores near the respective archaeological sites.

The main approach of the analysis performed here was based on the visual inspection of a polished section of a cross cut area of the shells that showed growth rings or bands with a seasonal orientation. To verify the season of capture, the oxygen isotope ($\delta^{18}O$) analysis of *C. concholepas* shells was also performed.

Because of variability in the patterns of shell growth ring formation, both genera are discussed separately below. In general, sclerochronology analysis is done on bivalve shells, as is the case with the genus *Semele*. Nevertheless, *Concholepas concholepas* is a gastropod with certain specificities that distinguish it from other taxa. Given the importance of *Concholepas concholepas* shells for this study, some basic biological and ecological information is presented below. Also, how the local human population currently catches this mollusk is discussed.

The mechanisms of growth and its formation patterns are not well understood (Guzman et al. 2004). The external rings of the shell, characterized by lamellar extensions, has an annual periodicity (Alderstein 1987; Bustos et al 1996; Lara et al 2007) associated with winter marks (eg. Adlerstein 1987).

Biology of the Seawater Mollusk *Concholepas concholepas* (Bruguière, 1789)

Classification:

- Phylum Mollusca
  - Class Gastropoda
    - Family Muricidae
      - Genus: *Concholepas*
        - Species *Concholepas concholepas* (Bruguière, 1789)

Concholepas concholepas (Figure 4.1) is found from the Islas Lobos de Afuera (6° S) in northern Peru to Cabo de Hornos (55° S) in southern Chile (Stuardo 1979; Castilla 1983 in Olguín and Jerez 2003). It is distributed across all biogeographic zones of the Pacific coast (Broitman et al. 2001 in Cárdenas et al. 2008). This species was chosen for analysis because it has well-developed and well-preserved growth rings increments. In addition, early-middle Holocene populations exploited it as documented at other archaeological sites along the Pacific Coast (Llagostera, 1979; Jerardino et al. 1992; Báez et al. 2004; Lavallée, 2011). Although there are numerous studies on the biology of this species (e.g., Ramorino M. 1975; Guisado and Castilla 1983; Wolff 1989; Olguín and G. Jerez 2003; Guzmán 2004; Manríquez et al 2008), studies that use growth rings as seasonal indicators are few (Falabella et al. 1991).

The genus *Concholepas* has only one modern species and it is endemic to this region (Castilla and Guiñez 2000; Guzman 2004). Commonly know in Chile as “*loco*” and in Peru as *“pata de burro*”, “*tolina*” or “*chanque*”, the *C. concholepas* mollusk is a local dietary favorite and an important economic resource in both countries. Harvesting for export began in 1976 (Rabí et al.1996; Dauphin et al. 2003). In 2003, it was one of the most exported mollusks from Chile. The country exported 174.982 kilograms worth 18 million US dollars[3]. In 1981, because of its intensive exploitation, Chile instituted a three-month moratorium during the spawning period. Nonetheless, to help the mollusk population recuperate, the fishery had to be closed from 1989 to 1992. To protect the mollusks, the minimum size for a collected loco is no smaller then 10 cm (Olguín and G. Jerez 2003), a size reached by a mollusk shell at 4 to 6 years old (Lara et al. 2007). To capture mollusks, a federal authorization required, even for scientific purposes[4]. Hence, the modern collection used in this study has only adult shells. However, the majority of the shells that formed the archaeological collection are smaller then 10 cm. This means they are younger than that modern ones. Younger shells have yet to undergo a reproductive cycle and grow faster than mature ones. Also in adults, the growth rings are formed closer together than in juveniles. For this research, however, it is expected that these changes will not impact the number of the growth lines, nor the direction of their angles. This topic is discussed in detail in the next section, when analyzing *Concholepas concholepas* growth ring shells.

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[3] The price per kilo is higher than the oyster, for example: $3.1 dollars while oyster costs $2.2 dollars (Indicadores de Comercio Exterior, *Banco Central de Chile*, Marzo 2003). Taiwan, Hong Kong and Japan are the main countries that import *C. concholepas*. Together they reach a total of 77.61% of the total exported by Chile in 2007 (Source: Informe, Febrero 2007: Exportaciones Recursos Bentonicos Loco, Lapa y Erizo – Base Enero 2003)

[4] All the required permissions were obtained for this research.

Figure 4.1: *Concholepas concholepas* mollusks after collection by a diver in Caleta Camarones. Photo: Ximena Rivera (2008).

Concholepas concholepas (loco) is an intertidal and subtidal organism that lives incrusted on rocks. Adults of this species can be found at depths of up to 40 meters (Rabí et al. 1996; Dubois *et al*. 1980). The mollusk is dioecious, in that male and female are distinct from each other. This difference is not discernable from looking at the surface of the shell (Ramorino M. 1975). A gregarious carnivorous mollusk, it mainly preys on mytilids (e.g. *Perumitylus purpuratus*, *Semimytilus algosus*) and barnacles (e.g. *Balanus laevis*, *Chtamalus scabrosus*) (Báez and Jackson 2008; Guisado and Castilla 1983).

A mobile organism, *C. concholepas* moves from deep to shallow waters during reproduction. There is a seasonal variation in density (Proyecto FIP 2006-56). During the spawning season, mature individuals move up towards the intertidal zone and more shallow waters, where they congregate in large numbers (Castilla and Jerez 1986; Rabí et al. 1996). Although spawning occurs throughout the year, it is most frequent in March to

April and August to September (Báez and Jackson 2008), with a peak at the end of summer, in March (Ramorino 1979; Adlerstein 1987). These periods can vary from one coastal region to another. In northern Chile, the major concentration occurs at the end of summer and fall, that is, between February and May (Olguín and G. Jerez 2003). In the Camarones research area (North Chile), the peak seems to occur in April/May (fall), when the mollusks congregate in more shallow waters for spawning. Nevertheless, some variations in these periods are observed in different years, depending on local temperature and food availability (Sr. Jorge Ardilles, local fisherman/diver, personal information, June 2008/June 2010). In summary, reproduction is less intense in spring, summer is a transitional period towards maximum gonadal maturation, fall is the maximum reproductive period, and winter is a transitional period towards a the end of the reproductive cycle (Lara et al. 2007).

After egg eclosion from capsules, the first stage of the loco life cycle begins in pelagic waters. The attachment of the larvae to the substrate and the metamorphosis from a proto shell to a juvenile occurs after three or four months (Wolff 1989). At this time, when the larva settles, it measures about 2 mm long (Báez and Jackson 2008; Guisado and Castilla 1983). The recruitment starts in August and extends until November in north and central Chile (Castilla 1983, 1982 in Wolff, 1989). The juvenile locos live in the intertidal zone until they reach 5 cm and then they start moving towards the subtidal zone. When they reach a size of 10 to 11 cm, they migrate from the shallow subtidal waters to deeper waters. In the area of Pisagua (north Chile), for example, local divers (“buzos”) used to capture locos of this size in about 4 meters of water (local fisherman: personal communication, 2007).

Environmental conditions can affect growth rates in mollusks, as well as spawning and breeding. Also, during their ontogenic development, shells have different growth rates and juveniles grow quicker then mature shells (Claassen, 1998). Each species has a range tolerance for physical-chemical conditions like salinity and temperature, but growth will be affected by abnormal conditions outside their tolerance rate. Temperature tends to have a direct effect on the growth rate of shells: the rate decreases with decreasing temperatures (Alderstein 1987). For *Concholepas concholepas,* the relation between water temperature and the growth rate is not clear (Fernandéz et al. 2007). Studies on such seasonal effects are lacking for this species. However, growth rates on a daily and monthly basis have been investigated under laboratory conditions and reported to be around 30 to 140/200 µm (Guzman et al. 2004; Lazareth et al. 2005). They averaged 0.03-0.2 mm per day or ~ 0.9 to 4.2/6.0 mm per month. Other studies point to a growth rate between 3.00 mm month^{-1}, at Puerto Talcahuano, in central Chile (Lozada et al. 1976 In: Guisado and Castilla 1983), and 3.57 mm - 3.52 mm month^{-1} at Puerto Ilo and Catarindo around Arequipa, in southern Peru (Rabí and Marabí 1997). A shell of one year and a half weighs 40 to 80 grams and measures between 5 and 7 cm in length; at three years, it reaches 10.5 to 12.0 cm and weighs 210 to 330 grams (Báez and Jackson 2008). In summary, although there are variations, a month of growth should be about 1 to 3 mm. A two years old shell should reach a size of 50 to 60 mm (Olguín and G. Jerez 2003).

Studies on the Shell Increments of *Concholepas concholepas*

Given the economic importance of *C. concholepas*, there are several studies on the biology of the mollusk and on the physicochemical structure of its shell (e.g., Guisado and Castilla 1983; Navarro and Torrijos, 1994; Rabí and Marabí, 1997; Dauphin et al. 2003; Guzmán 2004; Fernandéz et al. 2007, Guzmán et al. 2009). An external prismatic layer of calcite and an internal layer of aragonite form the shell. This aragonite layer has a crossed lamellar structure that is thin and less resistant than the calcite layer (Dauphin et al. 2003; Guzmán 2004; Guzmán et al. 2007). The *annuli* structures (or microgrowth increments, or shell growth rings) have been studied with a focus on their micro-nanostructure and chemical composition (e.g. Dauphin et al. 2003, Guzmán et al. 2009). However, despite the variety of approaches the study of the shell growth rings as a seasonal indicator has received none or peripheral attention. Falabella and collaborators (1991) observed, that studies on the shell the growth of the loco were not accompanied by studies on the shell's growth rings, a gap not yet filled by recent studies.

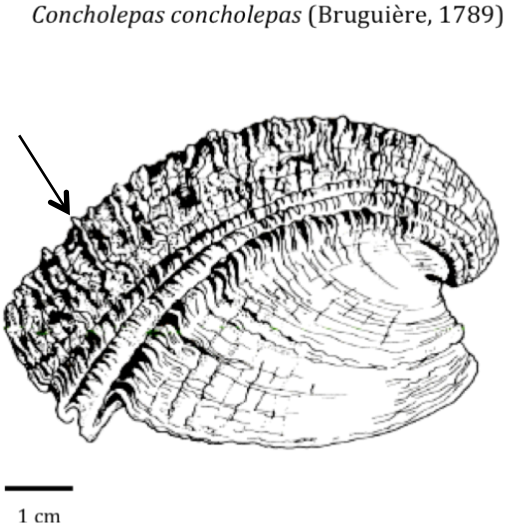

Figure 4.2: Lateral view of the shell (adapted from Bustos et al. 1986). Arrow shows shell ribs or lamellas marks, associated with winter.

The shell of *C. concholepas* is very thick and externally marked by a series of lamellose ribs arranged in a radial and circular-concentric distribution (Figure 4.2). These radial ribs are external growth rings; they are the result of changes in the growth rate of the shell caused by fluctuations in the deposit of calcium carbonate (Lara et al. 2007). Although traditionally used to study the age and growth rate of the mollusk's shells (Bustos et al. 1986; Alderstein 1987; Lara et al. 2007), the correlation of these structures as winter growth marks is generally associated with reduction or cessation of the shells growth's, but this is still not clear (Rabí et al 1996; Stotz 2000; Guzman 2004; Guzman et al. 2007). Variations in the external structure of the shells make it difficult to study the growth rings (Rabí et al. 1996; Stotz 2000). The lay out and formation of external lines varies from one shell to another. Moreover, they are not equally distributed around the external surface of the shell, a fact the author observed when studying *C. concholepas* for this thesis research.

Based on the assumption that the external rings have an annual periodicity, such that each ring represented a year in a mollusk's life, Lara and collaborators (2007) used external growth lines to study growth parameters in *C. concholepas*. To reassure accuracy, shells were double-checked by two different researchers. They identified a tendency in the annual growth cycle: a faster growth associated with the months of spring and summer, and a slow growth associated with fall and winter.

Bustos and collaborators (1986) identified two growth zones in *C. concholepas* shells, one of fast growth characterized by a large band with dispersed marks, and another of slow growth represented by a narrow band with contiguous marks[5]. Using the same approach applied on the study of fish otoliths, they also established that the hyaline ring would form during the winter months in southern Chile, the area of their study (Lara et al. 2007).

The first detailed study of shell growth rings in *C. concholepas* and their formation on a daily bases was done by Adlerstein (1987). She uses surface shell's growth rings as winter marks. These are identified in a cross-cut section of the shell by the dark zones found in the internal area bellow the lamellas. In her study counting the lines, she was able to identify the micro increments on an annual and daily basis (following a lunar cycle of 14 days).

Further north, along the Peruvian coast (Bahía Independencia and Punta Picata), Fernández and colleagues (2007, 2009) studied shells growth using fluorochrome calcein to internally mark calcified structures on locos. They observed that *C. concholepas* grows faster in periods of thermal stability at a temperature around 14^{o} C; growth slows down in

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[5] It is not very clear what the marks means or if the shells were cut, since there is no illustration showing the distinct growth marks.

temperatures higher than 16^{o} C and during periods of high thermal variability. They also called attention to the ontogenic in which shells of young mollusks growth faster than mature or old shells.

Stotz's (2000), in an in-depth study of age and growth rates of *C. concholepas*, notes that the Chilean coast does not have strong seasonal variations in water temperature. Hence, it is hard to interpret growth marks in the majority of the local invertebrate populations. In the case of *C. concholepas*, the reduction in shell growth rates would be directly related to food availability. Working with live populations of *C. concholepas*, Stotz (2000) observed a clear seasonal pattern. Shells showed diminished growth during the winter, in comparison to the spring, when growth increased. The summer and fall showed an intermediate pattern. These differences were directly associated with food availability, which, in turn, is related to temperature variations.

Consequently, the growth rate is, in a certain way, related to the seasons of the year. There are some periods in which the mollusk's growth is faster, unless inhibited by water temperature, food availability, or reproduction. Stotz's (2000) and Lara's (et al. 2007) studies, among others, are useful for the analysis of shell growth rings, as they help explain the growth pattern formation and seasonal growth rate. The challenge here is to understand and find these patterns for *C. concholepas*.

Modern Harvesting Strategies for *Concholepas concholepas*

Since the first settlements along the Pacific coast about 10,000 to 9,000 BP, *Concholepas concholepas* has been exploited and consumed by humans (*e.g*. Llagostera, 1979, Jerardino et al. 1992, Báez and Jackson 2008; Llavallée et al. 2011). In recent times, however, due overexploitation, the harvest of *C. concholepas* has been kept under strict control.

Concholepas concholepas lives part of its life cycle in intertidal zones, where it adheres to rock surfaces. This makes it an easy target for human prey, as during low tides they can be totally exposed. In such times, they can be easily collected in the shallow waters by human foragers. Corrales Muñoz (1988-89) observed that during the reproductive period, when *C. concholepas* congregates in large numbers, they form large spheres adhering one over the other that can be carry to the seashore by the currents. For extraction from the rocks, a type of hook is used to pry them off. With little effort it is possible to collect lots of mollusks t in a relatively short time.

In June, at the beginning of the 2006 winter, the author saw a fisherman-diver collecting *C. concholepas* at the south portion of the Chinchorro beach in Arica. Before he started diving, he and another fisherman opened a net close to the shoreline to catch fish. While he was diving, the other man was taking care of the net and splashing the water with his hands to keep a marine sea lion away that was swimming around. Sea lions come very close to fishnets to try to eat the fish already trapped, destroying the nets in this process. The man who was catching the "locos" did so about 100 meters from the shoreline in shallow waters about 2.0 meters deep. In an hour and a half, he collected 30 adult mollusks. Besides a small bag and a knife, no other equipment was used to collect them or extract the mollusk from the shell. The diver used only his thumb, forcing it between the mollusk's attached muscles and the shell, pulling out the animal from it (Figure 4.3). In 20 minutes he had extracted and cleaned all the 30 shells he had collected.

Figure 4.3: A loco being cleaned after it was collected by a local diver at Praia Chinchorro (Arica, Chile). No tools were used and the cleaning process took less then a minute for each shell. Photo taken in July 2006 by the author.

Figure 4.4: Local people harvesting shells and seaweed on the littoral rock shores close to the city of Arica (Chile). Photo taken in 2008 by the author.

On another occasion, the author noticed a small group of local residents, both men and women, near a flat rock platform along the coastline near Arica. Two were divers wore neoprene clothes to protect themselves from the cold water; another was helping from the surface, while the others were cleaning the shells (Figure 4.4). It seemed like a portrait of the past that had continued to the present day: local groups working together to harvest mollusks, seaweeds, octopus, and sea urchins.

Conclusions

Concholepas concholepas has been harvested by local people since the early Holocene. During spawning peaks, which occur around December and again in April/May in the coast of the Camarones river valley--that *C. concholepas* becomes a more easy prey for human foragers. This is when mature mollusks longer then 7-8 cm move to shallow waters for reproduction. Immature juveniles measuring about 5-6 cm or less, however, can be easily collected at intertidal waters during the entire year. In fact *Concholepas concholepas* is available all year.

Shell Growth Ring Analysis in *Concholepas concholepas* (Bruguière, 1789)

To assess seasonality at Camarones 14 and Camarones Sur, *C. concholepas* is analyzed here using growth ring formation on cross-cut surface sections of the shells. The objective is to determine the seasons of the year in which these shells were collected and used by the inhabitants at the target sites. This should provide a glimpse into mobility patterns.

The results show that internal growth lines in shells of *C. concholepas* can be used to assess seasonality of occupation of these sites. The growth patterns of the lines vary according to the seasons of the year. Therefore, comparisons between samples of archaeological and modern shells allow us to infer in which season harvesting interrupted the growth of archaeological shells. The comparisons are necessary as it is impossible to estimate the season in which an archaeological shell was collected, based solely on the archaeological sample. The procedure then is to map the growth ring patterns from a sample of modern shells and relate these to the different seasons of the year. Next, this constructed map has to be compared to the growth lines of the sampled archaeological shells.

The evidence on the seasons in which the inhabitants of the target sites collected shells enables us to draw conclusions about the seasons in which of the sites were occupied, and thus to make inferences about the mobility patterns. For example, if the statistical analysis shows that the archaeological shells were collected predominantly in the summer, this suggests a seasonal mobility pattern. On the other hand, if the shells were collected during all seasons, this gives indications of a more sedentary pattern. Once basic information on archaeological and modern shells is presented, complementary information data from the sites is also used to evaluate mobility patterns. Examples of other types of evidence include oxygen isotopic analysis, plants, and other faunal indicators (e.g. Bernstein 1990; Claassen 1998; Andrus 2012). Some of these points are addressed later in this chapter.

Three characteristics of the growth lines of modern shells are related to the seasons of the year: the angles of the lines, the space between lines, and the number of lines. This is done with the support of descriptive statistics (histograms), nonparametric analysis (contingency tables), and parametric analysis (chi-square tests and regressions). These rigorous techniques for analyzing data make the results of the research reliable. Histograms allow for the visual inspection of data. Contingency tables can detect correlations between the growth lines and seasons. Because it is nonparametric, it does not rely on assumptions about the underlying statistical distribution of shell populations. This is not the case for parametric tests, which do rely on population distributions. Thus, to make the results of the statistical tests valid, the data on growth lines and seasons must satisfy certain requirements. The data collected for this research fulfills these requirements. The advantages of the parametric tests is that they are able to summarize in a single number whether or not there is a positive correlation between the growth lines of the shells and the seasons of the year; the regression analysis gives us a sense of its extent.

As a reference point, the analysis of archaeological shells uses the correlations between characteristics of modern shells and the seasons of the year. The statistical analysis of archaeological shells compares their growth lines to the growth lines of modern shells according to different seasons of the year. If for a specific season, the sample of archaeological shells turns out to have the same patterns found in modern shells, we can infer that the archaeological shells were collected in that season. For example, if the proportion of downward slopping angles in modern shells collected during the spring-summer is not statistically different from the proportion found for archaeological shells, this suggests that the latter were collected in the spring-summer. The most appropriate test for the comparison of proportions is the exact binominal test.

This is a parametric test designed to deal with both a small sample size and qualitative data, which is the case for the sample of archaeological shells.

The statistical analysis of modern shells found that fall and winter are correlated with upward sloping angles (or high angles) in growth lines while spring and summer are correlated with downward sloping angles (or low angles). In the spring, the number of growth lines tends to be low and the lines are dispersed. Through the rest of the year, growth lines tend to be high in number and compressed. All these points are discussed below.

This section describes how the modern and archaeological shells were collected and how they were physically prepared for the analysis via crosscut sections. Then it explains, separately the analysis performed on modern and then on archaeological shells. Finally, the shell samples are compared.

Material and Methods

The sample of modern shells comes from areas surrounding the Camarones delta valley, which is near the targeted sites. A local diver collected the shells alive and the season of their collection was recorded[6]. The final sample for the analysis consists of 226 shells. Of these, 19 were collected in the fall (March/April), 48 in the early winter (June), 47 in the early spring (September), and 33 in the early summer (December) of 2008. Some 79 shells were collected during the high summer (January and February) of 2010 adding up to 112 for the entire summer (see Table 4.1)[7].

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[6] The necessary permit to collect this species was obtained at the Secretaria de Pesca (Chile).

[7] The initial sample had 265 modern shells. There were 39 shells that could not be used because they broke during harvesting, in their transfer to United States, or during sample preparation. In this last case, they ended up fragmented by the water saw while they were being cut. Since they

Table 4.1: Number of modern shells of *Concholepas concholepas* analyzed per season

Seasons			
Spring	Summer	Fall	Winter
47	112	19	48

For archaeological shells the sample consists of 69 specimens from Camarones 14 and 160 specimens from Camarones Sur. These were recovered during the fieldwork seasons of 2007 and 2008, respectively. The shells from Camarones 14 site come from a Preceramic context[8] of marine foragers related to the Chinchorro culture dated to around 7,500 to 6,000 BP (Schiappacasse and Niemeyer 1984), and from more recent layers not radiocarbon dated.

The shells from Camarones Sur come from two periods, the Terminal Chinchorro (Transitional Period Alto Ramirez/Chinchorro) about 3,000 BP and the Post-Chinchorro. The Post-Chinchorro is divided into the Alto Ramirez Regional Development[9] (RDA) about 1,000 BP and the Later Regional Development Period[10] (LRD) about 600 BP (Rivera, 1984, personal information 2012).

The initial number of shells selected and the final number of shells studied after samples preparation and trial are presented in the table bellow (Table 4.2). It shows the distribution of the shells in each of the sampled layers from both sites, Camarones Sur and Camarones 14.

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broke randomly the missing information should not interfere in the results of the statistical analysis.

[8] The more recent context, post-Chinchorro (Saxamar culture) (Schiappacasse and Niemeyer 1984), did not generate enough samples for analyzes.

[9] "Desarollo Regional Alto Ramirez" - RDA

[10] "Desarrollo Regional Tardío" – LRD

Table 4.2: *Concholepas concholepas* - Distribution of archaeological shells per layers

Camarones Sur			Camarones 14		
Final Layers	Shells studied	Shells selected	Final Layers	Shells studied	Shells selected
Layer 1	40	42	3	0	1
Layer 2	34	38	7	9	10
Layer 4	20	25	9	2	2
Layer 5	16	19	10	12	13
Layer 9	10	10	11	11	13
Layer 10	20	20	12	2	3
Layer 11	13	12	14	10	10
Layer 12/14	5	5	15	12	12
Burial area	4	4	17	12	13
Total	162	176		70	77

Seasonality and Growth Lines in *Concholepas concholepas*

In studies of *C. concholepas*, seasonality is mainly correlated with reproductive behavior (e.g. Wolff 1989; Rabí et al. 1996, Báez and Jackson 2008), age and shell growth (e.g. Bustos et al. 1986, Lara et al. 2007). The shell's external growth rings are used to study age-growth rates (Stotz 2000). In general, these growth rates are much reduced or cease entirely due low water temperatures in the winter (Claassen 1998). For the mollusks from the Chilean coast, however, this relation is not direct. The Chilean coast does not have such marked seasonal differences in water temperature, but only short time seasonal variations (Stotz 2000). Consequently, studies at the population level are necessary to identify possible seasonal patterns.

Stotz's (2000) study showed that the shells of *C. concholepas* reduced their growth in winter and increased it in the spring, while in other seasons it remained intermediate. Stotz proposed that in the case of *C. concholepas*, the reduction or cessation of growth would be directed related to the food availability.

The literature on *C. concholepas* never considers the angle at which the internal growth lines are formed. This is visible on the inside of the shell through a cross-cut section. In fact, relating the angle of formation of growth lines in shells of *C. concholepas* to the seasons of the year is an exploratory hypothesis studied here in this thesis. It follows a general observation made by Maia and Pimenta (2007) in studies of *Mesodesma,* that the direction of the angles of the growth lines change according to the seasons of the year. Based on this, the author decided to test whether this correlation would be valid for the *Concholepas concholepas*. In fact, a positive correlation was found between the angles and the seasons; for fall and winter the tendency was for the angles to be higher; during spring and summer, the angles were lower.

The next section discusses how the analysis of growth lines of *C. concholepas* was conducted. It shows that the growth line angles turned out to be a reliable indicator of seasonality.

Preparation of Shells and the Morphological Analysis

Modern and archaeological shells were first cut longitudinally with a diamond blade water saw machine. The resulting cross-sections were grounded and polished to make the growth lines more visible (Figure 4.5).

Figure 4.5: Section of a cut shell of *C. concholepas* being polished using a machine prepared with Brasso, a liquid polishing product used to highlight the growth lines.

The physical analysis was by visual inspection with a low magnification binocular microscope, a Bausch and Lomb under 0.7X to 3.0X resolution. Amplifying the visual field allows one to detect changes in the disposition of the growth lines along the prepared cross-section of the shell. This approach can highlight changes in the direction of the angles in which the growth lines were formed (growth line angles), as well as to observe the distribution of the last growth lines close to the shell tip[11].

Before the adoption of this final procedure, two other unsuccessful procedures were tried. In the first, a small number of shells from the archaeological and modern samples were embedded in epoxycure resin (Bueher) for acetate peels etching. The prepared cross-sections were etched in 10% hydrochloric acid for approximately 1 minute. This method with the acetate peels, however, did not work as expected and lines

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[11] This approach expedites and improves the analyses; changes in growth line directions are more easily perceived when compared with other portions of the shell.

were difficult to distinguish. Perhaps the etched time of 1 minute was excessive for the archaeological shells, and this damaged their growth lines.

Figure 4.6: Modern sample of *Concholepas concholepas* shell sectioned for the analysis. (Photo of the author).

In the second procedure, modern and archaeological shells were initially photographed using a metallurgical microscope with a camera connected to a computer. Photos were taken from the extreme edge of the shell using a 25X and/or 50X magnification. The idea was to focus on the area close to the edge of the shell. The high resolution, however, restricted the image to a short portion of the extreme edge and did not allow for a more complete view of the features formed along the cross cut section[12]. This short area covers one month or less in a mollusk's life span, which is insufficient for studying seasonal patterns in *C. concholepas*. This requires a more complete view in

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[12] This approach was too late and too inappropriate for this study. *C. concholepas* is a large shell, and the modern ones has a medium size of about 10 cm. This kind of analyses for this shell requires a view of the transitions represented by the seasons that include the analyses of a more large area to check the point in which growth lines change direction.

order to look for growth patterns. Below (Figure 4.7), is a photocomposition from a low resolution binocular that shows a *C. concholepas* shell already prepared for analysis[13].

Using visual inspection with low magnification, modern shells were analyzed first. The objective was to detect characteristics that are systematic in growth ring formation. This qualitative analysis is based on morphological traces. All modern shells were analyzed for internal growth lines, specifically, the distribution and position of the growth lines on the cross cut section.

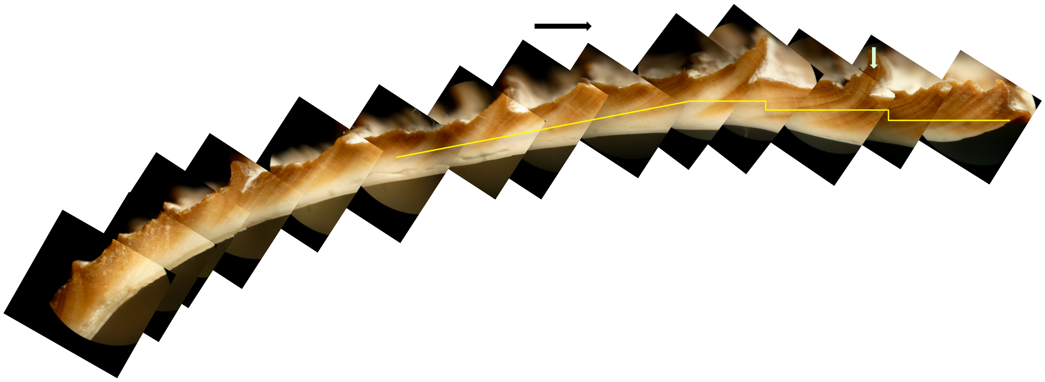

Figure 4.7: Mosaic view of a transverse cut of a modern *C. concholepas* with growth lines showing up along the section. The yellow line is an arbitrary plane traced in parallel with the internal margin of the shell to help visualize the angles at which the growth lines were formed. The small white arrow shows a point in which the angles of the lines are in upward slope. Immediately in front and behind, they are in downward slope position. The black arrow outside the photo shows direction of growth. Figure 4.8 and Figure 4.9, below, show a detached view of this section of the shell.

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[13] Figures 3, 4 and 5 presented later, are sections taken from this photo mosaic.

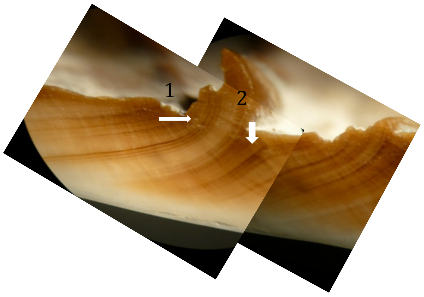

Figure 4.8: Detailed views of a shell section; arrow 1 shows the point at which the angles change direction from a downward to an upward slope; arrow 2, the change is from upward to a downward slope position.

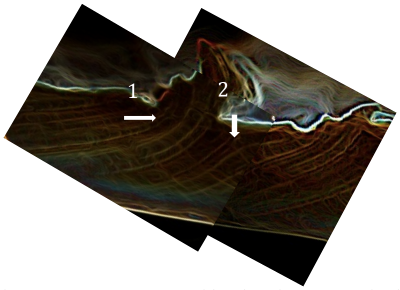

Figure 4.9: Detailed views of the shell section shown on figure 4, with growth lines detached by filter.

Before proceeding to the next step, note that the term "growth lines" is used here to describe the thin, dark, internal laminations that are formed between the white bands (Jones et al. 1978; Thompson et al. 1980). When referring to the external lines distributed on the surface of the shell, the term used in this thesis is "external growth lines".

After visual inspection, three main shell characteristics seemed potentially relevant to seasonal studies: the angles of the growth lines, the space between the lines, and the number of lines. It was observed that the distribution of the lines has a tendency to vary in relation to the angle at which the growth lines were formed. The next step was to verify if these variations did, in fact, reflect any seasonal parameter. The area close to the tip of each of the sampled shells was then studied and classified according to these three parameters.

a) Angles. The angles of the growth lines formed near the tip. It refers to the disposition of the growth lines based on their angles, that is, if the angles formed by the growth lines are low or high in relation to the preceding ones. In this study they were classified as downward sloping (dws), for low angles, or upward sloping (ups), for high angles (Figures 4.8 and 4.9, and Figures 4.10, 4.11, below).

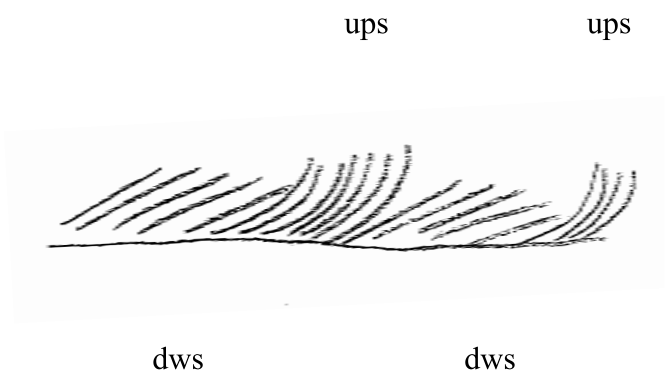

Figure 4.10: The classification of the angles in a schematic representation of shell growth lines. It shows lines with low angles or downward sloping (dws), and lines with high angles or upward sloping (ups).

Figure 4.11: Tip of a modern shell with growth lines in ups (n^{o} 1), then changing to dws (n^{o} 2) and at the extreme edge, they begin to return to ups (n^{o} 3).

b) Space Between Lines. This refers to where the lines are distributed on the very edge of the shell, if they are formed more distant from each other (dispersed) or if they are formed close to each other (compressed) (Figure 4.12; 4.13).

c) Number of lines. This refers to the number of growth lines near to the extreme edge of the shell, that is, if there are more or less lines formed in this area than in the preceding area (Figure 4.12; 4.13).

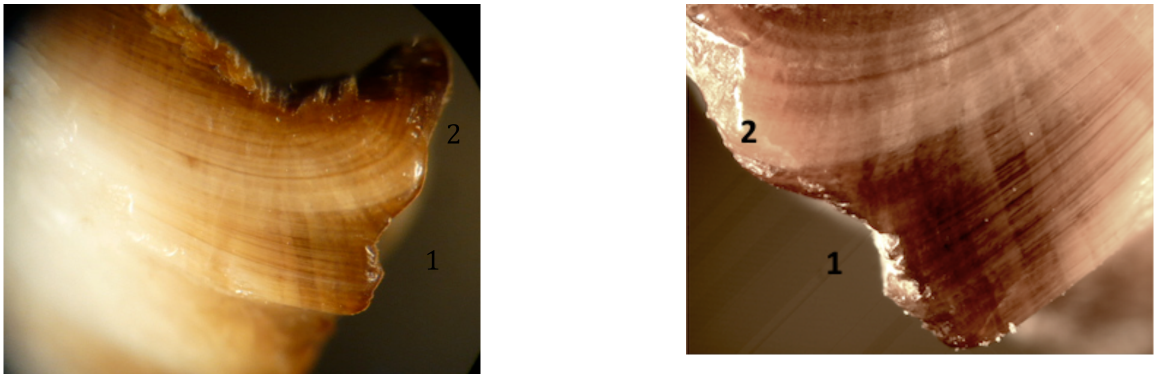

Figure 4.12 and 4.13: Details of a tip of modern shell sample. Zones 1 and 2 depict portions of the shell close to the tip in which the lines are dispersed (2) with line angles in upward slope positions. At the very end, the angles of the lines change (downward slope) and the lines are compressed (1), that is, formed closer to each other.

Notice that the second and third categories (b) and (c) are complementary. When growth lines are located close to each other, they are also occurring in large numbers, and when growth lines are formed more distant from each other, they are also occurring in smaller numbers (conf. Table 4.4). The opposite is also valid, that is, when growth lines are formed more spaced from each other, they are also in low numbers. Growth lines formed more spaced from each other are likely to reflect a faster growth of the shell; this point, however, is not conclusive, at least without live specimens studied in a controlled environment. Thus, although both categories were initially studied here separately, they can be understood as just one single category. The effect for this is that for the seasonal analysis, only one category, “space between lines”, was chosen and studied in comparison with the first category, “line angles.”

Before selecting the final patterns for this study, other alternative analysis were tried, but they are not applied by different reasons, as explained in the next section.

Alternative Approaches

An alternative approach to the study of the growth lines was to take the precise measurement of the angle. This was tried and turned out to be time consuming and with ambiguous results. The fact is that the angle in one line varies depending on at which point the line is being measured. This is because the lines are not straight, they twist in many points, what make them difficult to study (Ernesto Fernandez, personal communication, February 2011). The angles vary depending on the point where the line is initially formed, the point where it is finishing, and the shape of the surface and the base of the shell. To test accuracy, the angles of some shells were measured more then once, and gave different results. Measure the angles in *Concholepas* is challenge and it is an open field in its study (Ernesto Fernandez, personal communication, February 2011). Thus, a qualitative analysis by visual inspection was preferred to a questionable quantitative approach. The visual inspection it allowed the examination of an ample area of the shell and a way to categorize the tendency of the angles of the growth lines as distributed along the surface of the shell (Figure 4.7).

An approach based on the external characteristics of the shell, the lamellas, was also tried. The shape of the lamella was analyzed through a cross cut section. The idea was to look for patterns related to the seasons. A tentative typology based on shape, as seen in the cross cut section on the edge of the shell was constructed (e.g. Figure 4.14 and Figure 4.15). This typology was based on the shape of the prior lamella formed on the tip of the shell. Four types were identified according to the form of the shell tip in a cross-cut section: Type 1 in which the extreme edge has a format that resembles a hook; Type 2 (Figure 4.15) in which the lamella divides, forming a bifurcation; Type 3 (Figure 4.14) in which the edge of the shell grows straight after the rib was formed, and Type 4 in which the curvature of the rib forms a slight curve. However, during analysis, it was noticed that although this external decoration is highly elaborated, it does not develop equally along the entire line of the shell where it is formed, and different types can be observed on the same line, depending on where the cut is located (Figure 4.16). Hence, although it seems that some types relate to certain seasons of the year, a more complete analysis is still necessary prior to using these features as an indicator of seasonality. Consequently, this typology was not used in the statistical analysis presented here. The tables with the typology on modern and archaeological shells are presented in the Appendix section (Appendix A1 and A2). A preliminary analysis is presented in table 1a and it is based on the percentage of types and seasons of the year.

Table 4.3: Percentage of shell types, according with the seasons of the year (modern shells)

Seasons	Types 1 = hook, 2 = dividing, 3 = straight, 4 = curved				Total
Type:	1	2	3	4	%
Winter	30.4	28.3	28.3	13.0	100
Spring	14.3	34.7	32.7	18.4	100
Summer	19.2	26.9	27.7	26.2	100
Fall	26.3	15.8	26.3	31.6	100

The results suggest that winter is related primarily to Type 1 and secondarily to Types 2 and 3. These types are evenly distributed here. Spring is more related to Type 2, followed by Type 3. Summer is more related to Type 3, followed by Types 2 and 4. Fall is related primarily to Type 4, and secondarily to Types 1, and 3.

Despite the fact that the external growth lines show some irregularities (Figure 4.16), a progressive pattern is observed between types and the seasons of the year. The progression is based on the sequence from one type to another along the seasons that extend from Types 1 - 2 - 3 (winter), Types 2 - 3 (spring), Types 2 - 3 - 4 (summer), and Types 1 - 3 - 4 (fall). This sequence is a tip with a hook shape (Type 1), then this hook starts dividing and a linear point begins to form from the base of the hook (Type 2), then it develops straight down, probably indicative of fast growth (Type 3), and finally, the tip begins to curve, closing the formation cycle. The primary type for each season shows this sequence: winter – Type 1, spring – Type 2, summer – Type 3, fall – Type 4.

Bellow, Figures 4.14 and 4.15, show examples of two of the morphological variations in the terminal portion of the shell, defined as Type 3 and 2, respectively. As already discussed, this typology, although it has potential, was not used in the analysis of the archaeological samples. This was because variations in the shape of the tip could vary depending on where the shell was cut. Moreover, the external growth rings were not equally developed along the surface of the shell (Figure 4.16). However, it should be considered in the future as possible seasonal indicator.

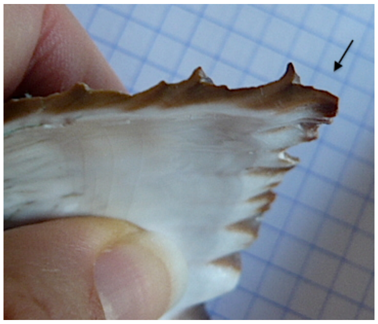

Figure 4.14: Type 3. The arrow shows the tip of the shell in a cross-cut section, classified as Type 3; it ends in a linear shape below the lamella.

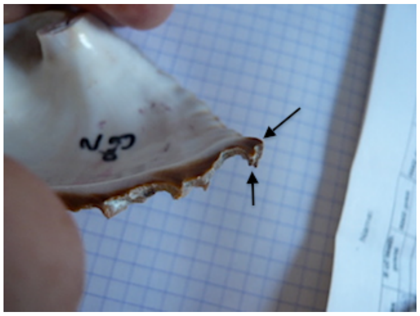

Figure 4.15: Type 2. Arrows show the bifurcation that characterizes this type.

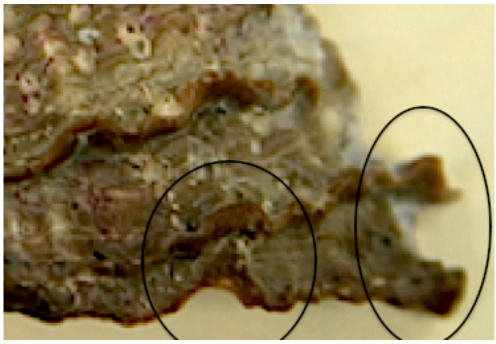

Figure 4.16: Example of irregularities in the morphology of the external growth lines and lamellar structures in the shells of *C. concholepas*. The circle to the left shows the two lines and the lamellas formed very close to each other, unlike the structures in the circle to the right.

In summary, it was concluded that the best approach for the analysis of seasonality in *Concholepas concholepas* was to focus on the disposition and distribution of the internal growth lines visible on the shell. Thus, for the classification of the shells, a qualitative approach based on the visual analysis of the shells was preferred.

The three categories selected for the statistical analysis based on the morphological aspects of the shells structure are: growth line angles, space between lines, and number of lines. These three categories were systematized on each of the modern and archaeological shells, and then analyzed using the statistical tests mentioned before. The results are presented in the following sequence.

Statistical Analysis

a) Characteristics of Modern Shells and Seasons of the Year

Table 4.4 summarizes the findings of the physical analysis with the three categories of the growth lines of modern shells, according to the different seasons of the year:

Table 4.4: Modern shells of *Concholepas concholepas*: Relation between seasons of the year and growth lines' features.

Categories / Seasons	**Spring**	**Summer**	**Fall**	**Winter**
No. of shells	47	112	19	48
Angle				
Downward Sloping	29	59	4	20
Upward Sloping	18	53	15	28
Space between lines				
Dispersed	27	46	4	19
Compressed	20	66	15	29
Number of Lines				
Low	26	46	3	19
High	21	66	16	29

As show in Table 4.4, with respect to the spring season, in the category "Angle", the growth lines of 29 shells are downward sloping, while the remaining 18 are upward sloping. For the space between lines category, 20 are compressed (formed close to each other) and 27 are dispersed (more spaced). For the third category, 26 shells have a lower number of growth lines near to the tip, and 21 have a higher amount of growth lines. As mentioned previously, notice the correspondence between "Space" and "Number of Lines," where both categories present almost the same results.

Below are the histograms (Figure 4.17) elaborated for modern shells in which each of the three categories is graphically represented according to the seasons of the year. Results are discussed after the charts.

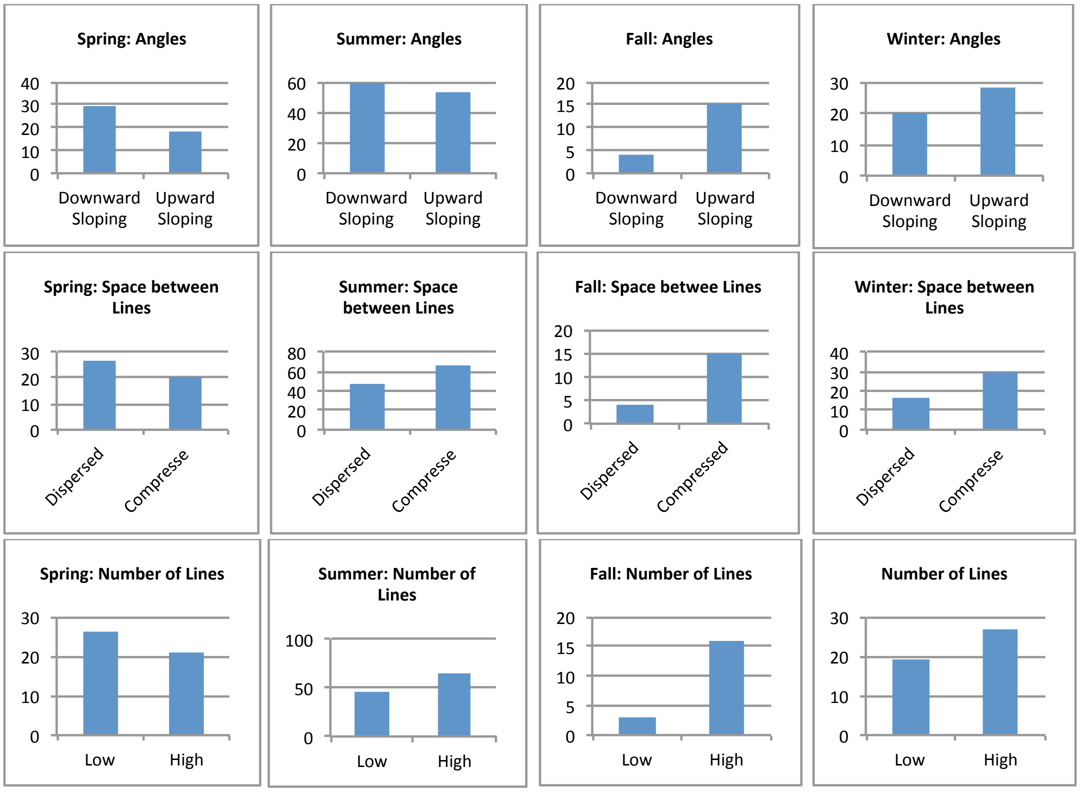

Figure 4.17: Histograms of modern shells of *Concholepas concholepas* with seasons of the year and growth lines' features

For the line angles (Label as "Angles" in the charts), two clear patterns emerge, one for summer-spring and the other for fall-winter. For summer and spring, there is a downward sloping trend. The opposite situation is seen during fall-winter, in which downward slopping angles are less frequent. The number of growth lines tends to be low and the lines dispersed only in the summer[14]. Throughout the rest of the year, growth lines tend to be compressed and high in number. This suggests a faster shell growth during spring and possible into the summer, as a transitional phase. During the fall and winter, the growth tends to diminish; growth lines are formed with upward sloping angles, which are closer to each other and higher in numbers.

In order to validate of the correlations between growth lines and seasons, more rigorous statistical tests are necessary. The following statistical analysis uses contingency tables (Table 4.5, 4.6 and 4.7), for chi-square tests. Two types of chi-square tests are used: Pearson and Likelihood. The results appear below each table.

Table 4.5: Contingency table for number of lines and seasons of the year (modern shells)

Angle	Spring	Summer	Fall	Winter	Total
Downward Sloping	29	59	4	20	112
Expected Frequency	*23.3*	*55.5*	*9.4*	*23.8*	*112*
Upward Sloping	18	53	15	28	114
Expected Frequency	*23.7*	*56.5*	*9.6*	*24.2*	*114*
Total	47	112	19	48	226

Pearson chi-square test: probability of $\chi^2 > 10.58$ *on 3 degrees of freedom = 0.014*

Likelihood-ratio chi-square test: probability of $\chi^2 > 11.025$ *on 3 degrees of freedom = 0.012*

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[14] The reasons for upward and downward slopes are not clear, but since they are having a seasonal effect in certain syncronity with the results report in Stotz (2000), this should be related with food availability connected with water temperature.

Table 4.6: Contingency table for space between lines and seasons of the year (modern shells)

Space between lines	Spring	Summer	Fall	Winter	Total
Compressed	20	66	15	29	130
Expected Frequency	*27*	*64.4*	*10.9*	*27.6*	*130*
Dispersed	27	46	4	19	96
Expected Frequency	*20*	*47.6*	*8.1*	*20.4*	*96*
Total	47	112	19	48	226

Pearson chi-square test: probability of $\chi^2 > 8.13$ *on 3 degrees of freedom = 0.043*

Likelihood-ratio chi-square test: probability of $\chi^2 > 8.38$ *on 3 degrees of freedom = 0.039*

Table 4.7: Contingency table for number of lines and seasons of the year (modern shells)

Number of Lines	Spring	Summer	Fall	Winter	Total
Low	26	46	3	19	94
Expected Frequency	*19.5*	*46.6*	*7.9*	*20*	*94*
High	21	66	16	29	132
Expected Frequency	*27.5*	*65.4*	*11.1*	*28*	*132*
Total	47	112	19	48	226

Pearson chi-square test: probability of $\chi^2 > 8.95$ *on 3 degrees of freedom = 0.030*

Likelihood-ratio chi-square test: probability of $\chi^2 > 9.57$ *on 3 degrees of freedom = 0.023*

Table 4.5 is a contingency table where the raw values for the angle of growth lines are distributed according to the seasons of the year. The main advantage of this analysis is that it does not make assumptions about the nature or parameters of the population from which the samples were drawn. For example, it does not assume a normal distribution underlies the population of shells. The raw values in Table 4.5 suggest that in the spring and summer there are more shells with downward sloping angles than in the fall and winter. Of the 47 modern shells collected in the spring and the

112 collected in the summer, 29/47= 62% and 59/112= 53%, respectively, present downward sloping angles. In the fall and winter the trend is inverted: 15/19=79 percent and 28/48=58 percent respectively present upward sloping angles.

The expected frequencies appear below the raw values on the table. They can be understood as the frequencies that one would expect if there is no relationship between the angles and the seasons of the year that define the rows and columns of the table. The chi-square test describes with a single number how much the observed frequencies in each cell in the table differ from the expected frequencies. In addition, if we expect a large number of shells to fall in a given cell, a difference of one shell between the expected and observed frequencies is less important than in cases where we expect only a few shells to fall in the cell.

The main advantage of using chi-square is that it is specially designed for qualitative data in which there is no arithmetic relationship between the different classifications of growth line characteristics. The test is a parametric statistical method, which implies that the population from which the samples were drawn follows a normal distribution. Because of this assumption, the main restriction built in the use of chi-square statistic is that the expected number of shells in all cells must be at least 5. The smallest value for an expected frequency observed in Table 4.5 is 9.4 (on the second row, third column). Therefore, the results of the test are reliable because this value fulfills the restriction.

The procedure for the chi-square test is to construct a null hypothesis. The adequate null hypothesis for this type of test states that there is no correlation between the angles of the growth lines and the seasons of the year. The value of chi-square is calculated using the data from Table 4.5. If the chi-square statistic is greater than a critical value (usually set at a 5% significance level), this means that the null hypothesis is not accepted and it must be the case that there is a correlation between the angles and seasons of the year. As shown in Table 4.5, the Pearson chi-square statistics is 10.58, which is greater than the 7.815 critical value. This means that the null hypothesis is not accepted and there is a correlation between angles and seasons. Another way to see the result is that the probability of chi-square should be greater than 10.58 on the bottom of the table. Any probability smaller than 5% means that the null hypothesis should not be accepted. In this case it has 1.4%, which is smaller than 5%. This is why the null hypothesis is not accepted.

The Likelihood ratio chi-square test is an alternative to Pearson and it is based on maximum likelihood theory. This test tends to deal with small samples better than Pearson and therefore it is added to the analysis. The procedure is the same as Pearson, only the calculation of the chi-square statistics is slightly different from Pearson. If we look directly at the probability of chi-square being greater than 11.025 we find that the value is 1.2%, which is smaller than 5%. We then do not accept the null hypothesis of no correlation between angles and seasons, and as for the test that uses Pearson, it must be the case that there is a correlation between angles and seasons.

Tables 4.6 and 4.7 are contingency tables where raw values for the space between growth lines and the number of growth lines are distributed according to the seasons of the year. Because the values of the two categories mirror each other they lead to the same results and therefore are presented together. The information referring to Table 4.7

appears between brackets. The analysis of both tables is analogous to the analysis of Table 4.5, therefore only the numerical results are discussed.

The raw values in Table 4.6 (3.3) suggest that in the fall and winter there are more shells with compressed (high number) growth lines. Of the 19 shells collected in the fall and the 48 collected in the winter, 15/19= 79% (16/19= 84%) and 29/48=50 percent (28/48= 58%) respectively present compressed (high number of) growth lines. The expected frequencies appear in italic below the raw values on the table and they fulfill the chi-square restriction that the expected frequency be at least 5. Therefore, the results of the test are reliable.

The Pearson chi-square statistic is 8.13 (8.95), which is greater than the critical value of 7.815. This means that the null hypothesis that no correlation exists between the space between lines (number of lines) and the seasons of the year is not accepted. Consequently, there is a correlation between the space between lines (number of lines) and the seasons. To see this, it is enough to look at the probability of chi-square being greater than 8.13 (8.95). The value is 4.3% (3%), which is smaller than 5%.

In the Likelihood ratio chi-square test, the probability of chi-square being greater than 8.13 (8.95) is 3.9% (2.3%) which is smaller than 5%. Again we do not accept the null hypothesis of no correlation between the space between lines (number of lines) and the seasons. Consistent with Pearson, it must be the case that there is a correlation between angles and seasons.

These tests were applied to modern shells of *C. concholepas* to verify if correlations existed between each of the three categories -- line angles, the space between the lines, and the number of growth lines -- and the seasons of the year. The results show that a correlation exists between these attributes and the seasons, and that the strongest association is that between angles and seasons.

To refine those results, a regression analysis was done for each category. The respective tables (4.8 and 4.9) and coefficients are presented below.

Table 4.8: Regression results for seasons of the year and angle of the lines (modern shells)

Dependent variable: seasons of the year	*Coefficient*	*Standard Error*	*z*	*P>z*	*95% Confidence Interval*	
Angle of the lines	*0.661*	*0.254*	*2.600*	*0.009*	*0.163*	*1.159*
/cut1	*-1.037*	*0.198*			*-1.425*	*-0.649*
/cut2	*1.228*	*0.206*			*0.823*	*1.632*
/cut3	*1.684*	*0.222*			*1.249*	*2.119*
Log-likelihood (1)	*-270.410*					
Likelihood-ratio χ^2 (1) (2)	*6.88*					
Prob > χ^2 (3)	*0.009*					
Pseudo-R^2	*0.013*					
Observations	*226*					

[1] The ordered logistic model uses maximum likelihood method in its calculations, which is an iterative procedure. The first iteration is the log likelihood of the "null" or "empty" model; that is, a model with no predictors. At the next iteration, the predictor is included in the model. At each iteration, the log likelihood increases because the goal is to maximize the log likelihood. When the difference between successive iterations is very small, the model is said to have "converged", the iterating is stopped and the results are displayed. For more information on this process, see Regression Models for Categorical and Limited Dependent Variables by J. Scott Long.

[2] This is minus two (i.e., -2) times the difference between the starting and ending log likelihood.

[3] This is the probability of obtaining the chi-square statistic given that the null hypothesis is true. In other words, this is the probability of obtaining this chi-square statistic (6.88) if there is no effect of the independent variables, taken together, on the dependent variable. This determines if the overall model is statistically significant. In this case, the model is statistically significant because the value is less than 0.05.

Table 4.9: Regression results for seasons of the year and space between lines

Dependent variable: seasons of the year	*Coefficient*	*Standard Error*	*z*	*P>z*	*95% Confidence Interval*	
Space between Lines	*-0.554*	*0.257*	*-2.160*	*0.031*	*-1.058*	*-0.050*
/cut1	*-2.143*	*0.413*			*-2.952*	*-1.333*
/cut2	*0.103*	*0.379*			*-0.640*	*0.845*
/cut3	*0.553*	*0.383*			*-0.198*	*1.304*
Log-likelihood	*-271.498*					
Likelihood-ratio χ^2 *(1)*	*4.7*					
Prob > χ^2	*0.030*					
Pseudo-R^2	*0.009*					
Observations	*226*					

The result of the first regression concerning “angles of the lines” and “seasons of the year”, shows that the upward sloping angles are associated with fall and winter (coefficient = 0.661). For the second regression, “space between the lines” and “seasons of the year”, the variable ‘dispersed lines’ are associated with spring and summer (coefficient = -0.554), while the third regression, “number of lines’ and “seasons of the year” shows that the higher number of lines close to the shell tip are associated with fall and winter (coefficient = 0.538). However, although all three categories are associated with certain seasons of the year, only “angles of the growth lines” shows a statistically significant relationship (.01 level or 1%) with seasons of the year. The other two categories have a somewhat weaker relationship with the seasons (statistically significant at the .05 level).

Based on these results, the main feature chosen to analyze the archaeological sample was the angle of variation. Since the space between lines and the number of lines correlated in the histograms, the category “space between the lines” (or space) was also selected to analyze the seasonality of archaeological shells.

b) Archaeological Shells and the Seasons of the Year

The objective of this study is to verify whether the shells from the target sites have seasonality patterns that could reveal when they were collected. If so, a careful analysis of the shells could indicate the time of the year that the sites were actively used. For this study, archaeological and modern shells were prepared as previously explained. The morphological and statistical analyses discussed above show that growth line patterns along a shell cross-section correlate with the seasons of the year. More specifically, these patterns are angles and distribution of growth lines located close to the tip of the shell. The database with the collected information is in the Appendix A1.

The statistical analysis of archaeological shells compares the growth lines of these shells with the patterns of growth lines on modern shells. If the archaeological shells have the same patterns found in modern shells for a specific season, we can infer that the archaeological shells were collected in that season. For example, if the proportion of downward sloping angles in modern shells for the spring-summer is not statistically different from the proportion found in archaeological shells, this suggests that the latter were collected in the spring-summer. The most appropriate test for the comparison of proportions is the “exact test for goodness-of-fit” or “exact binominal test”. The small sample data for the archaeological shells was the determining factor in the selection of this test. It is used for small samples where the nominal variable has only two values. This is the case here. The one nominal variable, “angles” for example, has only two values, “downward sloping” and “upward sloping”. The same is true for the nominal variable “space” with “dispersed” and ”compressed” as the two values.

The Exact Binomial Test calculates a single number to indicate whether or not proportions coming from two different samples are similar. The null hypothesis is that the proportion of a characteristic in modern shells is the same as the proportion of the same characteristic in archaeological shells[15]. With this in mind, for each season, data from the archaeological collection were compared with the frequency of the occurrence (the expected data) of each observed variable on modern shells per season; a two tail-test was applied. Using this method, a seasonal evaluation was generated for each site following the layers or macro strata in which the shells were collected.

b.1. Samples from Camarones Sur

The shells sampled from Camarones Sur came from nine layers collected from the East Profile that covers two periods, the RDA (Regional Development Alto Ramirez) about 3,000 BP to 1,000 BP (Terminal Chinchorro), and the LRD (Later Regional Development) about ~600 BP as well as from a burial, probably associated with the LRD period[16].

As already explained, the shells were initially analyzed according to their morphological characteristics. They were assessed by profile layer and then separated by each of the two categories, angle and space. After the qualitative analysis and

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[15] For example, if in one season the variables A and B for modern shells have an equal distribution, than the expected proportion of these variables on the archaeological samples would be 50% for each.

[16] During the excavation of June, 2008, by Rivera, a burial was found in the north portion of the East Profile (extension 1). Burial area refers to this section of the profile where human bones were found. The shells came from the same area, possibly, associated with these remains.

systematization[17], the markings on the archaeological shells were compared to those on modern shells were using the binominal test as explained before. The results are systematized and presented in the subsequent tables. Numbers marked in yellow refers to positive results that correspond to the seasons in which the archaeological shells fit.

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[17] For raw data see Appendix A2.

Table 4.10: Archaeological Shells from Camarones Sur. Exact Binomial Test

	Layer 1								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	21	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	19	18	38.30	53	47.32	15	78.95	28	58.33
Total	40	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.256		1.000		0.000		0.199
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	17	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	23	20	42.55	66	58.93	15	78.95	29	63.04
Total	40	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.077		0.873		0.003		0.513

	Layer 2								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	14	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	20	18	38.30	53	47.32	15	78.95	28	58.33
Total	34	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.020		0.229		0.009		1.000
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	12	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	21	20	42.55	66	58.93	15	78.95	29	63.04
Total	33	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.021		0.724		0.032		1.000

	Layer 4								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	13	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	7	18	38.30	53	47.32	15	78.95	28	58.33
Total	20	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.822		0.272		0.000		0.041
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	11	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	9	20	42.55	66	58.93	15	78.95	29	63.04
Total	20	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.825		0.176		0.000		0.107

	Layer 5									
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	12	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	4	18	38.30	53	47.32	15	78.95	28	58.33
Total	16	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.316		0.042		0.000		0.009
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	9	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	7	20	42.55	66	58.93	15	78.95	29	63.04
Total	16	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			1.000		0.215		0.000		0.066

	Layer 9								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	6	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	4	18	38.30	53	47.32	15	78.95	28	58.33
Total	10	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			1.000		0.757		0.008		0.337
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	8	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	2	20	42.55	66	58.93	15	78.95	29	63.04
Total	10	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.206		0.007		0.000		0.007

	Layer 10								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	15	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	5	18	38.30	53	47.32	15	78.95	28	58.33
Total	20	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.257		0.046		0.000		0.005
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	12	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	8	20	42.55	66	58.93	15	78.95	29	63.04
Total	20	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			1.000		0.068		0.000		0.038

	Layer 11								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	7	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	6	18	38.30	53	47.32	15	78.95	28	58.33
Total	13	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.578		1.000		0.009		0.408
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	3	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	9	20	42.55	66	58.93	15	78.95	29	63.04
Total	12	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.037		0.381		0.725		0.553

	Layer 12/14								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	3	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	2	18	38.30	53	47.32	15	78.95	28	58.33
Total	5	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			1.000		1.000		0.066		0.655
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	2	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	3	20	42.55	66	58.93	15	78.95	29	63.04
Total	5	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.657		1.000		0.284		1.000

	Burial area								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	3	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	1	18	38.30	53	47.32	15	78.95	28	58.33
Total	4	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			1.000		0.350		0.031		0.315
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	2	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	2	20	42.55	66	58.93	15	78.95	29	63.04
Total	4	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			1.000		1.000		0.197		0.630

In analyzing the sequence of the data (Table 4.10) presented, note that the data points to the seasonality in shell harvesting. The exceptions are in the "burial area" associated with the last period of the occupations (LRD) and in the last two layers (Layer 11 and Layer 12/14) about 3,000 BP and associated with the Terminal Chinchorro. The problem with Layer 12/14 is that the sample size is too small (5 shells) to draw any firm conclusions. Layer 11 shows a similar result. There is a lack of shells from fall for the variable "Angles", but not for the variable "Space", suggesting that maybe the shells were collected during all seasons. However, cross-data from both, "Angles" and "Space" also suggest that the shells were collected during the summer and/or winter, periods for which both variables show high values.

Layer 10 and layer 4, which correspond to the post-Chinchorro (RDA) period, shells are from the spring and/or summer (mainly for layer 4), indicating that they were possibly harvested during those seasons. For layers 9 and 5 the shells came mostly from just one season, that is, the spring. Some shells may be from the summer and winter, in layer 9, a conclusion based on the variable "angles"[18]. However, only spring has a cross-data confirmation for both variables. Cross-data for Layer 4 points to spring and summer. However, there are no shells from fall. This absence of fall shells was consistent throughout the next period, the post-Chinchorro (LRD) represented by layers, 1 and 2.

Examining layers 1 and 2 (LRD), summer and/or winter are the seasons in which shells were probably collected. At the last occupational period (layer 1), some shells may have been collected in the spring.

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[18] As mentioned earlier in this section, the variable "angles" has to be the one that presents the strongest correlation with the seasons of the year on modern shells.

For the burial area, the shells could have come from any or from all seasons. The small sample size, however, does not allow any conclusion. Moreover, shells from different seasons may have resulted from a mixed context. The burial was positioned inside an excavated niche that cut the layers bellow its original surface. This probably occurred when the burial ceremony was held.

The shells analyzed above were not collected during a systematic excavation; they were directly sampled from the profile already exposed at the site area. For the deepest layers, shells were collected from the excavation of a small trench opened close to the profile[19] that corresponds to layers 10 to 14. The layers that had the most shells for analysis were layers 1, 2, 4 and 10 with twenty or more shells each. The layers with the smallest number of samples were layers 12/14 and the burial area, with less than 10 shells each.

In summary, the data show that shells were being seasonally collected, mainly during spring, summer and/or winter. There is a significant lack of shells from the fall. In this sense, although the binomial test indicates that the null hypothesis for the fall shells should not be accepted, we have to allow for type 2 error, that is, the possibility that the sample contains fall shells that were not identified by the hypothesis test. This data, does not point to permanent sedentism, except perhaps for the period related to Terminal Chinchorro, around 3,000 B.P. It does suggest, however, a semi-permanent pattern in which the site was occupied seasonally.

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[19] Shells were collected during Rivera's research at the site in 2008, and were restricted to the area opened close to the profile east.

b.2. Samples from Camarones 14

As already explained, shells from this site came from eight layers that covered three periods: the Terminal or Transitional Chinchorro, the Middle Chinchorro and the Early Chinchorro. To increase the sample size the analyses were initially done by periods; shell layers associated with each period were all analyzed together. For example, the Early Chinchorro (7,600 - 7,000 BP) is associated with layer 17 (12 shells), layer 15 (12 shells) and layer 14 (10 shells). Therefore, all these layers were analyzed as a single unit, which generated a sample size of 34.

The same procedure for analyzing shells from Camarones Sur was followed. The first step was qualitative analysis. Shells were systematized according to their internal growth lines based on two selected categories (angle and space) for each layer, separately[20]; after that, the Exact Binomial Test was applied. The results are shown in tables 4.9 and 4.10). The results or archaeological shell that correspond to the seasons are statistically significant and are marked in yellow. In Table 4.11 layers are combined by periods, while in Table 4.12 the analysis shows results per layer, as presented in the sequence of tables bellow.

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[20] For raw data see Appendix A2.

Table 4.11: Archaeological shells from Camarones 14. Exact Binomial Test by cultural periods.

	Transitional Chinchorro (Layer 7)								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	6	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	3	18	38.30	53	47.32	15	78.95	28	58.33
Total	9	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.740		0.513		0.004		0.177
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	6	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	3	20	42.55	66	58.93	15	78.95	29	63.04
Total	9	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.742		0.174		0.004		0.085

	Middle Chinchorro (layers 9, 10, 11 and 12)								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	13	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	13	18	38.30	53	47.32	15	78.95	28	58.33
Total	26	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.231		0.846		0.001		0.429
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	13	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	14	20	42.55	66	58.93	15	78.95	29	63.04
Total	27	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.337		0.558		0.001		0.237

	Early Chinchorro (layers 14, 15 and 17)								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	22	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	12	18	38.30	53	47.32	15	78.95	28	58.33
Total	34	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.86		0.121		0.000		0.008
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	19	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	15	20	42.55	66	58.93	15	78.95	29	63.04
Total	34	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.864		0.084		0.000		0.031

The sequence of data (Table 4.11) clearly shows a pattern of seasonal harvesting for *C. concholepas* at the Camarones 14 site. Also there is a lack of shells from the fall season. For the early Chinchorro, the data suggests that the shells were collected during spring and/or summer. For the middle Chinchorro period, this pattern includes one more season, the winter. The trend of spring/summer/winter continues into the transitional Chinchorro. In conclusion, the middle and the terminal Chinchorro are the periods in which shells related to the winter season begin to appear. This points to a more extended site occupation. Shells related to the fall are not found for any of the periods.

Sample sizes from the early and the middle Chinchorro exceed 20 shells and are the most reliable. The period with the smallest sample is the terminal Chinchorro, with 9 shells.

In order to refine those results, The Binomial Test was also applied for all sampled layers. Although this reduces the number of shells per layers, only two layers, layers 9 and 12 both with only 2 shells each, were removed from the sequence (see, Table A2.3 in Appendix A2 for the results for all layers). The sequence in Table 4.12 below has the results of the Binomial Test realized for the sequenced layers.

Differences in the results between tables show the importance of an analysis on a micro scale represented here by Table 4.12 where shells are combined by layers instead of periods.

Table 4.12: Archaeological shells from Camarones 14. Exact Binomial Test for all sampled layers

	Layer 7								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	6	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	3	18	38.30	53	47.32	15	78.95	28	58.33
Total	9	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.740		0.513		0.004		0.177
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	6	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	3	20	42.55	66	58.93	15	78.95	29	63.04
Total	9	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.742		0.174		0.004		0.085

	Layer 10								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	9	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	3	18	38.30	53	47.32	15	78.95	28	58.33
Total	12	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.393		0.080		0.000		0.035
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	7	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	5	20	42.55	66	58.93	15	78.95	29	63.04
Total	12	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			1.000		0.250		0.005		0.142

	Layer 11								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	2	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	8	18	38.30	53	47.32	15	78.95	28	58.33
Total	10	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.009		0.055		1.000		0.210
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	5	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	6	20	42.55	66	58.93	15	78.95	29	63.04
Total	11	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.545		0.768		0.061		0.349

	Layer 14								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	4	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	6	18	38.30	53	47.32	15	78.95	28	58.33
Total	10	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.197		0.532		0.234		1.000
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	3	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	7	20	42.55	66	58.93	15	78.95	29	63.04
Total	10	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.109		0.541		0.448		0.754

	Layer 15								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	9	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	3	18	38.30	53	47.32	15	78.95	28	58.33
Total	12	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.393		0.080		0.000		0.035
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	9	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	3	20	42.55	66	58.93	15	78.95	29	63.04
Total	12	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			0.257		0.020		0.000		0.012

	Layer 17								
Angle	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Downward Sloping	9	29	61.70	59	52.68	4	21.05	20	41.67
Upward Sloping	3	18	38.30	53	47.32	15	78.95	28	58.33
Total	12	47	100.00	112	100.00	19	100.00	48	100.00
Exact Test p-value			0.393		0.080		0.000		0.035
Space	Archeological	Modern Spring	% Modern Spring	Modern Summer	% Modern Summer	Modern Fall	% Modern Fall	Modern Winter	% Modern Winter
Dispersed	7	27	57.45	46	41.07	4	21.05	17	36.96
Compressed	5	20	42.55	66	58.93	15	78.95	29	63.04
Total	12	47	100.00	112	100.00	19	100.00	46	100.00
Exact Test p-value			1.000		0.251		0.005		0.142

The results in Table 4.12, are similar to the patterns found when the analysis was done on a macro scale for each cultural period (Table 4.11). It points to a long-standing trend: the lack of shells during the fall season. An important difference is found with layers 14 and Layer 11. Layer 11 is from the end of the Early Chinchorro period about 7,000 BP, and Layer 14 is from in the Middle Chinchorro between 6,600 and 6,000 B.P. Results from these two layers point to the possibility of a full year occupation. For the first time, it was found shells from the fall season. Also, for the initial occupation (Layer 17), in addition to spring and summer shells (Table 4.11), there is a week correlation with shells from winter. Finally, examining the subsequent layer (15), the trend for spring and summer continues, but summer is weaker than in the analysis with the layers combined (Table 4.11).

In summary, for Camarones 14 the evidence for permanent sedentism is possible around 7,000 B.P and then again between 6,600 to 6,000 BP. For the other periods, the evidence points to at least a semi-permanent pattern. The site was possible abandoned for about 400 years in-between 7,000 and 6,600 BP.

Conclusions

Analysis of modern *Concholepas concholepas* shells associated the angles in which the internal growth lines of the shell were formed and the seasons of the year. There was also a possible relationship between the seasons and the distribution of the growth lines close to its edge. Using a comparative approach, the analysis of the archaeological shells from Camarones Sur and Camarones 14 shows that shells from both sites had been harvested on a seasonal basis. The seasons in which they were harvested, varied with the occupational periods, although some trends appeared. For the Terminal

Chinchorro (RDA) period at Camarones Sur, including the “burial area”, results were inconclusive.

At both sites, the summer is the recurrent season in which *Concholepas concholepas* was most likely harvested and the sites were possible occupied. Evidence for the winter also shows up regularly, being absent only during the initial Early Chinchorro at Camarones 14 and again during the post-Chinchorro (RDA) at Camarones Sur. Fall was the season in which the sites were possible deactivated and shells were not collected. This was the case at Camarones 14 and for the post-Chinchorro periods RDA and LRD at Camarones Sur. This lack of fall shells could be with a result of some climatic or seasonal variations that affected the mollusk bank. Or perhaps for some cultural reasons, groups kept away from the area or did not collect shells. This fall trend is broken at Camarones 14, around 7,000 BP when shells were collected in all seasons suggesting a year-round occupation of the site. The site was abandoned or occupation was sparse and occasional for about 400 years until it was reactivated or reoccupied around 6,600 BP. After that time, between 6,500 BP and 6,000 BP shells from all seasons appear, suggesting a period of year-round occupation. At Camarones Sur, only during the Terminal Chinchorro (RDA) about 3,000 BP, were shells from the fall possibly collected. The inclusion of shells from the fall at both sites opens up the possibility of year-round occupation for these periods.

Thus, from the analyses presented here, the strongest evidence for sedentism is at Camarones 14 for the period of ~7,000 BP and again between ~6,500 and 6,000 BP. In Camarones Sur sedentism is indicated, maybe, for the period of ~3,000 BP.

Shell Growth Ring Analysis in *Semele* sp. (Huaca Prieta Samples)

This section analyzis *Semele solida* and *Semele corrugata* growth ring increments from shells at the Huaca Prieta site. It takes an approach similar to that applied to *Concholepas concholepas*. Shell growth ring analysis was done on both modern and archaeological samples of *Semele* to determine seasonal growth patterns. The study was performed on modern shells of *Semele solida* (Gray, 1828) (SEMELIDAE) that represented 86% of the shells studied while the other 14% were constituted by shells of *Semele corrugata* (Sowerby, 1833) (SEMELIDAE) (Table 4.13). Both modern taxa were collected from the present-day seashore area near the site. The archaeological samples were recovered from different levels of the Huaca Prieta site. These levels correspond to the mound occupation, phases II, III, IV and V that range from about 7,500 to 3,500 cal BP, that is, from the early-middle Holocene period (Dillehay et al. 2012) (Table 4.14). Thus, the objective here is to determine the seasons during which *Semele* clams were collected and used by the inhabitants at the site.

Biological Data

Classification:

- Phylum Mollusca
  - Class Bivalvia
    - Family Semelidae
      - Genus *Semele*
        - Species *Semele solida* (Gray 1828)
          - *Semele corrugata* (G. B. Sowerby I, 1833)

The distribution of *Semele solida* along the Pacific Coast ranges from 12° S (north of Callao, in northern Peru) to 45° S (Archipelago de los Chonos, in southern Chile) (Urban and Campos 1994). *Semele corrugata* has a similar range, but with a more northerly distribution from 2° S to 14° S (Urban, 1994). They are both found in shallow-water at low tides partially buried in sand and gravel bottoms (Osorio et al. 1979; Viviani 1979; Brown et al. 2002). They can also be found on the subtidal zone down to 20 meters (Urban and Campos 1994). An important food resource, both mollusks are highly appreciated in Chilean and Peruvian gastronomy.

Detailed studies of these species in their north Peruvian coastal habitat are few. Their reproductive cycle can vary due to differences in ambient conditions, inter species specificities, and latitudinal effects (Urban and Campos 1994). In this respect, some studies points to a continuous or biannual reproductive cycle for southern latitudes and an annual cycle for northern latitudes for some mollusk species, notably *S. solida, G. solida* and *Protothaca thaca* (Urban and Campos 1994). In southern Chile, the reproductive cycle of *S. solida* is continuous throughout the entire year (Jeréz et al. 1999 in Brown et al. 2002). A detailed study in 1991-1992 from La Herradura Bay (29° 58' S) in northern Chile showed a reproductive period from June to February (winter/spring/summer) Gonads were empty by March with the beginning of the fall resting period (Brown et al. 2002). Similar data for *S. solida* from Ditacho Bay (36° 31' S) in Chile, noted an annual reproductive cycle that occurred during spring/summer (from October to January/February) with a second short spawning period in March/April (Urban and Campos 1994). The body-weight cycle is correlated with water temperature. Body weight rises with warmer water temperatures of the spring and summer (November to March), and declines as the water cools during the fall and winter (April to October) (Urban and Campos 1994). As these studies show, mollusks are very sensitive to changing water conditions such as temperature, salinity, and available nutrients. It is important to know the mollusks life cycle and its changes since they should be reflected in shell growth rings.

The temperature tolerance (LT_{50})[21] estimated for the Peruvian samples of *S. solida* is 28.5 ^{o}C, with a range of 10 - 26 ^{o}C, while for *S. corrugata* the LT_{50} is 30.6 ^{o}C, and the temperature range is 8 - 21 ^{o}C. The coastal ocean temperature is strongly affected by El Niño, which displaces the cool Humboldt Current. When this happens these mollusk species experience high mortality rates (Ramírez et al. 2003). This occurred during the 1982-1983 El Niño event (Urban 1994).

This covers the data on seasonality found for these species. In general, bivalves decrease growth during the winter and resume growth during the summer months. This seems to be the case for *Semele solida* clams.

Archaeological Context

In 2006, an interdisciplinary team coordinated by Dillehay (Dillehay et al. 2012) re-visited the Huaca Prieta site. Huaca Prieta was first excavated in the 1940s by Junius Bird. Located in the Chicama River valley, the site has access to the river delta's fertile wetlands as well as to the coastal estuary's marine environment. Semi-arid lowlands are to the north and south of the valley (Dillehay et al. 2012).

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[21] LT_{50} refers to the limit temperature in which 50% of the sample die after 24 hours.

The site covers three time periods. The initial presence of humans during the late Pleistocene extends from (13,720 to 13,260 cal BP). A pre-mound occupation during the early Holocene ranges from ~7,900 BP and ~6,600 BP (8,979 to 7,500 cal BP). Finally, a mound-building middle Holocene phase spans from about 6,650 to 3,500 BP (7,555 to 4,510 cal BP) (Dillehay et al. 2012). As observed by Dillehay et al. (2012), the mound was the result of a "deliberate and gradual, planned mounding over a period of ~3000 years". The mound structure was initiated during phase II. This included defining the mound's external limits, building the structural base for the inside space by "*haystacking*" strata, and by constructing a retention wall of layered cobblestone berms. Phase III expanded parts of the mound. Its structure and spatial distribution suggests an architectural plan combining features and space. Subsequent phases culminated with a sunken plaza and burial chamber rooms. At the end of the Preceramic period (Phase 5), the mound was used by later ceramic cultures that kept using it for rituals and burials, thus suggesting the long connection of the site as a sacred space.

Huaca Prieta Stratigraphy

The stratigraphy involves a complex series of features with floors and filled areas. Certain portions of the excavation reach 32 meters in depth. Strata chronologically related to the Holocene were divided into five phases as described in Dillehay et al. (2012), as follows:

Phase I: pre-mound phase from ~14,500-6,600 BP (~14,500-7,500 cal BP). Intermittent evidences associated with maritime foraging and incipient gardening. There were no architectural features. Around 80 meters in extension, it is restricted to the east part of the

Sangamon terrace and is close to the estuarine lagoon. However, no shell samples came from this phase.

Phase II: initial mound phase; from ~6,670-5,760 BP (7,572-6,538 cal BP). This is the first construction stage characterized by several layers of cobblestone and soil. The mound reaches at least 5 meters in height and is about 25 meters wide and 25 to 35 meters long. Construction started on the southeast side near the lagoon's shoreline and gradually spread to the north and west (Units 15/21 and HP-3 beginning in 7,429 and 6,899 cal BP.; Unit 2 beginning in stratum 7C-2 about 7,000 cal years ago).

Phase III: mound phase; from ~5,760 and 4,670 BP (~6,538 and 5,308 cal BP). On the eastern and western slopes, a "stepped platform-like form" begins along with the construction of terrace rooms. On the south portion of the mound, there is a "circular sunken pit" and on its northeast side a stone made retention wall. Several artificial layers of small "stone-faced" walls were added during this phase, and the mound got to a height of about 8-10 meters and with a length in some parts of about 80 m (Units 2, 15/21, HP-2, HP-3).

Phase IV: mound phase; from about ~4,670 to 3,620 BP (~5,308 to 4,107 cal BP). A retention wall was built on its upper portion; the initial layers of a ramp (about 40 m long to 35 m wide) were constructed on its east side, plus stepped structures for the sunken plaza. The mound increased in height, to almost its actual size (23 meters ground surface at present day). Distinctive layers are a thick yellowish clay cap about 25 cm that separates phase III and phase IV; a "thick cobble stone berm" used at the ramp layers, and other additional structures.

Phase V: mound phase; from ~3,620 to 3,040 BP (~4,107 to 3,455 cal BP). Incorporations during this phase were on the top of the mound. They included the construction of burial chambers along the sunken pit, and the addition of more layers to the ramp that consequently covered the retention wall. This phase marks the end of the Preceramic use of the site about 3,520-3,340 BP (~4,000-3,800 cal BP). From about ~3080 to 530 BP (3,500 to 600 cal BP) (from the Cuspinique to the Inca periods), people of later ceramic cultures used the mound's top for rituals and burials.

Material and Methods

Shells of *Semele corrugata and Semele solida* were studied together. Although different varieties, they are morphologically very similar. No significant differences in shell growth that would affect the present analysis are expected. Dr. Victor Vazques, a marine biologist working with Dillehay's shell material from north Peru, informed that both species have a similar growth pattern (Dillehay, personal information, 2010).

The initial sample consisted of 99 shells. However, after sorting the material, 14 shells were too fragmentary and were excluded from the study. Thus, the 85 remaining shells were examined for seasonal growth rings. Eventually, this number was reduced to 59 shells as 26 shell were correlated with fill or "*relleno*" from Phases 2 and 3. The archaeological samples studied here come from Phases II, III, IV and V.

All samples analyzed are from the mound-building phases, from about 7,572 to 3,455 cal BP. They are distributed as shown in Table 4.14. For the modern collection, 172 shells were collected from January to December of 2008.

The analyses performed here used the comparative approach and were done in two steps: the first one was the study of the modern collection in order to determine seasonal growth patterns, and then to project these patterns onto the archaeological collection to estimate the season during which they were gathered by the people at the Huaca Prieta site.

Table 4.13: Quantitative data of *Semele* clams from the archaeological collection (Huaca Prieta)

	S. corrugata	*S. solida*	Total shells
Total:	17	91	108
Tip broken	5	8	13
Tip not broken	12 (14%)	73 (86%)	85 (100%) analyzed shells

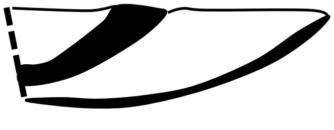
To establish the seasonal growth pattern for modern shells 10 to 15 shells were sampled from each month. One valve of each selected shell was prepared for sclerochronology analyzes based on the growth bands of the shells. Modern and archaeological shells were already cut following a parallel plane with the shell's umbo. The internal surface of each shell was polished with sandpaper and water, and then polished with Brasso following the procedures described for *Concholepas concholepas* in the methodology section (chapter 3) of this thesis.

The polishing process flattened the surface of the cut area and highlighted its features. This allowed the lines on its surface to stand more clearly thereby preparing the shell for subsequent analysis. After that, the polished surface of all selected shells from both collections was photographed with a metallurgical microscope (Leica DM 4000 M) at 25X magnification; all photos were 2.84 X 2.13 inches and saved in TIFF format. A binocular microscope (Baush and Lomb; 0.7X to 3X magnification) was also used for visual inspection.

To classify growth stage patterns in *Semele*, the method proposed by Quitmyer et al. (1997) for *Mercenaria* clams was adapted. Shells of *Semele* have an annual pattern of white and dark bands[22] and that are potentially seasonal indicators. The white bands (or opaque increments), and the dark bands (or translucent increments) have a well-marked alternate pattern close to the edge of the shell, which is visible at the cut zone (Figure 4.19). Thus, shells were initially divided into groups of dark and white bands, as the tip of the shell presents one of these two classifications. Also, the size of the last band was measured in the µm scale. The next step was to refine the growth stage and classified them as T1, T2, T3, and O1, O2, and O3 following Quitmyer et al. (1997), where T is for translucent and O is for opaque. A schematic drawing of all shells studied were done with a focus on the tip of the valves and its increments. The last increment was measured and them classified in one of the following categories bellow (Figure 4.18), as the patterns on the margins of the shells were defined.

Growth Stage Classification used in the Analysis

Figure 4.18: Cross-section of shell edges and their codes



T1 - Dark/translucent band beginning to be formed on the margin of the shell

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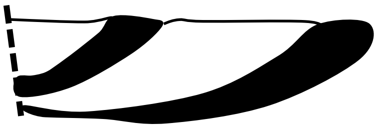
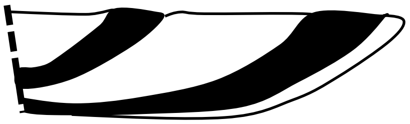
[22] The term band is been used here as a synonym for increment.

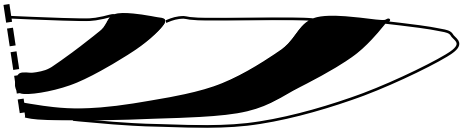
T2 - Dark/translucent band about half of the size of the previous one.



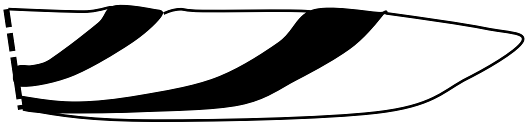
T3 - Dark/translucent band equal or bigger than the previous one.



O1 - White/opaque band in the beginning of its formation.



O2 - White/opaque band about half of the size of the previous one.



O3 - White/opaque band equal or bigger then the previous one.

Adapted from Quitmyer et al. (1997)

This classification scheme was used as a guide to the patterns observed on the margins of the shells. Their correlation to the seasons was based on the analysis of modern shells from the reference collection, as discussed below. It can be said in advance that the opaque bands relate more to winter and less to the end of spring.

The photos presented below (Figure 4.19, 4.20, 4.21, 4.22, 4.23 and 4.24) are cross-sections from modern and archaeological shells from the Huaca Prieta site sample, after they had been cross-sectioned and polished. Alternating translucent (gray) and opaque (white or light brown on the archaeological shell) bands are visible on the shells. Moistening the area with some water enhances the contrast of the bands (Figure 4.24).

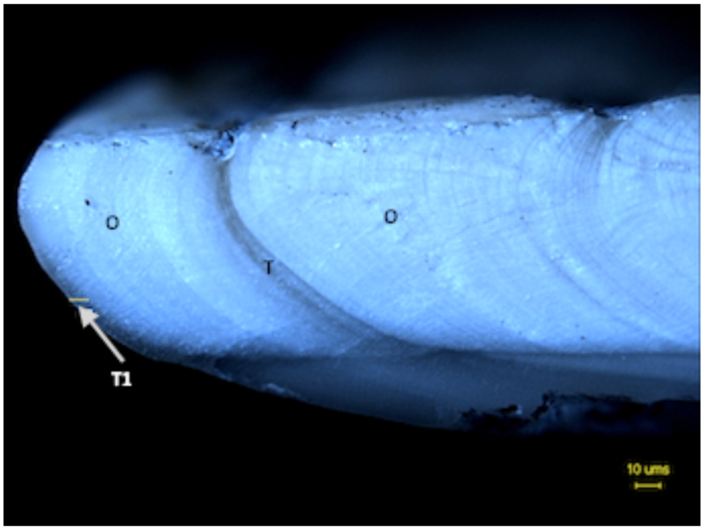


Figure 4.19: archaeological shell sample of *Semele* sp. from Phase 5, after being cut and polished. The photo shows the extreme edge of the shell with a Translucent (T) band – dark grey in the photo - and an Opaque (O) band – light white on the photo - at the tip of a T1 band (measurement: 8.1 µm). Adult sample (no. 66).

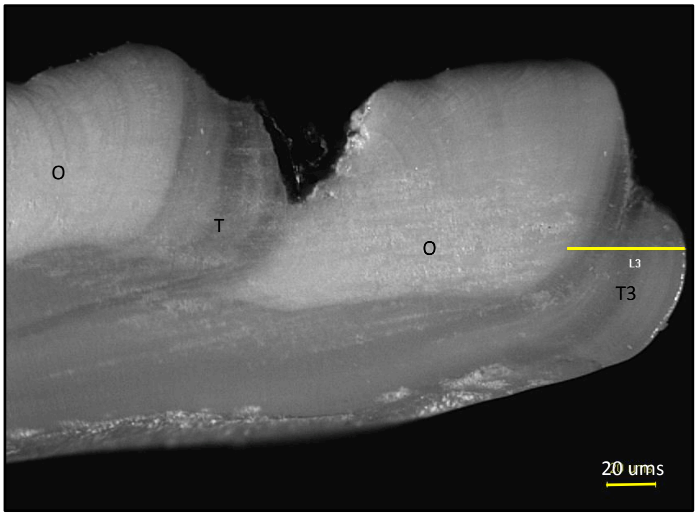


Figure 4.20: modern shell (no. 13) of *Semele* sp. collected in September 2008, after being cut and polished. Photo shows the extreme edge of the shell with the alternate bands: Translucent (T) band - grey light on the photo - and an Opaque (O) band - brown on the photo. At the tip, the dark band is classified as being in the T3 category (measurement: 48.5 µm).

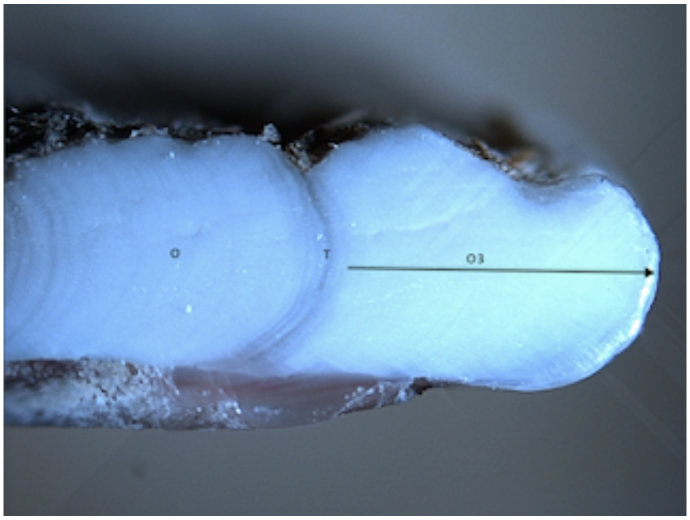


Figure 4.21: modern shell of *Semele solida* collected in July 2008, after being cut and polished. Photo shows the extreme edge of the shell with the alternate bands: Translucent (T) band - grey light on the photo - and an Opaque (O) band - white on the photo. At the tip is the O3 band (measurement: 138 µm). Adult sample (no. 9).

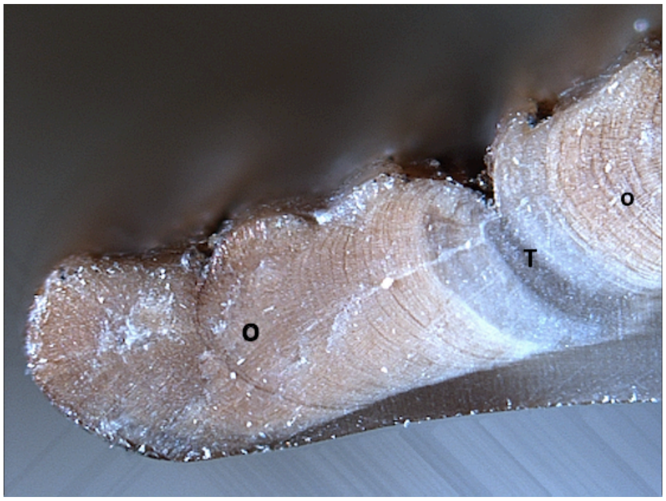


Figure 4.22: archaeological shell sample of *Semele solida* from Unidad 22, Piso 22. Photo shows the extreme edge of the shell with a Translucent (T) band - grey light on the photo -, and an Opaque (O) band - brown on the photo - at the tip classified as O2 (measurement: 215 µm). Adult sample (no. 23).

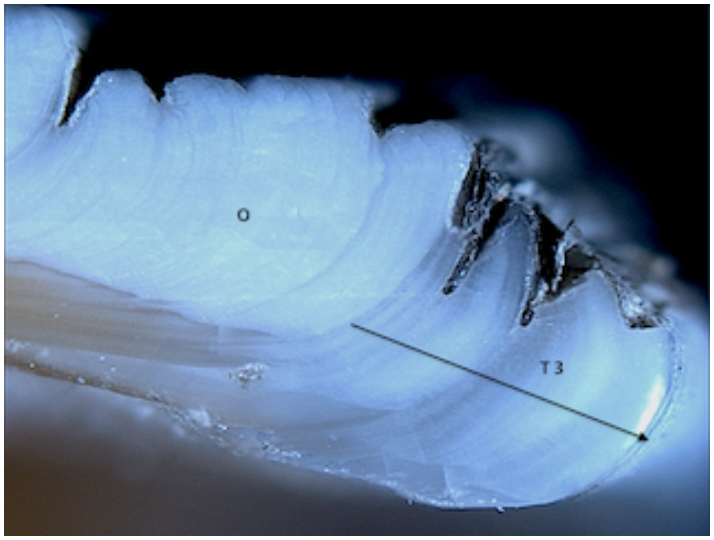


Figure 4.23: modern shell (no. 7) of *Semele* collected in April 2008, after being cut and polished. Photo shows the extreme edge of the shell with the alternate bands: Translucent (T) band - grey light on the photo - and an Opaque (O) band -white on the photo (measurement: 117 µm).

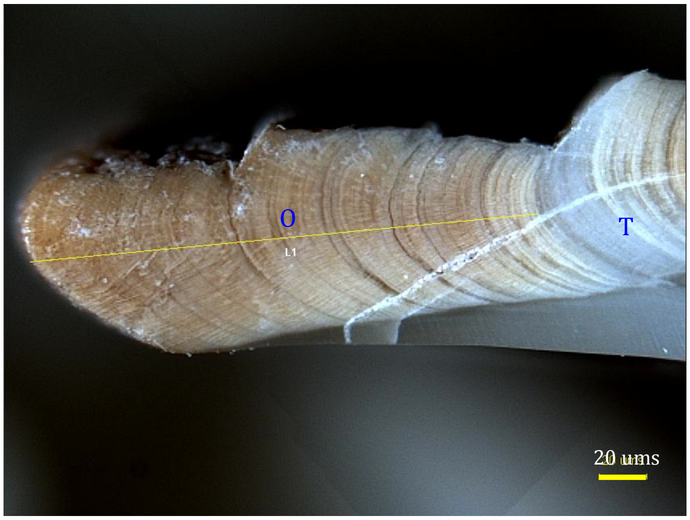


Figure 4.24: a dross-cut section of an archaeological shell sample of *Semele solida* (Unidad 22, Piso 25) moistened with water to enhance the colors. On the extreme edge of the shell an Opaque (O) band - brown on the photo; behind, a Translucent (T) band - grey light on the photo. Young sample (no. 51)

The measurements (Table 1 from Appendix B) cover the width of the last band formed on the margin of the shell, from the edge of the shell to the end of the band (e.g. Figures 4.19 and 4.20). These measurements were used to calculate the Standard Deviation and the t-Student test for modern and archaeological shells. Hence, the Standard Deviation was calculated for both collections for dark and white bands formation, arranged by months (Table 4.15 and 4.16). This was done to verify the distribution of mean intervals and set the maximum and minimum distribution intervals. Based on the mean sizes of band formations from modern collections compared with ones from the Huaca Prieta site, a T-statistic (Table 4.18) was used. This provided data confidence limits and the probable months in which archaeological shells were collected. Seasonal growth frequency histograms (Figure 4.26) were constructed for modern shells. For comparative purposes, another growth frequency profile was done for the archaeological samples (Figure 4.27 and 4.28).

Table 4.14 shows the chronological context of the shells from the archaeological collection in relation to their chronological phases. The results are discussed below.

Table 4.14: chronological context of the archaeological samples of *Semele* sp.

	Chronology (cal BP.)	Total shells
Phase II	7,572 - 6,538	26
Phase III	~6,538 – 5,308	7
Phase IV	5,308 – 4,107	9
Phase V	4,107 – 3,455	17

Results of the Shell Analyses

a) Modern Samples

The last growth increment formed on the edge of the shell was classified in dark or white bands and organized according to the months they were collected. Table 4.15 has the percentages with the occurrence of both variables distributed by month; a graphic representation follows the table (Figure 4.25). The first numerical column (dark count) in the table refers to the number of shells with a dark band on the edge followed by its percentage; the same was done for shells with white bands. The column with negative numbers is the mirror image of percentage values found for white bands[23].

Table 4.15: modern shells - number and percentage of dark and white bands distributed by months of the year.

Month	Dark Count	% Dark	White Count	% White		Total
Jan	11	100.00		0.00		11
Feb	12	100.00		0.00		12
Mar	14	100.00		0.00		14
Apr	12	80.00	3	20.00	-20.00	15
May	4	26.67	11	73.33	-73.33	15
Jun	6	40.00	9	60.00	-60.00	15
Jul	7	46.67	8	53.33	-53.33	15
Aug	14	87.50	2	12.50	-12.50	16
Sep	14	100.00		0.00		14
Oct	15	100.00		0.00		15
Nov	13	100.00		0.00		13
Dec	6	35.29	11	64.71	-64.71	17

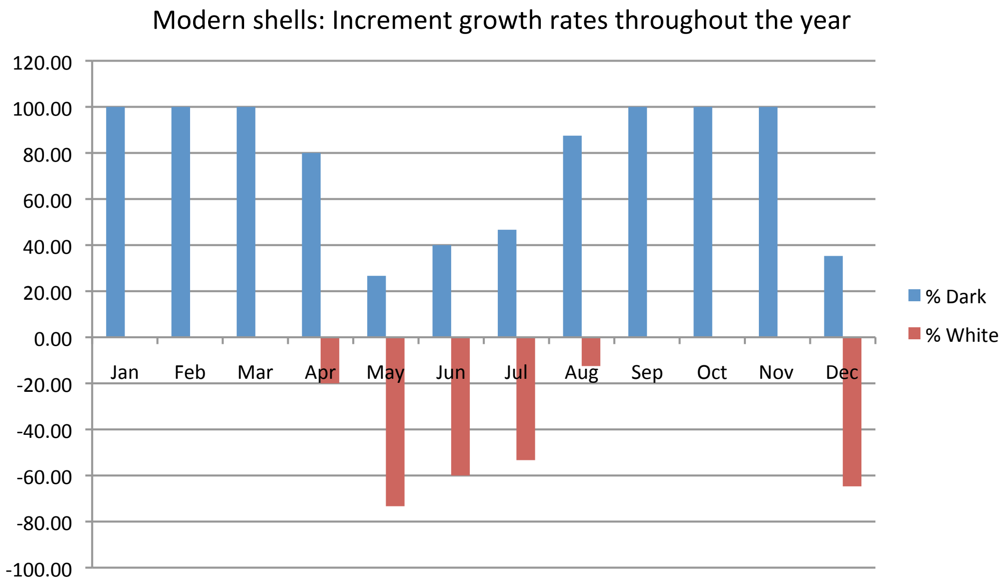


Figure 4.25: monthly percentages of dark /white bands in modern shells of *Semele* sp. at the Huaca Prieta area.

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[23] These are used to construct the chart (Figure 4.25).

The results are significant. White bands are concentrated in a brief interval, from April to August and again in December (Table 4.15; Figure 4.25). In other words, white band formation starts in the middle of the austral fall and extends throughout the winter, diminishing in mid to late winter (August) and stopping in spring. There follows a rapid recovery registered at the end of spring/beginning of summer (December) with a high percentage of white increments. This is graphically represented on Figure 4.25, which shows the proportions of the shells with dark bands compared with the proportions of shells with the white bands. White bands are concentrated between fall and winter, and again in December.

Therefore, the dark bands (translucent) were formed throughout the entire year, but with a sharp decline at the end of fall. Then in the middle of winter, they start recovering again. An isolated reduction of the dark bands also occurred in December (end of spring/beginning of summer), which contrasts with the high percentage of white bands at this time of the year.

A close look at dark band shell growth shows that for most part of the year clams are in the slow-growth cycles. A fast growth stage sets in during the fall and winter when white (opaque) bands are formed.

Below are the standard deviations (Table 4.16) for modern shells, showing the average values calculated from the bandwidth of the shell growth. The ones found for dark bands are less dispersed, while the ones for white bands are more spread out due its fast growth and concentrated in only one part of the year. The value found for April shows the highest dispersion for both bands, which may reflect a transition phase between summer and fall, a period that also marks the beginning of the white band growth. In general, the values obtained are consistent with the overall patterns of shell band growth.

Table 4.16: Standard Deviation for Modern Shells

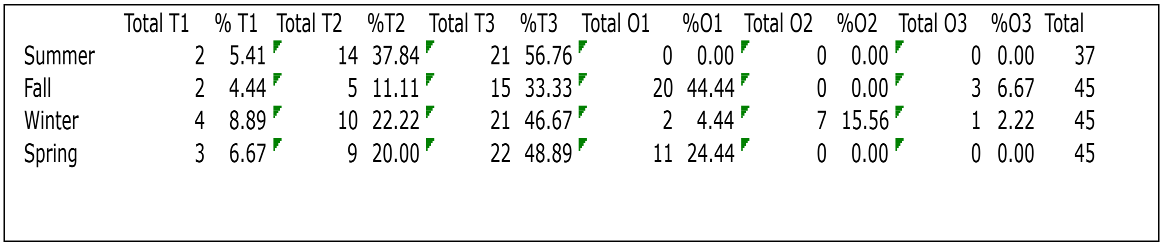
Dark Band						Interval	
Month	Obs	Mean	Std Dev	Min	Max	Mean-1 Std Dev	Mean+1 Std Dev
Jan	11	51.727	21.243	28.4	92.6	30.485	72.970
Feb	12	57.117	29.419	14.2	92.6	27.698	86.535
Mar	14	55.936	17.230	33.8	82.5	38.706	73.166
Apr	12	49.834	50.945	4.7	140.0	-1.111	100.779
May	4	15.560	4.498	9.7	19.8	11.062	20.058
Jun	6	32.433	21.152	12.2	57.3	11.282	53.585
Jul	7	58.343	34.596	12.0	104.0	23.747	92.938
Aug	14	38.371	21.633	9.5	78.8	16.738	60.004
Sep	14	33.421	14.651	18.9	71.9	18.771	48.072
Oct	15	33.080	15.141	13.9	62.5	17.939	48.221
Nov	13	28.219	15.487	4.3	52.7	12.733	43.706
Dec	6	19.117	6.396	13.0	29.1	12.721	25.513

White Band						Interval	
Month	Obs	Mean	Std Dev	Min	Max	Mean-1 Std Dev	Mean+1 Std Dev
Apr	3	121.400	126.233	33.2	266.0	-4.833	247.633
May	11	48.073	37.720	13.1	115.0	10.353	85.793
Jun	9	80.956	53.064	18.4	167.0	27.892	134.019
Jul	8	168.100	118.646	83.8	444.0	49.454	286.746
Aug	2	141.600	134.067	46.8	236.4	7.533	275.667
Dec	11	28.691	11.602	13.9	52.8	17.089	40.293

The next step was to classify modern shells according to their band formation (T and O), distributed seasonally (see Table 4.17). Seasonal patterns stand out better when percentages are plotted on histograms for each season (Figure 4.26).

Translucent bands, mainly T3, dominate samples collected in the spring. Opaque bands start to appear in late spring, with an isolated occurrence in December. In the fall assemblage, opaque shell growth frequency is more evident; by winter all of its subdivisions are formed and growth slows down (low frequency of the translucent formations).

Table 4.17: Band formation distribution for seasons (modern shells)



	Total T1	% T1	Total T2	%T2	Total T3	%T3	Total O1	%O1	Total O2	%O2	Total O3	%O3	Total
Summer	2	5.41	14	37.84	21	56.76	0	0.00	0	0.00	0	0.00	37
Fall	2	4.44	5	11.11	15	33.33	20	44.44	0	0.00	3	6.67	45
Winter	4	8.89	10	22.22	21	46.67	2	4.44	7	15.56	1	2.22	45
Spring	3	6.67	9	20.00	22	48.89	11	24.44	0	0.00	0	0.00	45

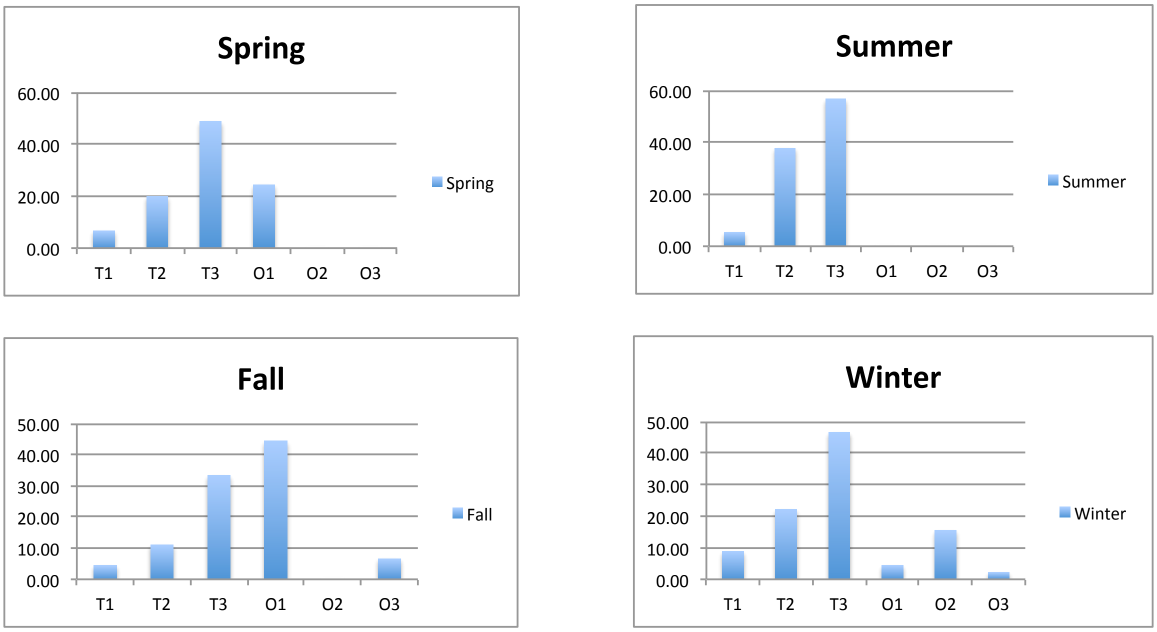


Figure 4.26: histograms for modern shells and its distribution during the different seasons of the year.

The band analysis presented above on *Semele* sp. fits the six–part subdivision presented in Quitmyer and collaborators (1997) for *Merecenaria* spp., which reinforces the methodology's validity. The technique is straightforward. The histograms are based on the frequency of band increments for each season. This provides a base line for the analysis of the archaeological collection.

As noted earlier, the biological cycle of the *Semele solida* clam has a resting period in northern Chile that goes from March to May. The spawning season occurs from June to February (Brown et al. 2002). As shown by the previous analysis of the modern shells, the formation of the white bands (opaque) is concentrated in the middle fall and winter months, with a short transitional period for the spring/summer (December), when they display an abrupt inverse correlation with the dark bands. Although dark bands are formed throughout the year, they decline in these periods (Figure 4.25). Unlike the white bands, which seem to be correlated with fast growth, the dark bands are related to slow growth. Focusing on the period in which white bands formed, it coincides in part with the resting period, that is, from fall to late winter[24]. Dark bands seem to reflect the spawning period that extends from spring to summer, with a break between late spring and early summer.

b) Archaeological Samples

The 59 shells from the archaeological samples were first analyzed in terms of band-width growth. For this, a histogram with percentage values was constructed. A T-student test and standard deviations were calculated. After that, samples were analyzed by their chronological phases at the site. As a final test to verify the seasonality of shells, the Exact Binomial Test of Goodness-of-fit was applied. This test was chosen because of the small sample sizes involved.

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[24] The difference found here could be a result of latitudinal variations and changes in ocean current along the Chicama coast.

The growth histogram constructed for the whole set of the archaeological sample with band distribution is presented below (Figure 4.27).

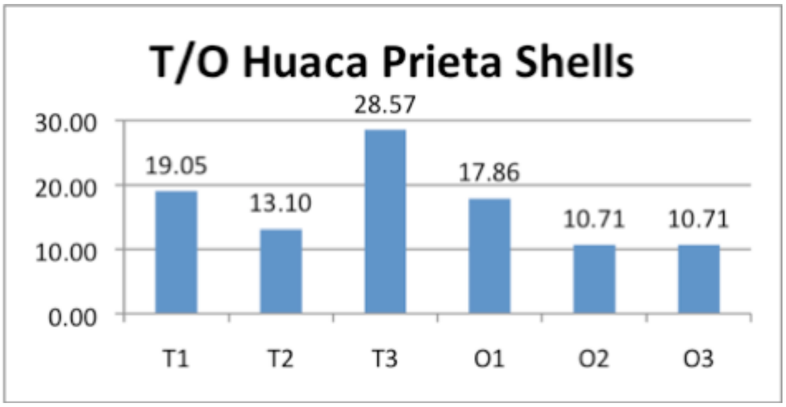

Figure 4.27: histogram of the distribution of the archaeological shell samples of Huaca Prieta

The archaeological and modern histograms (Figure 4.26) resemble each other. Both show a close resemblance with the winter growth-frequency profile in which *Semele* shells are already in the Opaque stage of full development; the first Translucent subdivision (T1) is recovering with a high frequency of shells in this stage. This suggests that most of the shells were collected from the end of fall through the winter season. Perhaps collection extended into early spring considering that the frequency of T1 starts to increase.

The tables below (Table 4.18) contain the mean and standard deviation for bands width of both dark and white band shells in modern and archaeological samples. The t-statistic is used to compare how close the value of the average band-width of the archaeological shells is to the value of the band-width of modern shells for each month of the year. It is important to note that the t-test assumes the values found for modern shells to be the same as the true values for the entire population of modern shells and that the population of modern shells has a normal distribution.

The first set refers to shells with dark band (modern samples on the first and archaeological samples on the next table) and the second set concerns shells with white bands (modern and archaeological, respectively). Starting with modern shells, the first row shows the average band-width for each month of the year. The highest averages for dark band shells occurred in January (51.7 μm), February (57.1 μm), March (55.9 μm) and July (58.3 μm). The second row indicates the standard deviations within each month; it gives an idea of how much dispersion is observed around the average. For example, dark bands on modern shells in May have lower dispersion than July because the standard deviation for May (4.5) is roughly one third of the mean value for May (15.5) while the standard deviation for July (34.6) is more than half of the mean value for July (58.3). The average band-width for modern shells for each month can also be used to calculate the T-statistic by applying the following formula:

(Average of band-width of archaeological shells - Average of band-width of modern shells)/(Standard deviation of archaeological shells/(Number of archaeological shells in the sample)^1/2)

With a 95% confidence level, the T-statistic indicates that the average band-width of archaeological shells is not statistically different from the average of modern shells. This was the case during June and November for Dark band shells, and during April, June, July, and August for the White band shells. This suggests that archaeological samples were collected from April (fall), June to August (late fall/winter to winter), and then November (middle Spring). These results apply for shells analyzed as a single unit and not broken down chronologically.

Table 4.18: T-Student test for Archaeological and Modern Shells

Dark Band Modern Shells

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	51.73	57.12	55.94	49.83	15.56	32.43	58.34	38.37	33.42	33.08	28.22	19.12
Std Dev	21.24	29.42	17.23	50.94	4.50	21.15	34.60	21.63	14.65	15.14	15.49	6.40

Dark Band Archaeological Shells

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
t-value	-7.78	-9.48	-9.11	-7.18	3.67	**-1.67**	-9.87	-3.55	-1.98	-1.88	**-0.34**	2.54

Sample	
Mean	27.15
Std Dev	23.01
N	53
N-1	52

White Band Modern Shells

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean				121.40	48.07	80.96	168.10	141.60				28.69
Std Dev				126.23	37.72	53.06	118.65	134.07				11.60

White Band Archaeological Shells

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
t-value				**1.55**	4.52	3.19	**-0.34**	**0.73**				5.30

Sample	
Mean	159.70
Std Dev	139.80
N	32
N-1	31

The next step was to separate the archaeological samples by their chronological context as found at the Huaca Prieta site (Table 4.19). The histograms below (Figure 4.28) show the growth stage pattern for each occupational level, classified in phases 2, 3, 4 and 5.

Table 4.19: Archaeological shells from Huaca Prieta site (*Semele* sp.) - Growth stage patterns by its chronological context

T/O	Total T1	% T1	Total T2	% T2	Total T3	% T3	Total O1	% O1	Total O2	% O2	Total O3	% O3	Total
Fase2	2	7.69	3	12	11	42	3	11.5	2	7.69	5	19.2	26
Fase3	1	14.3	0	0	0	0	2	28.6	3	42.9	1	14.3	7
Fase4	2	22.2	3	33	1	11	2	22.2	1	11.1	0	0	9
Fase5	7	41.2	2	12	3	18	2	11.8	1	5.88	2	11.8	17

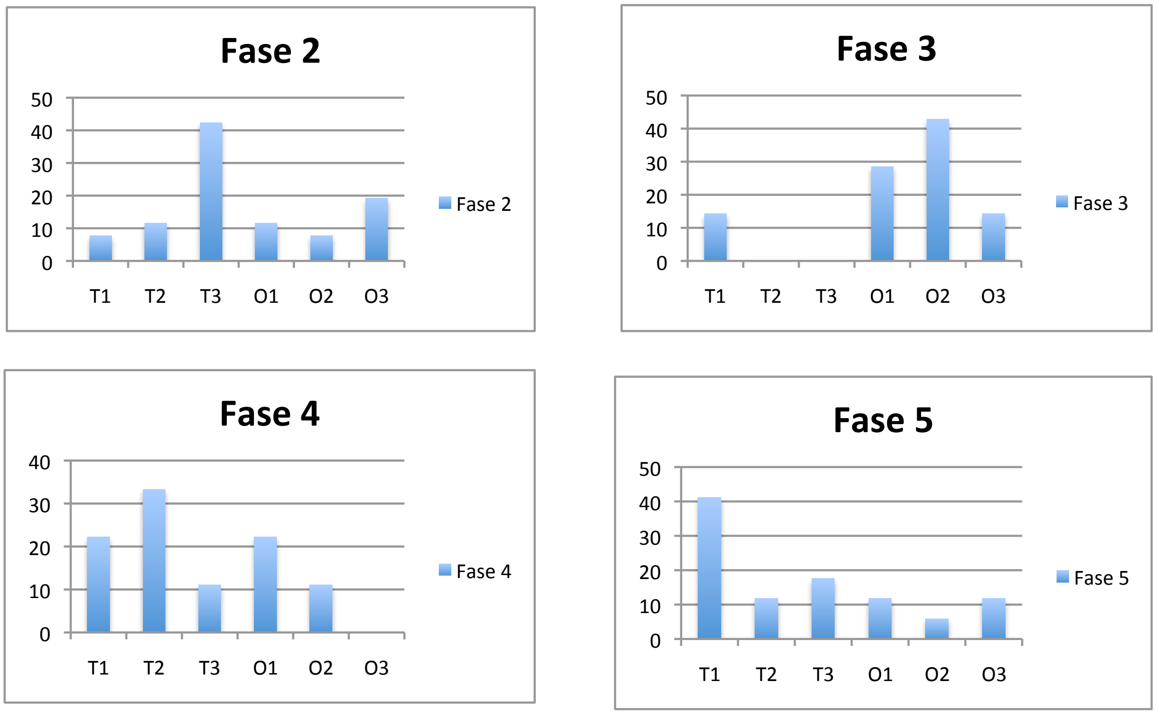

Figure 4.28: histogram of the growth stage patterns and chronological distributions of shells from the Huaca Prieta site (*Semele* sp)

Based on frequency of the growth stage patters, the following assertions can be made.

The shells from Phase 2 (Fase 2) correspond to a period in which opaque bands are in development, O1 and O2 are shifting to the O3 phase with a high percentage of O3 bands, while translucent bands are ending their cycle with a high percentage of T3 phase and low values for T1 and T2. This could indicate the transition between fall and winter (late fall/early winter).

Phase 3 (Fase 3) corresponds to fall in which opaque (dark) bands are at their maximum development and translucent (white) bands are just beginning to be formed. It is probably the peak of fall.

Phase 4 (Fase 4) may correspond to early fall when opaque bands initiate their formation but without reaching the O3 phase. Translucent increments are in transition to T3, starting to complete the cycle, but still with high values for T1 and T2.

Phase 5 (Fase 5) is more ambiguous. It could correspond to late winter and/or spring when T bands are initiating their cycle with a high percentage in the T1 phase and just starting to move into the other phases, while the formation of the opaque bands are in balance with a low percentage. The T-test for the whole sample (not divided by phases) supports the appearance of shells from middle spring, as shown in Table 4.18.

The histogram for modern shells is a good reference point for the analysis of the archaeological shells. However, when the trend is not clear, it is difficult to draw a conclusion, as shown in phase 5. This is a problem with a small sample size, a common problem with archaeological material. In this case, it is important to know the behavior of the samples as a single unit. For this reason statistic tests were performed for the archaeological shells as a whole. This provided some information not only about the validity of the samples and the patterns found, but as the histograms did for modern samples, they show the seasonal distribution of the samples that work as a guideline. However, if samples are too small, the assumption of a normal distribution cannot be made. Therefore, the Exact Binomial Test was used, which is suitable when the sample size is small. A normal distribution is not a requisite for the test.

Archaeological Shells from Huaca Prieta: Exact Binomial Test

Here, data from both modern and shells were integrated with the quantitative analysis for comparative study using the binominal test. Numbers marked in bold refers to positive results (p> 0.05) that correspond to the seasons in which archaeological shells fit. Results are presented on Table 4.20, for all phases studied here, as follow:

Table 4.20: Exact Binomial Test of Goodness-of-fit

PHASE 2	Arch	M_ Spring	% Spring	M_ Summer	% Summer	M_ Fall	% Fall	M_ Winter	% Winter
Dark Count	16	28.00	71.79	37.00	100	23.00	50	36.00	78.26
White Count	10	11.00	28.21	0.00	0	23.00	50	10.00	21.74
Total	26	39.00	100.00	37.00	100.00	46.00	100.00	46.00	100.00
Exact Test p-value			**0.276**		0		**0.327**		**0.054**

PHASE 3	Arch	Spring	% Spring	Summer	% Summer	Fall	% Fall	Winter	% Winter
Dark Count	1	28.00	71.79	37.00	100	23.00	50	36.00	78.26
White Count	6	11.00	28.21	0.00	0	23.00	50	10.00	21.74
Total	7	39.00	100.00	37.00	100.00	46.00	100.00	46.00	100.00
Exact Test p-value			0.003		0		**0.125**		0.001

PHASE 4	Arch	Spring	% Spring	Summer	% Summer	Fall	% Fall	Winter	% Winter
Dark Count	6	28.00	71.79	37.00	100	23.00	50	36.00	78.26
White Count	3	11.00	28.21	0.00	0	23.00	50	10.00	21.74
Total	9	39.00	100.00	37.00	100.00	46.00	100.00	46.00	100.00
Exact Test p-value			**0.718**		0		**0.508**		**0.419**

PHASE 5	Arch.	Spring	% Spring	Summer	% Summer	Fall	% Fall	Winter	% Winter
Dark Count	12	28.00	71.79	37.00	100	23.00	50	36.00	78.26
White Count	5	11.00	28.21	0.00	0	23.00	50	10.00	21.74
Total	17	39.00	100.00	37.00	100.00	46.00	100.00	46.00	100.00
Exact Test p-value			**1.000**		0		**0.143**		**0.392**

The test shows a strong tendency for archaeological shells to have been collected during fall, winter and/or spring. This is observed for phase 2, phase 4 and phase 5. Only phase 3 diverges from this pattern with shells collected exclusively during the fall. Again, there are no indications of shells collected during the summer. It is important to notice that the size of the samples from phases 3 and 4 are small with 7 and 9 shells, respectively. Nonetheless, the results are consistent with the preceding tests and reinforce the idea that the shells have been seasonally harvested.

Conclusions

As presented in this section, the biological cycle of *Semele solida* shows that this clam has short resting period during the fall (Urban and Campos 1994). In the modern samples from Huaca Prieta, the shorter cycle coincides white bands, which are occurring during the fall/winter period from April to August and again in a short term in December (late spring). The dark bands seems to coincide with the spawning period that occurs along the years with a reduction from April to August, with a break in December.

For the archaeological shells, the binomial test suggests that the shells were harvested in the fall, winter and spring. The fact that shells were collected during the reproductive cycle leads to two conclusions. First, no attempt to safeguard the clam population was undertaken, since their preferred period for foraging was during the period of clam reproduction. Second, a possible factor that drove people to collect shells at this time was that clams had reached their maximum weight.

Data for the whole context, not separated by phases, shows that shells were probably being harvested in April, then from June to October, and in November. Another reason for the presence of clams at the site during these months may relate to specific rituals enacted between April and August (fall/winter), and in November (spring) during the wet season and beginning of the dry season in the coast. Dillehay observed (personal communication, 2011) that shells were not directed related to any human burial. They were found disperse all over the site and maybe were not used in funerary rituals.

Studying the Huaca Prieta shells in their chronological context, and considering all the statistical tests, the data shows that the shells were collected between the early-fall through the winter, and into the spring season. Among these seasons, fall stands out as the most popular season for shell collection. The seasonal use of the site, based on the study of the clam shells of *Semele*, is related to the following phases, as noted bellow:

Phase 2: late fall/early winter (June/July)

Phase 3: high fall (June)

Phase 4: early fall (April)

Phase 5: middle spring (November)

There is a clear pattern in the formation of the translucent and opaque bands. Shells were not collected during the summer. The shells from the first three chronological phases of Huaca Prieta were possible collected between early fall through the winter seasons. The change in the pattern for Phase 5 with shells from the spring season correspond to the later period of the mounds use, around 4,000 and 3,500 cal BP (~3,620 to 3,040 BP) that also marks the end of the preceramic use of the site.

The site of Huaca Prieta is complex and it is not an occupational but a ceremonial site (Dillehay et al. 2012b). For example, the context in which the shells were found also incorporates architectural features. Therefore, to check the seasonality of the site's use, it is worth to look for additional indicators of seasonality.

Oxygen Isotopic Analysis in *Concholepas concholepas*

Archaeologists have used stable isotopic analysis on shells to determine the seasonality of a site's occupation. It is based on sea temperature variations, determined by isotopic curves from a stable isotopic of ^{18}O ($\delta^{18}O$) (e.g. Kennett and Voorhies 1996; Andrus 2011; Thompson and Andrus 2011; Andrus 2012).

Initially planned to complement the shell growth ring analysis discussed above, this technique was applied to the archaeological shells recovered from the Camarones 14 site. However, as discussed bellow, although the analysis performed on a modern sample of *C. concholepas* indicated its potential for this type of study, the investigation carried out on the archaeological samples generated ambivalent results, and were not used to discusses seasonality of the site occupation. With respect to Semele shells from the Huaca Prieta site, Tom Dillehay sent samples for oxygen isotopic analysis[25], but the results are beyond the scope of this thesis. This section discusses only the oxygen analysis performed on shells of *Concholepas concholepas* from the Camarones 14 site.

Concholepas concholepas is one of the most common mollusks found at archaeological sites along the coast of northern Chile and southern Peru (Báez and Jacson, 2008). Locally known in Chile as "loco", it's biology has been studied intensively, and although it has few works about its potential as a paleoclimate proxy (e.g. Labonne and Hillaire-Marcel 2000; Guzmán et al. 2004; Lazareth et al. 2005; Guzmán et al. 2007), little was done regarding its application as a seasonal indicator of a site occupation.

C. Concholepas is found in the Pacific from the northern coast of Peru (6° S) to the Estreito de Magalhães (55° S) in southern Chile (Castilla 1983 in Olguín and Jerez, 2003). Active at night, it moves between inter and subtidal zones. This species has a slow grow rate that varies between 1.0 to 3.0 mm per month (Olguín and Jerez, 2003). These variations are due to such environmental factors as temperature and salinity, and to biological conditions (Falabella 1991; Adlerstein, 1987), such as the ontogenic process in which juvenile shells grow faster then the adult ones.

Applying the $\delta^{18}O$ analysis to archaeological shells, Falabella and collaborators (1991) demonstrated that *C. concholepas* shells could be used for paleoenvironmental reconstructions. Working with modern samples from Chile's central coast, they applied

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[25] The shells of Semele were sent to Dr. Fred Andrus at the Department of Geological Sciences at the University of Alabama (Tuscaloosa) and to Dr. Larisa DeSantis at the Earth and Environmental Sciences Department of Vanderbilt University.

the method to three different species: *Mesodesma donacium*, *Fissurella maxima* and *Concholepas concholepas*. From these, *C. concholepas* was considered the most reliable. They worked with archaeological shells from two sites near Las Cruzes (33°S) - LEP-C and La Aldea -, dating from 2000 BC to 1500 AD. The method pointed to a change from cold to more warm water conditions about ~1,760 BP (2,000 cal. BP). However, their study was not precise in acquiring seasonal data from the shell profile showing incongruences between temperature and salinity. For this refinement, they suggested that samples needed to cover at least two years of shell growth to reconstruct summer and winter temperatures. Combined with a large sample size, this would provide a basis for interpreting the data sampled from the edge of the shell.

Experiments conducted in laboratorial conditions by Gúzman and collaborators (2004) with *C. concholepas,* showed that temperature and δ^{18}O were well correlated when growth variations are limited, but variations in the growth rates seemed to affect the oxygen isotopic ratio. Another study by Lazareth and collaborators (2005) also showed some correlation between δ^{18}O and temperature; however, when applying the Epstein and others (1953) equation[26] it is observed a difference of 5 grades low between the calculated temperature and the measured temperature in laboratorial conditions indicating a certain grade of incertitude.

Such studies have demonstrated that although *C. concholepas* has a potential for paleoenvironmental analysis using oxygen isotopes, more experiments were needed to understand its peculiarities (e.g. Falabella et al. 1991; Gúzman et al. 2004; Lazareth et. al.

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[26] This is a widely used equation for paleotemperature works to relate temperature variation and fraction of stable oxygen isotopes.

2005; Gúzman et al. 2007). Shell growth rate is a crucial component for the precision of isotopic analyzes, and in the case of *C. concholepas*, it is critical (Gúzman et al. 2004).

Regarding seasonality studies, a large number of shells is recommended for the isotopic analysis, as well as a time series covering about two years of growth (Andrus 2011). It is important to know the growth rate of the species to be studied to trace the sampling strategy.

Stable Isotopic Analysis for the Site of Camarones 14

Stable isotopic analysis of ^{18}O ($\delta^{18}O$) was performed on shells of *C. concholepas* from the Camarones 14 site. The objective was to reinforce data from the shell growth ring study. It also complements Billings (2001) cursory isotope study on seasonality with shell samples from Camarones Sur, which was inconclusive.

A modern shell of *C. concholepas* with a length of 82 mm collected in June 2008 was first analyzed to test its validity as a temperature indicator. To do this, a total of 49 samples drilling from the calcite layer were extracted by the author, as described above, covering around two years of shell growth. Two sets of archaeological shells from Camarones 14 (Table 4.19) were also prepared and sent for analysis to Dr. Fred Andrus at the Department of Geological Sciences at the University of Alabama (Tuscaloosa). The first set was of nine shells, from the following levels: 14 (2 shell), 13 (2 shells), 12C (1 shell), 12B (1 shell), 12 (1 shell), 7 (1 shell), 6 (1 shell); the second set was of two shells from levels 13C (2 shell) and 12 (1 shell). All these samples are from about 7,600 to 6,000 B.P.

Table 4.21: Estimated age of the shell of *Concholepas concholepas* based on relative size and growth. Samples for isotopic analysis.

Shell number	Shell size Length x Width (mm)	Shell age (years)	Sampled size (mm)	Sampled age (years)	Tidal zone
Cm14/1-14/	57x44	2 - 2.5	15	0.5 - 1	Intertidal/subtital
Cm14/2-14/	Fragment	2 - 2.5 (?)	20	?	Intertidal/subtital
Cm14/4-13/	45x48	1.5 - 2	13	0.5 - 1	Intertidal
Cm14/5-13/	52x41	2 - 2.5	21	1 year max.	Intertidal
Cm14/2-12C	58x46	2 - 2.5	39	1.5 - 2	Intertidal
Cm14/2-12B	41x35	1.5 - 2	12	0.5 - 1	Intertidal
Cm14/10-12/	57x44	2 - 2.5	31	1 - 1.5	Intertidal/subtital
Cm14/1-7/	66x55	2.5 - 3	34	1 - 1.5	Intertidal/subtital
Cm14/1-6/	44x36	1.5 - 2	18	1 year max.	Intertidal
Cm14/2-13C/	67x50	2.5 - 3	?	?	Intertidal/subtital
Cm14/1-12/	51x38	2 - 2.5	?	?	Intertidal

Table key: Cm14/1-14/
Cm14 = site name (Camarones 14) /1-14/ = shell number 1 from archaeological layer 14

As explained in Chapter 3, all selected shells were transversally bisected using a water saw with a diamond blade. One side of each shell was selected and then polished with sandpaper and water. Samples were taken by drilling at specific intervals along the cut axis of the shell. To cover an entire year of growth prior to the shell's death, around twelve samples of shell calcium carbonate were drilled from the inner calcite layer of each shell. The direction of the sampling was from the tip of the calcite layer toward the umbo of the shell[27]. The interval between drillings was approximately 2.0 – 4.0 mm for the first set of shells. The second set was sampled with a 1.0 mm distance interval from each hole (Figure 4.29). The weight of each sample was between 40 to 100 microgram calculated on an analytical scale. A G9928 Flex Shaft Grinder with the support of a binocular microscope was used to drill and power the samples.

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[27] The number of samples drilled from fragments may vary according to the size of the each piece.

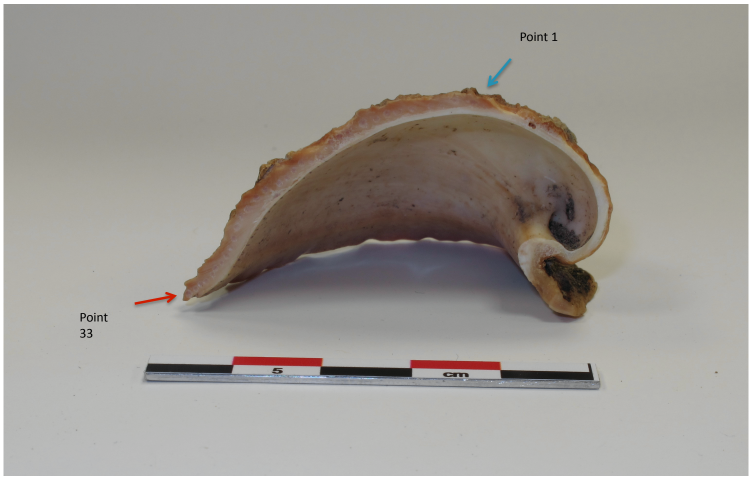

Figure 4.29: *Concholepas concholepas* from Camarones 14 sampled for isotopic analysis. Shell sample: Cam14/2-13c/ – blue arrow points hole number 1 (Cam14/2-13c/1); red arrow shows hole number 33 (Cam14/2-13c/33).

Results and Conclusions

The result of this analysis demonstrated that seasonal variation was recorded in oxygen isotope profiles done on a modern shell in a consistent way, indicating that shells of *C. concholepas* could be analyzed using this technique (see Appendices D for tables with analytical data).

Given this positive result, the first set of nine archaeological shells from Camarones 14 site were sampled[28] and sent for analysis. In this first set, however, a seasonal range in $d^{18}O$ was not clear and did not generate a clear sinusoidal curve obscuring any annual cycle (Andrus, personal communication, November 2010). One possible problem (pointed out by Andrus, personal communication 2011) could be that the interval between each hole sampled may not reflect monthly growth. Hence, the

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[28] Due the negative result of this analysis, shells from Camarones Sur site were not analyzed.

analysis was redone with the second set of samples. To get better results, the sampling strategy was refined and samples were drilled at smaller intervals of 1 mm. Despite the change for a high profile in the sampling interval, the results still remained unclear and did not show seasonal variation. One of the reasons could be the water runoff from the seasonal rainfalls in the highlands during the summer, presuming the archaeological shells were collected near the river mouth. Mixing fresh river water mixed with seawater increased turbidity and would lower salinity values leading to higher $\delta^{18}O$ values. Higher $\delta^{18}O$ values will reflect lower seawater temperatures, suggesting the winter season and thus obscuring the true seasonal profile variation (Falabella et al. 1991).

To summarize, a seasonal variation was recorded on a modern shell of *Concholepas concholepas*. Similar results, however, were not obtained for the archaeological samples from Camarones 14. An annual seasonal cycle was not clear from shell profiles and could not be used to compliment the shell growth ring analysis conducted previously.

There were additional complications. The modern shell studied was a mature mollusk, about four to five years old. The archaeological samples, by contrast were from young individuals about one and a half to two years and a half old. Since growth variations are critical for *C. concholepas* (Gúzman et al. 2004) one source of error could be the use of young shells for the oxygen isotopic analysis; young individuals grow faster and could present more variations in growth then in adult ones. Thus, one refinement would be to select adult shells from the archaeological sites to run the $\delta^{18}O$ analysis, to check its potential.

Another potential problem comes from diagenetic effects on *C. concholepas* as pointed out by Labonne and Hillaire-Marcel (2000). The authors demonstrated that in a hyper-arid environment,[29] shells of *C. concholepas* are not good paleoenvironmental markers. That is because high values on ^{18}O and ^{13}C do not correspond to environmental conditions as the aragonite layer is more affected by isotopic enrichments than the calcite layer[30].

For this research, the powdered samples were collected from the inner calcite layer that is less affected by isotopic enrichment. Even so, the isotopic values found did not show seasonal variations. This could be the combined result of the area's hyper-arid condition, with the shells embedded within soil from the early-mid Holocene.

In any event, the results obtained by isotopic analysis of archaeological shells at the Camarones 14 site were inconclusive. This reinforces the point already made by Labonne and Hillaire-Marcel (2000) that *C. concholepas* is not a good paleoenvironmental proxy, at least under the hyper-arid conditions of the Atacama coast. Another factor is that the isotopic composition was affected by fresh water river runoff that reached the sea, shells were collected from the coastal rocks close to the borders of the river valley.

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[29] Their samples are from the marine terraces of Northern Chile; one is a modern sample, another one from the Holocene (about 7,000 BP) and other two samples from the Sangamonian interglacial period, of about 100 ka.

[30] The authors did not exclude the possibility that the calcite outer layer better preserves the isotopic information. However, they concluded that under the hyper-arid conditions of the northern Chile coastline the enrichment observed in ^{18}O and ^{13}C values did not permit paleoenvironmental reconstructions based on stable isotope compositions of whole shells of *Concholepas concholepas.*

Therefore, applying isotopic analysis to archaeological shells of *Concholepas concholepas* (at least under the hyper-arid conditions of the Atacama Desert) is not a useful technique for accessing seasonality at this site.

Shell Overexploitation

Subsistence resources in small-circumscribed areas such as the delta of Camarones River were possibly impacted by people if they were living in the area during the whole year. In this sense, prehistoric societies living in circumscribed areas year-around maybe had to manage resources to avoid overexploitation and to impact the mollusk banks. This may be the case for the population living at the Camarones River delta. If overexploitation occurred and the resource is deeply imbibed within the societies culture, and its substitution is not feasible, this could indicate a pressure for the group to move to other locations while the mollusk population recovers.

The assumption here is that a decrease in the size of the shells found at archaeological sites could indicate overharvesting. This, in turn, provides at least circumstantial evidence of long-term occupation and/or an increase in human population's size. This line of investigation is commonly applied in resource overexploitation studies and can also include changes in the abundance of the mollusk through time (e.g. Billings 2001; Doucet 2012; Mannino and Thomas 2001).

Given this, although human foragers can impact shellfish populations due to intensive exploitation, other explanations for changes in shell size and harvesting are possible (Claassen 1998). Changes in the mean size and shell's abundance can also be due to environmental changes (Claassen 1998) or diversification of the diet with the incorporation of new resources. For example, Báez and Jackson (2008) observed that size reduction could result from the incorporation of different elements into the subsistence system of human groups. In another example, paleoenvironmental data from Los Vilos site (Central Chile) show that during the early Holocene, the sea level regression changed the local ecosystem what facilitated the extraction of shells from the bottom rock substrate where the larger specimens concentrated (Baéz et al. 2004). After this period the Holocene transgression raised the sea level and potentially drowned the river valleys.

The high and extension of sea level changes in bays and coastal valleys varies. In north-central Chile for example, about 6,000 BP of maximum transgression, the sea level was estimated in about 5 and less than 3 meters high at Herradura and Tongoy Bay, respectively (Ota and Paskoff 1993). Projecting this change for the Camarones River delta, a sea level rising of this magnitude possible drowned the river delta. In shells harvesting, however, the impact would not be significant considering that the local area is characterized by high coastal rock littoral. Also, the sites are located in elevated areas, about 30 meters above sea level, with ease access to the rock substrate. Changes in other variables, as water temperature and salinity that could affect mollusks growth, however, are not known. Thus, paleoenvironmental data including seasonal indicators such as isotopic analysis are important.

As addressed earlier, *Concholepas concholepas* or “loco,” has been exploited by early human populations along the south central Andean coast since the Early Holocene (e.g. Llagostera, 1979; Jerardino et al. 1992; Báez and Jackson 2008). With multiple uses, *C. concholepas* became an attractive resource deeply integrated in to marine hunter-gatherers culture. Among the Chinchorro, this mollusk was an important element in their economic and ideological systems. Not only was it a food resource, but it also had symbolic meaning, for example, as a burial offering (Standen 2003). Given this long history of exploitation found in early occupations and the shell's preservation through time, *Concholepas concholepas* can be used to assess overexploitation at Camarones 14 and Camarones Sur.

Such an investigation is centered on changes in shell sizes through time, which may point to overharvesting. The analysis of seasonality raises questions of overexploitation. Are changes in resource exploitation, indicated by seasonal harvesting linked to overexploitation? Did the Chinchorro people impose resting periods for shells predation to insure the mollusks resilience? The way to verify this is through the following assumption: when signs of overexploitation appeared, foragers avoided or reduced harvesting during the mollusk's reproductive period, so as not to jeopardize the mollusks stock. As already observed, there is a lack of shells from certain seasons, mainly fall. The next step is to investigate the extent to which this suggests overexploitation, and if so, maybe year-round occupation and/or a population increase.

The length of the shells of *C. concholepas* is considered a reliable indicator for assessing the impact on prehistoric harvesting (Rivadanera 2010). It is been used to test the hypothesis of resources depletion in mid-late Holocene sites in Chile (Jerardino et al. 1992, Billings 2001; Mannino and Thomas 2002; Báez and Jackson 2008). Billings (2001) analyzed the Chinchorro sites of Quiani 1, Quiani 9, and also, Camarones Sur. The first sites are located around Arica city in the northern Chile. The shell sample from Camarones West (synonym for Camarones Sur) examined by Billings (2001), was composed of selected shell species collected from column samples opened in the exposed profiles of the site. The shells, however, were too fragmented to perform the analysis, and only shells from Quiani were studied. The results for the Quiani sites, however, do not show overexploitation.

The coast of the Atacama Desert is a very harsh, fragile system in which human interaction needs to be in a harmonious balance to support permanent occupation without jeopardizing the resources extracted from the surrounding land and seashore. To verify whether or not people tried to manage this environment to avoid the exhaustion of resources, shells of *Concholepas concholepas* from Camarones 14 and Camarones Sur were collected and analyzed to check for overexploitation. The main objective of this study is to verify if overexploitation occurred, fact that perhaps points to long-term occupation.

Material and Methods

As pointed out elsewhere in this thesis, Camarones Sur and Camarones 14 are located on the southern portion of the Camarones valley coast, the first over the slopes facing the open ocean and the second over a marine terrace facing the valley delta and an open beach (Figure 4.30). Both sites are characterized by an initial pre-ceramic occupation related to the Chinchorro culture, and a later ceramic occupation related to horticulturalists. All occupations, however, are marked by the intensive exploitation of marine resources as shown by the occurrence of marine shells, fish bones, and fishing artifacts (Schiappacasse and Niemeyer 1984; Rivera 1984; 2002). The early-middle Chinchorro occupation (~7,500 to 6,000 BP.), characterizes the pre-ceramic occupation at Camarones 14, followed by a transitional period (Schiappacasse and Niemeyer 1984) best represented at Camarones Sur by a period connecting the Chinchorro and later ceramic horticulturalist cultures about 3,000 BP (Rivera 1984, 2002).

Figure 4.30: Delta of the Camarones river valley with the location of Camarones 14 and Camarones Sur site.

Shells from Camarones 14 were collected from 2 m x 1 m squares excavated in 2007 for this research. Samples from Camarones Sur were recovered from the open profile (profile east) left from Rivera excavation (Rivera 1984). Shells from this site were also collected during the site intervention realized by Rivera in 2008 when shells from the deepest layers and from a close by burial area were collected.

The length and width of the shells of *C. concholepas* were measured following Jerardino and collaborators (1992) description (Figure 4.31). When possible, broken shells were also measured in order to apply the regression equation for *Concholepas* developed by Castilla and Jerez (1986) and tested for archaeological shells by Jerardino, Castilla, Ramirez and Hermosilla (1992) when analyzed shell samples from the site of Curaumilla-1 in central Chile. Castilla and Jerez developed the relationship between width and length. They used the equation to analyze length frequencies and estimate growth parameters for modern shells for the management of this resource in Chile. It describes isometric growth patterns for the *C. concholepas* shells (Castilla and Jerez 1986). Jerardino and collaborators applied the equation to estimate the width of broken shells. Here, it was applied for shells from Camarones 14 to increase sample size. It was used on shell fragments that allowed measuring one of the variables, width or length. Width was calculated by the direct application of the formula below, while length was derived from the relationship between both variables from that same equation[31].

The equation for the length-width in *Concholepas concholepas* (Castilla and Jerez 1986) is: Width = $0.597 \times \text{Length}^{1.052}$, ($n = 112$, $r^2 = 0.989$)

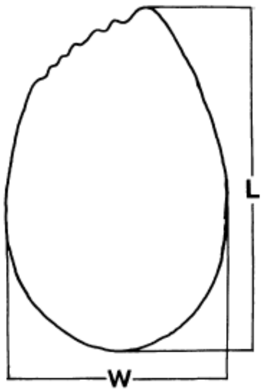

Figure 4.31 Schematic representation of *Concholepas concholepas* shell, ventral view, with indications for morphometric measurements. L = length; W = width (source: Jerardino et al. 1992)

For this analysis, shells were measured using digital calipers on the nearest tenth of a millimeter (0.1 mm). Descriptive statistics were applied to compare the relationship

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[31] The derived equation for length was elaborated by Isleide Zissimos (Economics Department, Vanderbilt University).

between layers and the size of the shells (length and width), with the calculation of the mean sizes of the shells in each layer, the standard deviation, plus the minimum and maximum values for each layer.

Samples from Camarones 14

A total of 115 shells and fragments were collected. After sorting, small sample of 109 shells (57 broken and 52 unbroken) were selected for analyses. After removing layers from the mixed context, a total of 94 shells were studied. Table 4.22, below, has the shells' distribution per layer and their cultural contexts. It is noticed that some layers have small sample sizes. Hence, two approaches were applied to compare the results: one using data from all layers and another one including only layers with large samples.

Table 4.22: Camarones 14: *C. concholepas* shell samples distribution per layer

Camarones 14		Mean	
Layers	Number of shells	Length	Width
Layer 3	2	68.67	50.15
Layer 7	3	41.45	35.69
Layer 9	2	72.5	59
Layer 10	26	35.08	29.01
Layer 11	14	30.38	23.61
Layer 14	16	46.38	35.61
Layer 15	11	41.82	33.11
Layer 16	2	26.5	18.77
Layer 17	18	24.99	20.79

Color code:	IV Post-Chinchorro	III Transitional Chinchorro	II Middle Chinchorro	I Early Chinchorro

When including all the layers analyzed, data from Camarones 14 points to an increase in the average size of the *Concholepas concholepas* shells trough time (Figure_4.32). However, when the layers with small sample sizes are removed from the analyses - layer 3 (2 shells), layer 7 (3 shells), layer 9 (2 shells) and layer 16 (2 shells) – this trend is not as strong (Figure_4.33).

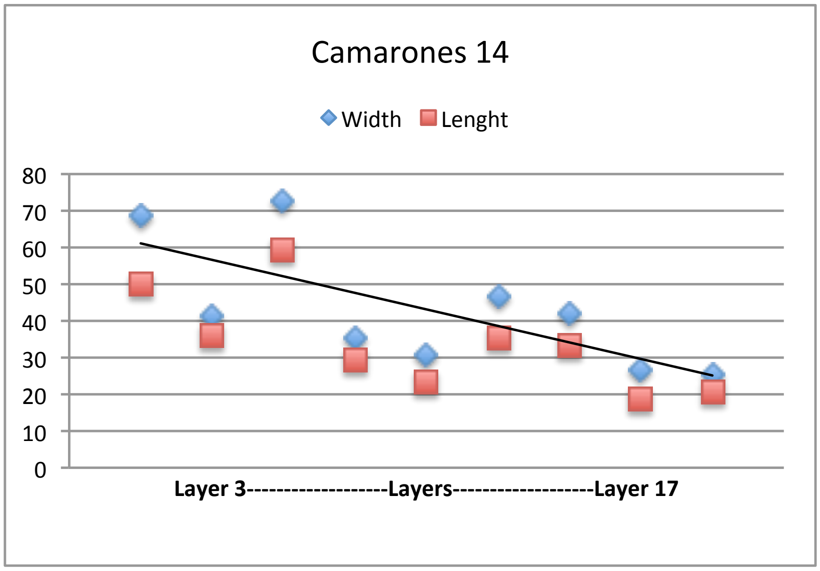

Figure 4.32: Chart representation from data presented in Table 4.20 including all the layers sampled.

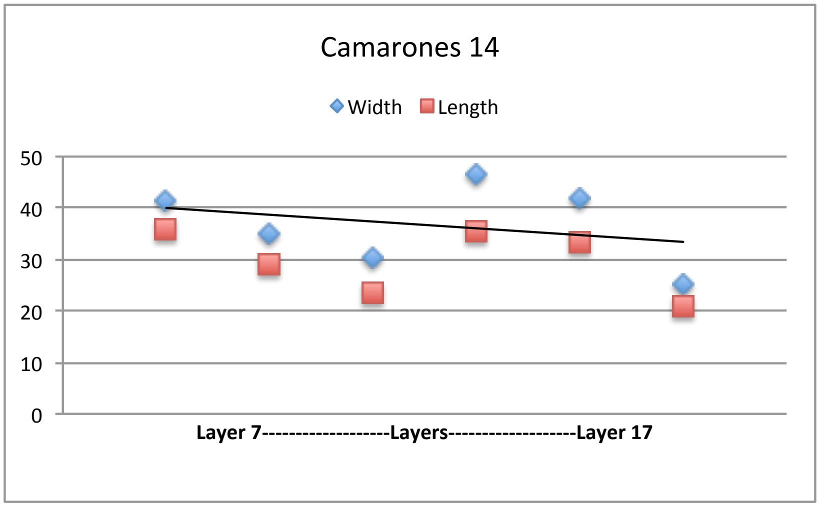

Figure 4.33: Chart representation from data presented in Table 4.20 including only the layers with large sample sizes.

Both approaches point to a tendency for shells size to increase through time. This is the opposite of what the overexploitation hypothesis predicts. A large sample would help to improve the data to make a stronger inference. However, assuming that the sample reflects a real tendency, as suggested by the test with all samples (Figure 4.32), a possible explanation is that forager groups exploiting the area were improving their skills and selecting the larger shells. Although younger shells of *Concholepas* are found in shallow waters in the intertidal zone, the larger samples are found in the sub-tidal zone and require people to dive in order to collect the shells (Castilla and Jerez 1986; Wolf 1989; Eduardo Cepeda, personal communication, 2007). Another possibility is that the shells were collected during the reproductive phase, when they migrate to more shallow waters. Both possibilities, however, indicate the gradual adaptation of the local population to the marine environment.

Based exclusively on the data studied here, namely by shells of *Concholepas concholepas*, the local marine environment was not overexploited by human foragers during the Chinchorro occupation of the Camarones 14 site.

The analysis of the samples from Camarones Sur, presented in the sequence, offer a view of the trends for the subsequent periods of the Late Holocene. These correspond to the contact between the terminal and post-Chinchorro periods when there was contact with horticultural societies from the highlands from about 3,000 BP to 600 BP (see Table 4.23).

Samples from Camarones Sur

A total of 176 samples were collected; shells of *Concholepas* were not found in all layers. From the total samples, 36 pieces were discarded and a small sample of 140 shells were studied. Detailed data with metric analysis for each shell and the descriptive statistic analyses per layer can be found in the Appendix C. Table 4.23, below, has the distribution of shells and the average size for length and width per layer sampled. The data was analyzed in two sets, as for Camarones 14, that is, one with data from all layers and a second one removing layers with small sample sizes (layer 7 and 13). The subsequent charts, Figure 4.33 and 4.34 show the results.

Table 4.23: Camarones Sur: Concholepas shell samples distribution per layer

Layers	Number of shells	Mean		Periods*
		Length	Width	
Layer 1	41	50.50	40.40	Post-Chinchorro (LRD)
Layer 2	30	57.60	42.50	
Layer 4	20	46.50	36.70	Transition (LRD/RDA)
Layer 5	14	48.90	40.60	Post-Chinchorro (RDA)
Layer 7	2	74.00	67.30	
Layer 9	7	47.60	35.30	Alto Ramirez/Chinchorro (Contact zone)
Layer 10	16	63.60	51.80	
Layer 12	8	60.60	51.10	Terminal Chinchorro
Layer 13	2	54.40	48.70	

Notes: Post-Chinchorro period

LRD – Late Regional Development (Ceramic)

RDA – Regional Development Alto Ramirez (Agropastoralism)

*Adapted from Rivera 1984 and from Rivera's personal information 2012

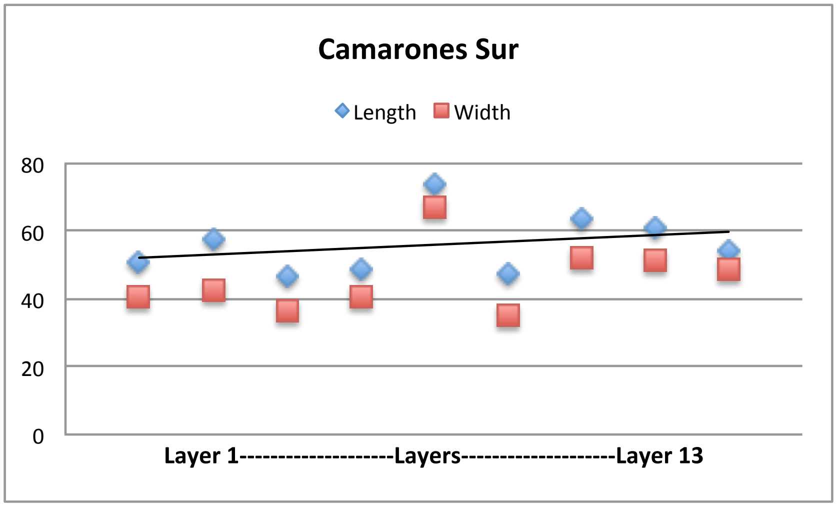

Figure 4.34 – Chart representation from data presented in Table 4.21 with all layers.

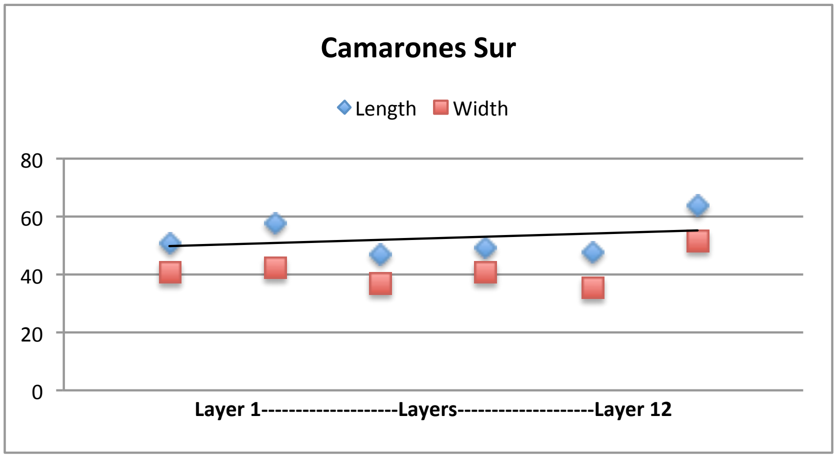

Figure 4.35 Chart representation from data presented in Table 4.21 including only layers with large sample sizes.

When analyzing all layers together (Figure 4.34), it is not observed any strong trend indicating a reduction in the size of the shells, only a slight tendency in this direction. This result remains even after the removal of layers whose sample sizes are less representative, namely layer 7 and layer 13, both with only two shells each (Figure 4.35).

In conclusion, although there is a slight tendency towards a reduction in shell size, the trend is not significant enough to suggest overexploitation of *C. concholepas* at Camarones Sur during the late Holocene period. The mean size of the shells suggests that larger shells around 3,000 BP were harvested, which would require foragers to dive, unless collection was restricted to the reproduction period when mature individual of *C. concholepas* come up to more shallow waters. In sum, based on the Camarones Sur shell samples, there is no clear trend across the layers pointing to a shell size reduction or increase over time. Also, the size of the samples analyzed here were small what may had impact the results.

Conclusions:

There is no indication of *C. concholepas* overexploitation for the early periods of Chinchorro occupation of the Camarones delta river valley (middle Holocene) at Camarones 14. Quite the opposite; the results show a slight tendency for the average size of the *C. concholepas* shells to increase trough time. Due to the small size of the samples, the results are not conclusive. Even so, the data shows a process of adaptation in which people were improving their skills and knowledge of the local environment, the marine coast.

The later occupation of the Camarones Sur site, from about 3,000 BP to 600 BP, indicates a more generalized shell foraging process, although there is a slight tendency for shell size to decrease in the more recent layers. The model suggested by the present data is that, at the beginning, people were foraging mollusks opportunistically in shallow waters; with time they improved their knowledge of the marine environment and their skills in exploiting it. By diving, they could select larger shells. Although not strong, for the post-Chinchorro there is a slight tendency for the shell size to decrease. Perhaps contact with and the introduction of an agro-pastoral economy diversified subsistence activities promoting in a certain way, a cultural detachment from the sea landscape. This is marked by the end of the characteristic Chinchorro artificial mummification practice that occurs around 1,720 BC (Arriaza 1995), that is about 3,500 BP.

No trend in the direction of seasonality or year-round occupation regarding overexploitation was found in the analysis. The lack of shells from the fall period in layers for both sites is not to relate with overexploitation. There is no reason to think that overexploitation would have occurred during the fall. In conclusion, there is no evidence to suggest pressure on the group to move due to overexploitation of *C. concholepas*.

Summary

In this chapter is presented the analysis of seasonality performed in the shells of *Concholepas concholepas* (Camarones 14 and Camarones Sur) and *Semele* sp. (Huaca Priera). The analysis was based on the morphology of the internal growth rings studied throughout a cross section of the shell. Both species yield positive results.

Modern shells were initially analyzed in search for growth variations associated with seasonal patterns. These patterns were then compared with the ones observed in the archaeological shells in order to determine the season the shell was harvested. For *Semele* sp., identification of growth bands was straightforward and the analysis followed Quitmyer et al. (1997) based on the size of the bands, divided in Translucent and Opaque.

Concholepas concholepas is a gastropod and the formation of the shell is different from the bivalves. Bands were not easily perceived as in a clam and there is no study focus on seasonality of the growth lines in *C. concholepas*. Well marked in this gastropod's shell are the growth lines and the angles they were formed. Thus, for this research growth lines were the feature chooses to check for seasonal variations in *C. concholepas*. The analysis performed here in modern shells shows a positive correlation between the angles of the lines and the seasons of the year. This study was based on the visual observation of the angles, and not in their measurement. The visual approach was preferred over measurement because of the variations of the lines that sometimes returns different measurements when shells were double-checked. The twist show in their lines makes their study difficult. Visual inspection gives a broader eyeline and was more reliable with results more consistent when shells were double-checked.

Another tentative approach also applied to check seasonality in *C. concholepas* was based on the morphology of the last external ring or ornament (rib) on the surface of the shell. Four types were identified and maybe they have a seasonal formation. Although it has a potential as a seasonal indicator, variations observed in the same line of ornament discourage its direct application here and more tests are necessary before its use in seasonal analysis.

Oxygen isotopic analysis was performed in *Concholepas concholepas* shells from Camarones 14. A modern sample was tested and returned a positive result, but for archeological samples results were inconclusive. The negative aspect is that oxygen isotopic data could not be compared with the results from the growth rings analysis. Water conditions that maybe prevails when shells were harvest, such as turbidity and changes in salinity and water temperature due the river discharges maybe explains the negative results. Shell preservation in the archaeological sites, under hyper-arid conditions of the Atacama coast, could also affect the results (Labonne and Hillaire-Marcel 2000).

Analysis of overexploitation conducted in shells of *Concholepas concholepas* shows that although its many uses such as food resource, or offerings in funerary rituals, this gastropod was not overexploited during the period studied here.

The seasonality studies performed throughout the analysis of shell growth in *Concholepas concholepas* from both Camarones 14 and Camarones Sur sites indicate that sedentism was possible during certain periods: for Camarones 14, about 7,000 BP and, again, between ~6,500-6,000 BP, and for Camarones Sur maybe about 3,000 BP. In the case of Camarones Sur the number of shells analyzed for this period (in layer 12/14) is relatively small (5 shells) and no strong conclusion can be made. The subsequent layer associated to the same period has a better sample size suggesting year-round occupation. For other periods in both sites, seasonality is marked by a lack of shells from the fall season.

The result for the study of shell growth bands in shells of *Semele* sp. from the Huaca Prieta site shows that during the preceramic period (Phases 2, 3, and 4) the shells were collected mainly during the fall season, suggesting a repetitive pattern of seasonal activities during the wet season. This pattern changes in Phase 5 that marks the end of the preceramic period at the site 4,000 and 3,500 cal BP (~3,620 to 3,040 BP) with shells probably collected during the middle spring, possible in November.

For all the analysis the main problem was the small number of the archaeological shells studied. For the statistical analysis the Binominal Analysis was performed. This was chosen because it is used for small samples as the ones here with reliable results.

In the sequence, Chapter 5 has the results of the paleoenvironmental data collected from Camarones 14 as well as coprolites, shell and lithic artifacts, giving the context of the local environmental and cultural background of the groups living in the area at the time of the site occupation during the Middle Holocene.

CHAPTER V

THE PALEOENVIRONMENTAL DATA AND ARTIFACTS

This chapter examines paleoenvironmental and cultural data recovered from the Camarones 14 site. It includes botanical remains, lithic and shell artifacts, radiocarbon dates, as well as coprolites and fish otoliths.

Botanical remains are divided into macro-remains, pollen, and phytoliths. Such materials shed light on the paleoclimate and the composition of the local landscape during the periods of site occupation. In some cases, macro-remains can give information about the seasonality of plant harvesting. Artifacts, mainly lithic, shell, and fishhooks provide cultural data. Although not the main element of this thesis, they are described, and an attempt is made to link them to mobility patterns. Other types of artifacts (bone and cordage) are also briefly described. A few wood artifacts are described in Appendix E, as part of Garcia's macro-botanical remains report.

As a remind, paleoenvironmental and cultural artifacts from Huaca Prieta are not object of analysis in this theses. However, some artifact description from Bird's 1940's excavation can be found at Bird et al. (1985). From Dillehay's project, initiated in 2006, paleoenvironmental data from Huaca Prieta are presented in Dillehay et al. 2012a, while site chronology and excavation context are described in Dillehay et al. 2012b. Other analysis and cultural artifacts can be also found in Dillehay (s/d.).

Botanical Data: Seasonal and Paleoenvironmental Approach

Plants are sensitive to variations in soil characteristics and climate; they are good indicators of the surrounding environment at the times when the sites were occupied. Plants also open a window to the cultural aspects of human adaptation to prevailing environmental conditions. This is demonstrated by the diversity of plants used and how such knowledge was integrated into the cultural aspects of human society (Pearsall 2008; Villagrán M. et al. 2004). Plants were used to make fire, food, medicine, and as narcotics; they were used in ritual and are made into artifacts). In the past, plant cultivation has transformed the structure of forager-hunter-gathering societies (e.g. sedentism, ideology), changing their interaction with nature (Denham et al. 2007; Price et al. 1995).

Botanical remains recovered from archaeological sites are a rich source of information about the paleoclimate data. They also give information about the knowledge the inhabitants had of plants, both in economic and ideological terms. Plants can help to infer about the seasonality of a site's occupation, as well as the exchange networks linked to other groups (e.g. Bar-Yosef et al. 1998). Given new recovery methods, plant remains can be studied on a macro- (e.g. seeds, roots, charcoal) and microscopic scale (pollens, phytolith), amplifying the information that can be gleaned from archaeological sites (e.g. Piperno 2006; Iriarte 2006; Schell-Ybert 2001). Its use as a seasonal indicator, however, is not so direct; some plants are available throughout the year or can be harvested later in the season, while others may still be stored (Scarry and Hollenbach 2012).

As noted in Chapter 3, sediment for pollen and phytolith analysis was recovered from the Camarones 14 site, as well as macro-botanical remains.

Macro-botanical Remains

This section discusses the macro-botanical remains from the Camarones 14 site collected for this dissertation research. This material was analyzed by Garcia B. (MASMA) whose report “El material vegetal asociado al area doméstica de Camarones 14” is annexed at the end of this dissertation (Appendix E). The maize remains found were not analyzed in Garcia’s report. Instead, they are presented later in this chapter. The maize comes from disturbed contexts and are probably from post Chinchorro occupations.

The expectation was that the plant remains found would allow a better understanding of both the terrestrial biota in which the settlements were established and the environmental conditions in the area during the Late/Middle Holocene. The main point was to know if cultivated plants were used, and if so, if this led to sedentary settlement bases. Other goals were to understand subsistence, and to check climatic conditions at the time of the site occupation. Finally, this work contributes to a set of data concerning the Middle Holocene paleoclimatic conditions for the north coast of the Atacama.

A brief overview of the valley’s physical setting and its botanical composition today is reintroduced in this section. This gives a baseline against which we can understand the changes between past and current landscapes.

The Actual Landscape at the Camarones River Valley

The environment of the Atacama Desert is challenging. Precipitation from fog is a key element in plant adaptation. It provides humidity and covers plants from the sun during part of the day (Ferreyra 1983; Rundel et al. 2007). In addition, mist from the ocean concentrates in the Camarones River Valley and its estuary, providing moisture for highly specialized plant communities adapted to the local environment (Personal observation, 2007; Arriaza et al. 2008).

Figure 5.1: Photo showing the river and the vegetation growing on the north portion of Camarones River valley during the summer 2008.

To the north and south, the river valley is surrounded by the mountainous Cordillera de la Costa. To the west is an open beach about 4 km wide at the valley mouth.

The valley, narrowed by the cliffs, stretches east from the mountains. At its delta, the valley has two distinct sections. On its south portion, there is a marine terrace about 37 meters above sea level. This is where the site of Camarones 14 is located, as well as the tiny fishing village of Caleta Camarones, with about 20 houses. On the north section (Figure 5.1), in the valley's bottom, the vegetation is rich. A lagoon forms close to the beach, but its occurrence is intermittent as it can dry out during periods of extreme aridity. During the summer, the vegetation flourishes and the lagoon is usually connected to the ocean by the runoff waters that come down from the altiplano rainfalls. The lagoon can also open during periods of strong waves and high tides when the seawater flows to the lagoon and mixes with fresh water. Plants are concentrated in the wetlands on the valley floor. They are well adapted to the saline and desert soil conditions of the area (Pöhlmann and Reiche, 1900, 1980; Garcia 2009 internal report). When the lagoon initially formed in the past is not known. However, remains of *Typha* (totora reed), and *Phragmites australis* (reed), both plants associated with a wetland environment (Table 5.2) (see pollen analyses section in this chapter), suggest the existence of a wetland nearby, at the time of the site's early occupation.

The current vegetation in the river valley includes *Atriplex imbricata* and *Atriplex madariagae,* both from the family Chenopodiaceae, along with *Distichlis spicata* (Graminae) and *Tessaria absinthioides* (Compositae). In the wetlands close to the river's mouth, the predominant species are: *Typha angustifolia* (totora), *Scirpus spp*. (round reed), and *Phragmites spp* (common reed) (Garcia, 2009 internal report; Belmonte et al. 1988). Belmonte and colleagues (1988) also included the following species for the delta of the Camarones River: *Atriplex atacamensis* (Chenopodiaceae), *Baccharis petiolata*

(Compositae), *Pluchea chingoyo* (Compositae), *Schinus molle* (Anacardiaceae), *Scirpus americanus* (Cyperaceae), and *Cortaderia* sp. (Graminae). Higher in the valley, at the end of the 19th century, Pöhlmann and Reiche (1900, 1980) reported the pampas grass or cortadera--(*Gynereum argenteum*) as well as the small junquillo, *Scirpus chilensis* (Pöhlmann and Reiche 1900). Also, higher around the Cuya locality, they also noted the infrequent occurrence of *Schinus molle*, which became more regular inside the valley, as well as two species of acacias and small clusters of chanar - *Gourliea chilensis* (Fabaceae). An Anacardiaceae know as *carza*, was also observed. Although some crops, like alfafa (*Medicago sativa*) and maize (*Zea* mays) were cultivated on a small scale, the Camarones Valley is not suitable for crops or fruit cultivation due to water and soil salinity (Pölhmann and Reiche 1900). Garcia (internal report, quoting Pinto 2005) observes the existence today of only one area where *lomas* formation occurred[1]. This is at Cerro Ballenato, some 18 km from the Camarones River delta.

Schiappacasse and Niemeyer (1984) observed that during the later Formative period[2], the delta of the valley should have presented conditions for the cultivation of some plant species. They listed the following cultivated species found at Camarones 14 during that period: *Zea mays* (maize), *Tripsacum dactyloides* (a wild ancestor of maize), beans (poroto), calabaza (possible *Lagenaria sp.*), and cotton (algodón). They also found seeds of *Prosopis* sp., and remains of Heliconia (Genus *Heuconia*), an exotic plant for this arid zone that is commonly found in the tropical forests of Peru and Bolivia, on the eastern slopes of the Andes (Berry, 1922). In Schiappacasse and Niemeyer (1984), this corresponds to strata b (see stratigraphy in the Chapter 3).

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[1] Two other areas with *lomas* are found in Quebrada Suca (Chiza) and Quebrada Vitor (Garcia's internal report, quoting Pinto 2005)

[2] Associated with Saxamar ceramic contemporaneous to the Inca domination.

Laboratory Analyses

Samples were collected from 0.20 x 0.20 square meter sections during the site excavations of 2007 when two sectors of 1 x 1 square meter were opened. The sample sizes varied according to a layer's thickness. They were selected depending on their potential for botanical information. The main layers sampled were layers 9, 11, 12, 14, 15, 16, and 17. Macro botanical remains from material sorted in the field and from the bucket samples sorted later in the laboratory were incorporated in the analysis. All material was brought to the Museo Arqueológico de San Miguel de Azapa – MASMA - (Arica, Chile) and analyzed by Garcia. The methods used for the analysis and identification of the remains can be consulted in Appendix E at the end of this dissertation.

Flotation was initially executed by this author, and then finalized by Garcia. With flotation water was used to separate light and heavy fractions of material from the floated sediment. From flotation samples, only the light fraction was analyzed.

Results and Discussion

Below, the material identified in the site is introduced. This includes habitat, the type of remains identified, and their traditional uses by modern populations. The stratigraphic and chronological distribution is discussed later, as well as their seasonal occurrence.

The list of macro botanical remains collected and identified at Camarones 14 site is presented below (Table 5.1). It combines the taxa from the excavation performed for this dissertation, plus the work realized by Schiappacasse and Niemeyer (1984).

Table 5.1: General list of plants identified at Camarones 14 site

Taxa identified at Camarones 14 for this research. Compiled from Garcia B. Internal Report (Appendix E)						
Taxon	**Family**	**Life form/ Habitat**	**Arq. remains**	**Observation**	**Common name (English / *Spanish*)**	**Uses**
Schinus molle	ANACARDIACEAE	Tree 0-3500 m	Fruits	Fruits: Summer	California pepper / *molle*	Medicinal uses; seeds used to make *chicha* (*chicha de molle*)[3]
Phragmites sp. / *Phragmites australis*	GRAMINEAE/ POACEAE	Perennial herb	Leaves/ stalk /stem	Blooming time: late Summer to early/mid Fall[11]	Common reed / *cañaveral, caña*	As roof in houses, to block wind, in handicraft products (basketry, mats, etc) [12]
Typha sp. / *Typha angustifolia*	TYPHACEAE	Perennial herb /marshy wetlands	Stem /stalk	Early flower stems harvested in early spring-summer. Flowers mature in mid-summer; rhizomes collected from late fall to early spring[2]	Cattail / *totora*	Eatable; Processed rhizomes: source of starch and pollens. Also dried flower's stalk as tinder for fire[2]. More for *Typha angustifolia* in the respective item, bellow
Compositae /Asteraceae	COMPOSITAE /ASTERACEAE		Flowers			
Eulychnia sp. (conf.) Cactaceae	CACTACEAE		Thorn, seed		Thorn / *Copao*	Eatable fruits. In the site context: fishhooks
Scirpus sp.	CYPERACEA	Perennial herb /wetlands	Seeds, rhizome and stalk /stem	Seeds shed during end of dry season (April to December)	Round reeds/ *Junquillo*	Many uses including handicraft products, and boats[1]
Prosopis sp.	FABACEAE/ LEGUMINOSAE	Tree; can reach 20 m. high. Desertic coastal zones and slopes, till 3000	Seeds	Hunter-gatherers resource in the altiplano[4]. Saxamar culture[14]. Seeds in Dec/March	*Algarrobo Tamarugo*	Many uses in medicine, construction, as food supply, etc. Also for charcoal[12]. Flour and bread from

		masl.[6]		(main period) and Jun/July		gridding pod, without the seeds. Also *chicha*. Easy storage[4] pods as source of protein[6]
Tessaria absinthioides	ASTERACEAE	Shrub, perennial Close to water	Flowers	Flowers: Summer (Dec-March)[8]	*Brea sonora*	Alternative plant to feed livestock, house's roof, leaves with medicinal properties. Can produce "brea" to caulk[12]
Leucocoryne sp. / *Zephira elegans*	AMARYLLIDACEAE	Perennial herb/ *lomas*	Corm (*cormo*)	Leucocoryne flowers: September[13] (winter / spring)	*Huille, flor de viuda*	Eatable (corn) *Lomas* flowers: from June to September[15].
Lagenaria sp.	CUCURBITACEAE	Herb	Pericarp	Cultivated since prehispanic periods at the peruvian coast[6]	Squash / *calabaza*	
Equisetum giganteum	EQUISITACEAE	Coast/ Sierra/ Selva	Stalk, stem		*Qosqosa*, *Colla de caballo*	Medicinal[12]. Also for polishing purposes (high concentr. of silica in its dry form)[6].
Macrocystis integrifolia	LAMINARIACEAE[5]	Perennial / marine, deep waters to surface, intertidal zone; northern Chile[5,10]	Aerociste	Perennial[10].	*Huiro*	Eatable, handcraft. Dead plants easily collected ashore[10].

Taxa previously identified at Camarones 14 (Schiappacasse and Niemeyer, 1984)

Taxon	**Family**	**Life form, habitat**	**Observation**	**Common name (English /*Spanish*)**	**Uses**
Trichocereus cuzcoensis (Echinopsis cuzcoensis)[7]	CACTACEAE	Sierra[6]		Cactus / *collai, ahuacolla*	Many medicinal uses, including injuries and infected wounds-use of the sap in poultice[6]
Tripsacum sp. (possible *T. dactyloides*)	GRAMINEAE/ POACEAE				Cultivated in Peru, Bolivia and Paraguay.
Scirpus californicus	CYPERACEA	Perennial herb /wetlands	Also found at Punta Pichalo site		Found from California to South Chile.
Typha angustifolia	TYPHACEAE	Costa, Sierra and Amazonian areas[6]	Cultivated by the Uros at the Titicaca lake[6] Registered at Quebrada Tarapaca (2000 a.C.[4])	Totora reed / *totora verdadera*	Eatable; raw or cooked- flower/ rhizome/ sprout. Medicinal: coal plants to heal wounds[6]
Lessonia nigrescens	LESSONIACEAE[5]	Marine,low intertidal - shallow subtidal zone, found on exposed rocks; large sizes: 4 m long, 50 cm holdfast diameter[9].	Fertile period is restricted to winter[9]. Settlement occurs in winter.	Kelp, brown seaweed / *chascón, huiro negro*	Eatable, for harvesting, the entire plant is removed or had the stipes cut[9]. Dead plants easily collected ashore.
Macrocystis integrifolia	For this taxon, see the respective item listed above				

Source:
1) Gossen, Candace. 2007; 2) Brill, S. and Dean, E. 1994; 3) Moseley et al. 2005; 4) Pardo B., Oriana and Pizarro T., Jose L. 2005; 5) Guiry, M.D. and Guiry, G.M. 2012, http://www.algaebase.org; 6) Egg, Antonio Brack. 1999; 7) Brako, L. and Zarucchi, J. L. 1993: 8) Reiche, Karl 1905; 9) Vasquez, J. A. and Santelices, B. 1990; 10) Vásquez, J. A. 2008; 11) Dave's Garden URL: http://davesgarden.com/; 12) Villagrán M. et al. 2004; 13) Schick 1991; 14) Schiappacasse and Niemeyer 1984; 15) Ferreyra, R. 1983.

Zea maiz was also recovered, but probably linked with a post-Chinchorro occupation discussed at the end of this section. Additional subsistence remains included shrimp, fish, mollusks (mainly *C. concholepas*, *Mesodesma sp.* and *Choromythilus chorus*), birds, and some mammals.

As Table 5.1 shows the site had a diverse set of exploited plants. Thirteen taxa were identified by Garcia (Appendix E): seven at the species level (*Equisetum giganteum, Macrocystis integrifolia, Phragmites australis, Typha angustifolia, Schinus molle, Tessaria absintioides, Zephyra elegans*), four at the genus level (*Leucocoryne*, *Lagenaria*, *Prosopis*, *Scirpus*), and two at the family level (Asteraceae and Cactaceae). Plants were typically from wetland, valley, and coastal zones. This indicates that during the occupational period of the site, the environment was similar to the present time. However, as already shown, variations were detected in pollen and phytoliths that show changes in the environment, through time.

Due to the remarkable preservation of organic material in the arid desert, the flowers and seeds of certain plants were recovered and at least one was identified. Therefore, an attempt was made to incorporate such data into a discussion of the site's seasonality. The plants identified are systematized in the table below (Table 5.2) according to their cultural and chronological context.

Table 5.2: Stratigraphic distribution of the identified plant remains and their cultural context recovered during the excavation carried out for this research in 2007 and identified by Garcia (see Appendix E).

	TAXA												
LAYERS	*Schinus molle*	*Prosopis* sp.	*Scirpus* sp.	Familia Cactaceae	*Zephira elegans / Leucocoryne* sp.	Familia Compositae / Asteraceae	*Typha* sp. (conf.)	*Phragmites australis / Phragmites* sp.	*Tessaria absinthioides*	*Equisetum giganteum*	*Lagenaria* sp.	*Macrocystis integrifolia*	Cultural Context
Surf		*	*										V - Modern
1	*	*											
3			*		*								IV - Post Chinchorro
6	*		*										
7			*		*								III - Transit. Chinchorro
8					*								
9			*		*	*							II - Middle Chinchorro (Less than 6000 to 6700 BP)
10	*	*	*		*	*	*	*				*	
11	*		*		*	*	*	*	*	*			
12	*		*	*	*	*	*	*					
14	*		*		*	*			*				I - Early Chinchorro (~7000 to 7600 BP)
15			*		*	*	*	*					
16			*										
17	*		*		*		*	*			*		

The distribution of plants through time (Table 5.2) shows a clear differentiation according to their presence/absence in each layer. These data, however, could be biased in certain respects as some of the upper layers were disturbed and mixed and thus could not be considered in this analysis[3]. In addition, as explained earlier, not all layers were submitted to flotation, which could decrease the chances for recovering small seeds. Selective collection prioritizes areas and layers with plant evidence reflected in a stratigraphic distribution that gives a general panorama of their occurrence through time. Factors such as paleoecology, however, could also explain some patterns and are discussed later. For flowers, selective collection prioritized these remains from the sieve and bucket samples, and their distribution should closely reflect their original distribution at the site.

Plant diversity is higher in the layers below layer 9, which marks the limits between the Middle and Transitional periods. This is a thin layer with abundant plant remains that lie over the layer underneath, which is a thick shell layer (layer 10) mainly composed of *Mesodesma* shell remains. It dates to the final limits of the Middle Chinchorro period, sometime after 6,000 BP[4]. In this sense, the limit here between the Transitional and Middle Chinchorro seems well marked

Another point to note concerns the strong concentration of flowering plants (inflorescences) observed between layers 9 and 15. Identified to Family level (Asteraceae/Compositeae), it has three different taxa, two remain unidentified, and one is identified as *Tessaria absinthioides* (Garcia, Appendix E). This concentration of Asteraceae in the middle of the occupation (about to 7,000 BP and up to 6,000 BP) is indicative of a change in the local environment, with the expansion of plants environmentally adapted to drier conditions. This is supported by data from pollen and phytoliths that indicate a drier period for the Middle Chinchorro. Some plants adapted to

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[3] Results of mixed layers can be found in Garcia's internal report in Appendix E.

[4] The radiocarbon date of 7,283 ± 48 (AA99973) for this layer is older then expected and is not considered here.

wetland areas, like *Typha* and *Phragmites*, disappeared from the upper layers, with no occurrence registered for the Transitional and post-Chinchorro periods. The reason for this was probably the onset of a drier period. Other factors, however, could also be involved. There were periods of contact with inland groups. Consequently, the population living in the delta of the valley was under the influence of ceramic agriculturalists (Schiappacasse and Niemeyer 1984). These contacts could have changed the pattern in the exploitation of products from the delta's valley, like *Typha* and *Phragmites*, both with diversified uses including human mummification.

Scirpus has a marked occurrence through almost all periods of the site's occupation. This suggests that the river delta, despite an increase in aridity, still kept enough moisture for *Scirpus* to grow. Pollen samples from the Early and Middle Chinchorro periods reinforce this evidence. It shows that *Typha* pollen types diminished during the Middle Chinchorro, while Cyperacea pollen (related to *Scirpus*) was still a strong presence in the landscape, although with a tendency to decline. Even so, *Typha* was still being harvested during the Middle Chinchorro. This shows that the river was still bringing water to the valley keeping the land saturated enough for *Typha* to grow.

Regarding seasonality, seeds and flowering can be tentatively used as an indicator for this. In an environment like the Atacama coast where preservation is highly favored, dry plants would be present during the entire year, and flowers and seeds can be dispersed by wind. On the other hand, Camarones 14 is located over a terrace about 33 meters above the valley floor. This increases the site's isolation from the valley. Moreover, dunes without vegetation characterize the areas surrounding the site. Consequently, plant remains were probably discarded by foragers. As Garcia notes

(Appendix E), flowers and seeds should be brought adhere to plant twigs. Therefore, the concentration of flowers and seeds at certain levels could support seasonality when compared to other type of evidences.

In this particular case, however, *Scirpus sp*. remains (seeds, rhizomes and stalks) are constant in the stratigraphic context. This implies the persistence of a wetland area nearby, and its use by ancient people. Seeds are found only in the Early and Middle Chinchorro contexts. From the initial occupation, they are from layer 17 (level 13C), layer 16 (level 13B), layer 15 (levels 12C, 12C (ceniza), and 12C2), and layer 14 (level 12), while from the Middle Chinchorro they are from layer 12 (level 9A), layer 11 (level 8C), and layer 9 (Rasgo 1)[5]. The largest concentration of seeds was found in layers 11 (19 seeds) and 15 (51 seeds). *Scirpus* seeds mature and shed in the beginning of the dry season[6]. This implies that plants were harvested in early fall. A radiocarbon date from level 8C (layer 11) has an age of 6,522 ± 54 BP (AA85507 5) in the Middle Chinchorro. Besides the many uses of this plant, it has edible parts (rhizomes and new stems). Seeds of *Scirpus* are protein rich and can be used to enrich other flours.

Inflorescences of *Tessaria absinthioides* are registered in layer 11 (levels 8B, 8C), and layer 14 (level 12), in addition to other mixed layers. They are linked with the Middle Chinchorro context and the largest concentration is registered for layer 11, with 11 remains. The radiocarbon date of 6,522 ± 54 BP (AA85507 5) mentioned for *Scirpus* is also applied here. Inflorescences from layer 14 also came from a radiocarbon dated stratigraphic level, level 12, with an age of 7,015 ± 50 BP (AA85505 3). This places them at the end of the Early Chinchorro. Flowers bloom during the summer.

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[5] For a complete list of plants and remains by layers and levels including mixed layers, see Appendix E.

[6] Dry season is from April to December.

The genus *Typha*, know as cattail ("*totora*"), has about eleven species worldwide. However, along the Peruvian coast, the local human population only exploits *Typha angustifolia* (Brako and Zarucchi, 1993). In Chile *Typha angustifolia* is associated with human contexts from about ~4,000 BP at Quebrada Tarapacá (Pardo 2005 quoting Núñez 2000). *Typha* is a key plant used for multiple purposes. As an edible plant, it is consumed by humans as well as livestock. With medicinal properties, carbonized plants can be used to heal wounds. This plant is also important in manufacturing handicrafts like mats, and in the construction of roofs, houses, and boats. Given its importance, *Typha* is cultivated by communities like the Uro from Puno, who cultivate it on the edges of the Titicaca Lake (Egg 1999).

Typha's stems were identified in the context of Camarones 14[7]. They were found from the initial occupation of the site until the intermediate layers of the Middle Chinchorro. They are from the Early Chinchorro context--layers 17 (level 13D) and 15 (level 12C, ash, 12C2), and from the Middle Chinchorro - layer 12 (level 9A), layer 11 (levels 8C, 8B), and layer 10 (levels 5, 5dp3, 5dp4). Since the plant was available during the entire year, it would not be a good seasonal indicator (Garcia, personal information 2013). However, foragers preferentially collect some edible parts of the *Typha* plant when they are still tender, like the core of immature flowers (sprouts), or young rhizomes harvested from mid spring to summer, and from late fall to early spring, respectively. Since none of these were found at the site, *Typha* is not used here as indicator of site seasonality.

Leucocoryne sp./Zephira elegans occur in *lomas* formations. Plants growing in

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[7] The majority of remains, classified as *Typha sp*., however, need confirmation (Appendix E, in Garcia's report).

this biome flourish during the winter, from August to September, when the coastal fog ("*camanchaca*") is more intense. This provides atmospheric humidity and protects the plants from solar radiation (Ferreyra 1983). Depending on local weather conditions, plants can extend their period until November. *Leucocoryne* flowers in September (Schick 1991). Its presence at the site is relatively constant throughout the entire occupation. What identifies these plants at the site is their corm, rather than their flowers. The corm is the eatable root-like part of these plants. Corms are easily stored for a certain period. Brought to the site, they indicate that people were exploiting the *lomas* and collecting these plants that probably were a part of the local diet.

Fruits of *Schinus molle* were also recovered from many layers, but were concentrated at the middle of the occupation (layers 10, 11 and 12 from the Middle Chinchorro). The plant flowers from spring to summer (October to January.) Fruits maturation occurs during the summer from February to March. The initial remains appear at the base of the site in layer 17 and in layer 14 (Early Chinchorro). It is also present in the upper layers during the post-Chinchorro period (in layer 6). This data indicates that people exploited this section of the valley[8] throughout these periods, particularly about 6,000 BP during the middle of the occupation.

Table 5.3 summarizes the botanical evidence for the Camarones 14 site that can be linked with seasonal data, according to the remains found, such as when the plants were harvested, when they bloomed, or when the seeds shed. This data is integrated in the next table (Table 5.4) by layer in a tentative approach to interpret the seasonality of the site's occupation.

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[8] Upper the area where nowadays lies the locality of Cuya.

Table 5.3: Camarones 14: botanical remains and seasonal data

Evidence	Taxon	Spring	Summer	Fall	Winter
seeds	*Scirpus*		X	X	
flowers	*Tessaria* (dec-march)		X		
corms	*Leucocoryne* sp. / *Zephira elegans*				X
seeds	*Prosopis*		X		X
fruit	*Schinus molle*		X		

Although there is evidence of *Prosopis* seeds, they are from a disturbed area (layer 4) and from the surface (superficial, layer 1). An isolated occurrence was registered for layer 10. This layer is characterized by a concentration of mollusk shells of *Mesodesma donacium*. Evidence of *Prosopis* found by Schiappacasse and Niemeyer (1984) are related with the "agro-alfarrero" period (Saxamar culture) that corresponds to the intermediate level here. The almost negative evidence for the Early and Middle Chinchorro periods (from layers 17 to 9) suggests that maybe the interior valleys were not exploited during these periods, at least for the areas with evidence of *Prosopis.* The plant is found along the Loa River and the Tamarugal area (Núñez and Santoro 2011). Due to its many uses, people living on the coast were expected to exploit *Prosopis* had they been in contact with the interior valleys. *Prosopis* seeds and its products such as bread, flour, and *chicha* are of easy storage. *Prosopis* is a rich source of protein and an excellent food resource not only for human beings but also as rations for animals. Schiappacasse and Niemeyer (1984) report that six metate stones, used to grind grains, were recovered from the Preceramic layers of Camarones 14. Apparently, however, they were not related to grinding *Prosopis* seeds as long as they were not found in the same strata. They could have been used, however, to process *Scirpus* seeds or *Typha sp*. Widespread evidence across Europe (e.g, Italy, Russia and Czech Republic), for example, shows that grindstones were used to process cattail rhizomes (*Typha*) at least ~30,000 BP

(Revedin et al. 2010).

Algae evidences are of *Macrocystis integrifolia* from layer 10, from the Middle Chinchorro. Schiappacasse and Niemeyer (1984) excavation also include the algae *Lessonia nigrescens* (Bory). Both algae are found in the intertidal littoral and can easily be collected during low tides or ashore.

Table 5.4 below, summarizes the data already discussed. It presents the seasonal data derived from plant remains from Camarones 14. These data, however, have to be used with caution because there is no seasonal indicator for spring. Only summer, fall and winter are included in the present data, that is, the spring season is not represented due a lack of a good seasonal indicator among the plant remains. Also, some plants are available all seasons, but only their seasonal indicators are analyzed here. For example, although Scirpus' seeds can be linked with end of summer and early fall, the stems, which were also found in the site, can be available during the entire year. In conclusion, it is possible to infer when the site was occupied by foragers, but not exactly when they were not.

Table 5.4: Camarones 14: seasonal data and occupational layers based on the botanical remains* (Table key: Sm= summer; F= early fall; W=winter)

Season	**Layer**	**Taxon**					**Cultural Context**
		Scirpus	*Tessaria absinthioides*	*Leucocoryne*	*Prosopis*	*Schinus molle*	
Sm/W	1				9	1	V - Modern
Sm/F/W	3	1			2		IV - Post Chinchorro
Sm/F	6	1				1	
W	7			8			III-Transitional Chinchorro
W	8			1			
Sm/F/W	9	1		2			II - Middle Chinchorro
Sm/W	10			12	2	1	
Sm/F/W	11	19	11	7		18	
Sm/F/W	12	5		4		2	
Sm/F/W	14	6	2	5		2	I - Early Chinchorro
Sm/F/W	15	51		6			
Sm/F	16	5					
Sm/F/W	17	13		5		2	
Evidence		Seed	Flower	Corm	Seed	Fruit	

*The total number of remains is given for each taxon per layer. Spring is not represented.

Macro-plant data suggest an intense period of occupation at the beginning of the Early Chinchorro (summer, early fall and winter) followed by a dual seasonal period of exploitation divided between the summer and early fall. Occupation intensified again for subsequent layers during the summer, early fall, and winter seasons. The division between the Early and the Middle Chinchorro is marked by the abandonment of the site for about 400 years from 7,015 ± 50 (AA85505 3) – layer 14, to 6,641 ± 49 (AA85506 4) – layer 12. After this time, the occupation is as intense as it was during the Early Chinchorro and only layer 10, characterized by a thick layer of shells, shows a dual season of summer and winter. In the Transitional Chinchorro (layers 7 and 8), the pattern changed completely and only winter is marked. During the post-Chinchorro (layers 3 and

6) the seasonal exploitation is extended again, initially for summer and early fall, but with the later addition of the winter, as shown by the introduction of *Prosopis*.

Regarding early cultigens, the occurrence of a small fragment of *Lagenaria sp.* squash is the only evidence of a cultivated plant at the site related to the Chinchorro strata. Garcia (Appendix E) notes that evidence for this cultigen in the region is comes from the late archaic period and it was found at the Camarones 15 site from about 4.000 BP. In Camarones 14 it is from a radiocarbon context (level 13 C, sector A2) from layer 17 at the base of the site, dated to 6,980 ± 50 BP (AA85504 2), which indicates an early introduction of this cultigen into the area.

Maize (*Zea maiz*) remains were found in a disturbed context and are associated with the post Chinchorro occupation. In fact, three samples of maize cobs, two from level 8 (sector A2), and one from level 1C (sector A2) where sent for radiocarbon date by Mario Rivera together with the other remains. So far, only one sample, from level 8, has been radiocarbon dated to around 785 ± 35 (AA84945) (T. Franco/M. R. Rivera). Although this is more recent than expected, the sample was close to an area with concentration of coprolites and other mixed sediment that started in layer 1C (A2) related with layer 2, and reaching layer 5. The date in question should be linked with this zone.

The remains of a possible fragment of a husk fragment (A2, level 13D) and possibly a silk fragment (A2, level 13B) may be related to the Chinchorro strata. It would be interesting to date these remains and place them in their appropriate context. Table (5.5) below covers the maize fragments:

Table 5.5: Maize's samples recovered from Camarones 14

Sector, level	Husk	Cob	Silk? (hair?)	Radiocarbon date	Lab no.	Observations	Layers
A2, 1C	X	X				Mixed	2
A2, 1C (60 cm)	X	X				Mixed	2
A2, 1D	X					Mixed	L
A2, 5dp2	X					Associated with coprolites	10
A3, level 7 (bajo 92 cm)	X						11
A2, 8 (78 cm)		X				Associated with coprolites	11
A2, 8 (81 cm)		X		785 ± 35	AA84945*	Associated with coprolites	11
A2, 13B			X (?)				16
A2, 13D	X						17

* T. Franco/M. R. Rivera

Conclusions

Macro-botanical evidence consists of wild, local plant remains such as *Phragmites* sp*.*, *Scirpus* sp., *Tessaria absinthioides*, *Typha* sp. (cattail), *Equisetum giganteum*, *Leucocoryne* sp./*Zephira elegans*, and two cultigens, *Lagenaria sp*. and *Zea maiz.* Maize, however, seems to be more related to the post-Chinchorro occupation, given its radiocarbon date of 785 ± 35 (AA84945). The occurrence of *Lagenaria* sp., introduced from other regions, had an early appearance in Camarones valley with a radiocarbon date of 6,980 ± 50 (AA85504 2). This cultigen was already presented in southern Peru, the Quebrada de Los Burros site, between 8,875 ± 40 to 6,985 ± 35 BP (Chevalier, 2012: 194).

Plant remains from Camarones 14 points to seasonal activities by foragers exploiting the delta and parts of the valley. When integrating these data with shell growth ring analyses, the most significant point is that plants, through the occurrence of seeds of *Scirpus*, give indications that the site was still active during early fall for almost all layers, from the Early into the Middle Chinchorro. This suggests that although shells of *Concholepas concholepas* were not collected during the fall, people were still living in the area during the beginning of this season.

Concerning the local environment, the data show similarities with the current one, although an increase in arid conditions seems to have taken place during the period of the site's occupation. This is in line with data from the pollen analysis, which indicates more humidity for the initial period of the occupation between ~7,600 and ~7,000 years ago with seasons well marked, and the presence of *Notofagus*, a taxon not detected in the macro-botanical material[9] during the Chinchorro period.

Periods of more humidity were suggested by the presence of *Leucocoryne* sp./*Zephira elegans*, locally known as desert violet. It flowers during El Niño events and/or during the fog winter season that increases humidity along the coast. Paleoenvironmental data from Central Andean sites point to El Niño inactivity or reduction from 9,000 to 5800 cal BP, returning after 5,000 BP and having its activity increased after 3,000 cal BP (Sandweiss et al. 1996; Anderson et al. 2007, Sandweiss et al 2007). Hence, the occurrence of the desert violet in almost all layers should be more related with fog intensification and winter humidity; its occurrence in the occupational layers suggests that regular winter season humidity had occurred during the Middle

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[9] This could be because that plant was not economically exploited or because the right method was not applied. For example, this thesis did not contemplate anthracological analyses that could detect fragments of *Nothofagus* used for fire, if it was used in this way.

Holocene in the river valley, despite possible increases in aridity conditions. It is also an indicator of the exploitation of the *lomas* biome by local population.

During the time of the site's occupation the lagoon or a swamped zone was probably part of the landscape at the river delta, as suggested by the occurrence of wetland plants, *Phragmites australis* and *Typha* sp. about 6,980 ± 50 BP (AA85504 2).

Given its multiple uses, *Typha*, mainly *Typha angustifolia*, or "*totora*", was an important plant for local communities. Middle Holocene people living along the coast, including the Chinchorro, could also have managed its use to protect it from overexploitation, although there is no indication this took place.

The macro-botanical remains analyzed shows that the people settled at Camarones 14 were seasonally exploiting the local flora of the coastal seashore, wetland, the valley, and *lomas*. Corms of *Leucocoryne* sp. suggest the exploitation of *lomas* areas during the winter.

Pollen and Phytolith Analyses

This section summarizes the pollen and phytolith records from the sediment layers recovered at the Camarones 14 site. These records help define the landscape and climatic scenario for early-middle Holocene cultures from the Camarones delta area and verify the presence of specific cultigens. Scott-Cummings and Logan (Paleo Research Institute) examined the pollen samples, while Iriarte and Watling (Laboratory of Archaeobotany and Paleoecology, University of Exeter) examined the phytoliths. Appendix F presents the report "Paleo Research Institute Technical Report 09-92", and Appendix G the report "Phytolith Analysis of site Camarones 14". Diagrams with the results are reproduced in Figure 5.3 and Figure 5.4 at the end of this section. The results presented here are compiled from these reports[10].

The objective was to test the hypothesis that gradual shifts in mobility would be followed by the incorporation of cultivated plants. The results, however, did not show the presence of cultigens on pollen or phytolith samples. Based on this data, it seems that local paleoenvironment underwent a gradual transformation in the area of the Camarones River delta, from a more humid to drier environment.

The author collected samples from five layers at the end of the excavation, from the North and East profiles of the site (Figure 5.2). To check on changes through time with respect to cultigens, these units were selected based on evidence of the site's occupation (e.g. artifacts, hearths). The selected areas were cleaned, scraping their surfaces with a trowel. Samples were taken from the lower units to the top. To avoid or minimize possible contamination by modern material, samples were collected from the zone more inside the sediment matrix. A garden weeder or a trowel was used to take the samples; they were all cleaned with alcohol in between samplings. The sediments were placed separately in individual plastic bags with tags, and then sent to the respective laboratories for analysis. Sample sizes for pollens were between 491 g. and 365 g., while for phytoliths they oscillated between 23.2 g and 63.1 g. A flake fragment, probably the active part of a hammer ("*chancador*") collected during the excavation, was also sent for phytolith analysis.

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[10] Any mistakes here are responsibility of the author of this thesis.

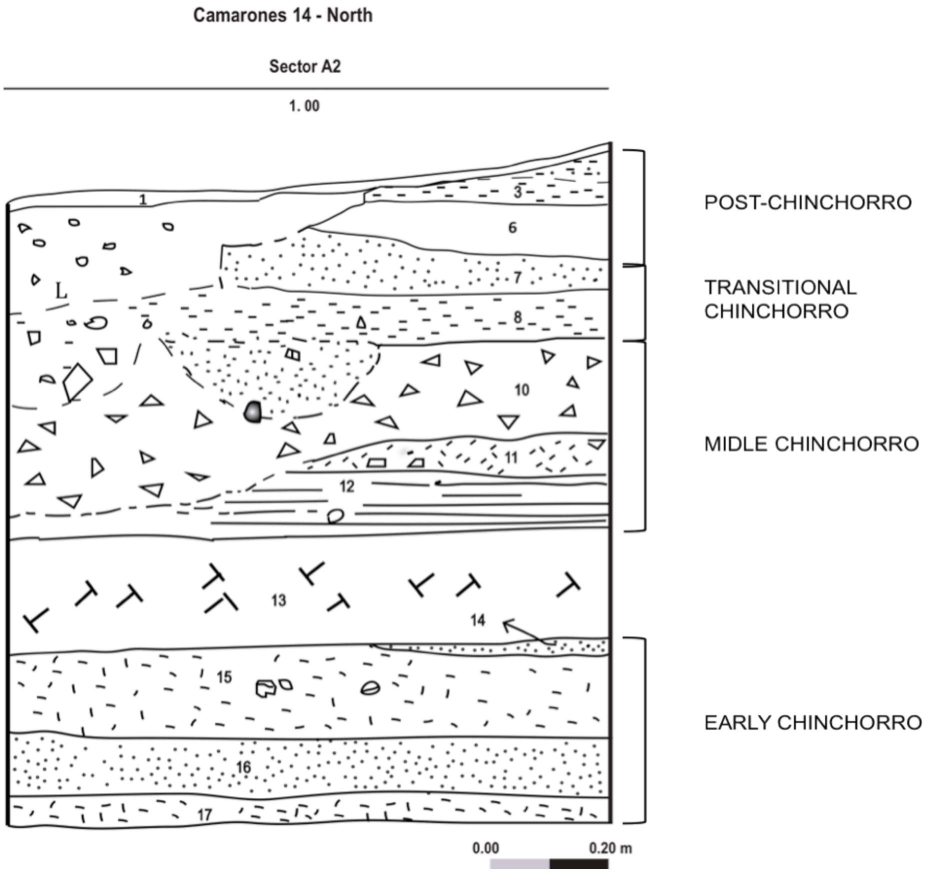

Figure 5.2: Layers sampled for pollen and/or phytoliths (17, 16, 15, 12, 11) Layer 13 is a compact and sterile stratum separating the Early and Middle Chinchorro occupations.

Table 5.6 summarizes samples and radiocarbon dates from sampled layers. Four samples were collected from the first period of the occupation (layers 17, 16, and 15) that corresponds to the Early Chinchorro context date between 7,669 ± 54 BP and 7,015 ± 50 BP. Three samples came from the Middle Chinchorro layers deposited directly above the sterile compact zone (layer 13), that is, layers 12 and 11 in the profile (figure 5.2). These last layers refer to a period between 6,641 ± 49 and 6,088 ± 50 BP. An anomaly is observed in layer 17, which has a more recent date (6,088 ± 50) than layer 16 (7,669 ± 54). Although this suggests that pollen samples could also be from an anomalous context, it does not seems to be the case because the pollen diagram shows progressive changes in plants composition from sample 1 to sample 2 (from layer 15). Therefore, pollen samples from layer 17 (sample 1) should be correlated with a period around 7,669 ± 54 BP and early than 7,015 ± 50 BP. Nonetheless, this date and layer correlation should be applied with caution. Also, there is no date for layer 15 from pollen sample 2 and phytolith samples Cm2/Cm3. Hence the date show in the table is from layer 14, showing that the sample is older than 7,015 ± 50 BP.

Table 5.6: Pollen and Phytolith summary including layers, samples correlation, and chronology

	Layer	Pollen*	Phytolith	Chronology yr BP	Sample
Middle Chinchorro	11		Cm1	Between 6,522 ± 54 /6,088 ± 50	Hammer fragment ("*chancador*"); dimensions: 5.8 x 4.2 cm. Phytolith: arboreal type samples, probably due its use to work wood. Traces of Asteraceae
	12	3	Cm6	6,641 ± 49	Sand with organic material, mainly botanical remains. Pollen: retraction of wetland plants and expansion of grass plants. Phytolith: dominance of grasses, possible *Distichlis spicata* (spike tower phytoliths) that it is found on the river valley, nowadays, or *Cortaderia* sp.
Early Chinchorro	15	2	Cm2, Cm3	~7,015 ± 50**	Sand mixed with botanical remains, mollusks fragments and fish bone remains. Pollen: grass in the background; retraction of *Nothofagus*, wetland plants still present, but in slightly retraction. Phytolith: retraction in Cyperaceae samples; grass assemblage is more diverse, with signals of expansion.
	16		Cm5, Cm4	7,669 ± 54	Sand with charcoal, shells and crustaceous remains. Phytolith: dominance of Cyperaceae (sedges), *Phragmites* (brackish water red); grasses in the background.
	17	1		6,980 ± 50	Sand mixed with botanical remains, small fragments of mollusk shells, crustaceans, fish bones, and charcoal. Pollen: wetland, dominance of *T. angustifolia*, followed by Cyperaceae (possible *Scirpus* - juncos). *Nothofagus* indicating cold/wet period.

Pollen Results and Discussion

The analysis of pollens and phytolith samples presented in the respective reports did not show the use of any cultivated plants. The pollen diagram (Figure 5.3) shows that sample 1, from the initial phase of the Early Chinchorro (~7,669 ± 54) context, has a strong dominance of *Typha angustifolia*-type charcoal, followed by Cyperacea pollen, probably *Scirpus*. Both plants are adapted to humid environments. This indicates the existence of wetland areas in the delta, which suggests that maybe the lagoon was already formed and active. Local grasses represented by Poaceae pollens are also present, but in small quantity. At that time southern beach trees were also growing in the area, represented here by *Nothofagus*. The species of this genus are sensitive to climate changes and cannot survive for long periods of drought[11]. *Nothofagus* is characteristic of a Mediterranean type climate marked by aridity with hot dry summers and cool wet winters (Donoso 1996). Even with regular rain in winter, it rains less then 100 mm/year (Muñoz S. 1985). Currently, the northern limits for this species on the Coastal Range ("Cordillera de la Costa") is between 33° and 34° S, around Coquimbo city (Veblen et al. 1996; Donoso, 1996). It is possible that at the time of the initial occupation of the site, during the Early Holocene about 7,600 BP., its limits were further north.

Sample 2, from the late phase of the Early Chinchorro occupation, shows a similar pattern. The local landscape is dominated by wetlands as observed by the predominance of cattail (*Typha angustifolia*) and juncos (Cyperaceae) pollen. However, changes were taking place. Local grasses, represented by the Poaceae pollen, increased

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[11] *Nothofagus* is one of the characteristic species of Chile's Mediterranean climate divided into and is divided into five different subtypes: prearid, arid, semiarid, subhumid, humid, and perhumid. The first two are very dry, marked by about two to six months of hot dry summer followed by mild rainy winters (Donoso 1996).

slightly, while *Nothofagus* was still present although in smaller quantities. The Cheno-am and *Sida* (Malvaceae) pollen appeared in very small amounts indicating the occurrence of *Atriplex* (Malvaceae, mallow family) in the landscape.

At the time of the initial phase of the Middle Chinchorro occupation, represented here by sample 3, changes were effective and the *Nothofagus* southern beach trees had already disappeared completely from the area. Pollen from local plants indicates that the environment was dryer than before. The retraction of wetland plants, mainly detected in *Typha angustifolia* pollen, and the dominance of high-spine Asteraceae, in conjunction with the increase of grasses growing in the area (Poaceae), are representative of these changes. The wetland areas dried up significantly but not completely. Cyperacea sedges were still growing there with pollen presented in moderate quantities. The local lagoon on the delta of the Camarones River was reduced or disappeared at this time.

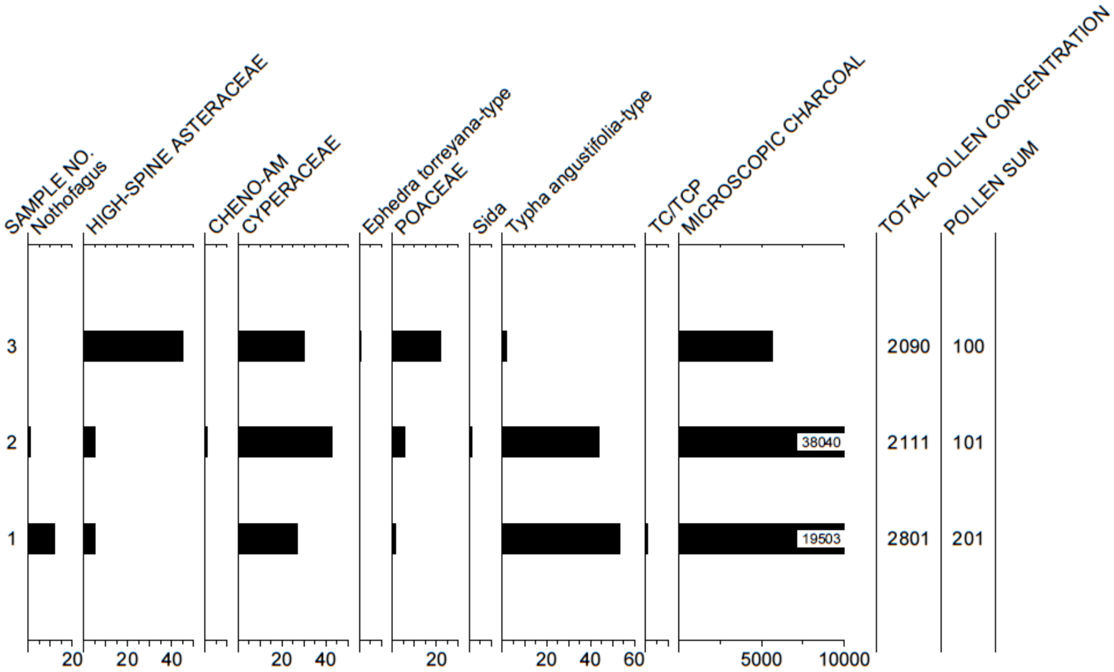

Figure 5.3: Pollen Diagram for Camarones 14 archaeological site. Source: Scott-Cummings and Logan, Paleo Research Institute Technical Report 09-92 (in Appendix F)

Phytolith Results and Discussion

The phytolith diagram (Figure 5.4) shows that the CM4/CM5 samples for the Early Chinchorro period had the greatest percentage of phytoliths from Cyperaceae sedges (junco), including traces of *Phragmites*; both plants are adapted to the wetland environment, implying humid local conditions. The CM2/CM3 samples show a tendency for drier conditions increasing during this period. Phytoliths from Cyperaceae sedges were still present, but to a lesser degree than in the previous samples; grass plants are in the background represented by phytoliths from Poaceae, Panicoid, Chloroid, and Pooid types. The CM6 sample - Middle Chinchorro period - shows the dominance of grass phytoliths and the reduction of phytoliths from the wetland sedges (Cyperaceae). Grass phytoliths are mainly of the spike towers type, possibly from seashore salt grasses of the Poaceae family. Samples for this period point to the same interpretation given for pollen results, that is, that the local environment changed from early moist conditions to drier conditions.

An artifact fragment (sample CM1) from the Middle Chinchorro period, a hammer's flake ("*chancador*"), reveals it was used to work wood. The sample is dominated by arboreal type phytoliths, including a few phytoliths from Asteracea, as well as traces from Panicoideae.

From the phytolith samples, no evidence for plants of economic importance was found. However, this analysis revealed an environment dominated by wetland plants mainly during the Early Chinchorro period of the Camarones 14 site around 7,600 BP. Samples from the subsequent period point to a decrease in phytoliths from plants adapted to a moist environment. Grass type phytoliths increased in the upper layers. Samples from the Middle Chinchorro period (CM6) around 6,500 BP suggest drier conditions, which is in line with the pollen results. Below are the pollen and phytolith diagrams discussed in this section.

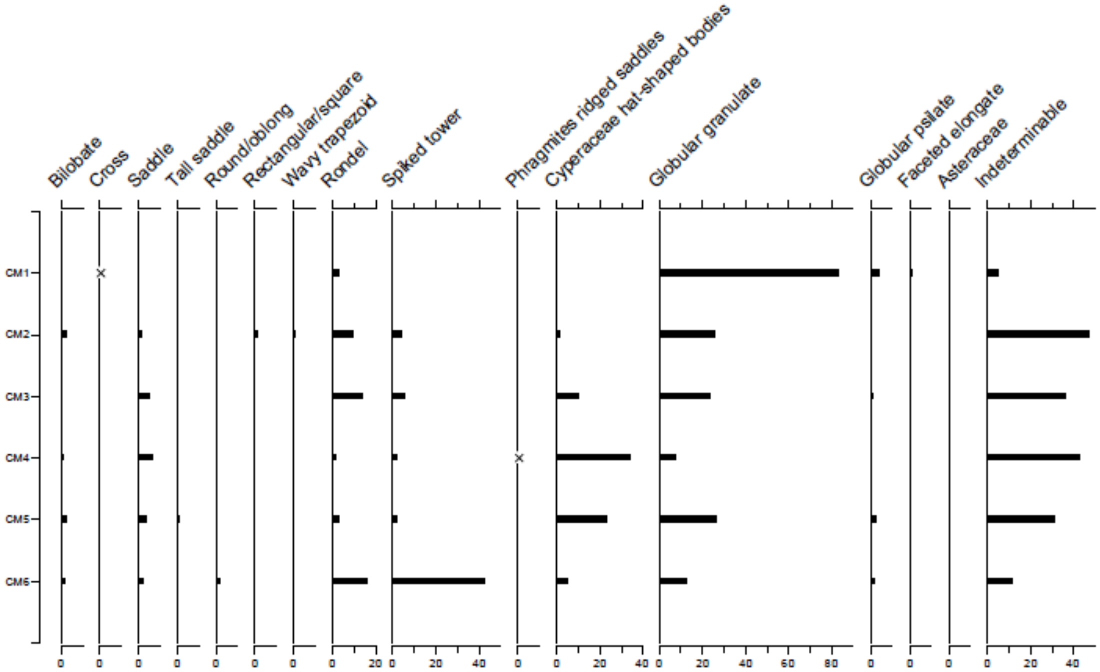

Figure 5.4 - Phytoliths Diagram for Camarones 14 archaeological site. Source: Iriarte and Watling Phytolith Analysis of site Camarones 14 (Appendix G)

Conclusions

No traces of cultivated plants were found in the pollen and phytolith samples. Corn cob fragments were found at the site, but associated with a more recent period. Pollen and phytolith samples identified were from plants found on the valley of Camarones River and its delta. The exception is for the genus *Nothofagus* that disappeared from the area some time before 7,000 BP; pollen from the this southern beach tree were restricted to the two oldest samples analyzed, both situated below the sterile layer that divides the stratigraphy of the excavated area (layer 13, see Figure 5.2).

Southern beach *Nothofagus* is indicative of a colder climate, but with dependable winter rain, conditions that prevailed during the initial occupation of the site.

Sediments from pollen and phytolith samples show significant changes in the local flora of the river valley and its delta through time. Wetland plants that were dominant in the earliest periods of the occupation retracted in the subsequent period and grass plants that once were in the background of the mosaic composition of the landscape became dominant. This replacement of wetland plants by species adapted to a dry environment indicate that the climate was dryer than before and possibly that the local lagoon or swamped areas that had existed during the period of the Early Chinchorro occupation (~7,600 –7,000 BP) was much reduced about 6,641 BP.

In certain coastal valleys in southern Peru, by contrast, humid conditions remained for extended periods, as registered at the site of Quebrada de Los Burros, on the south coast of Peru (Tacna). There, local paleo-climate data indicates a relatively humid period during ca. 9,640 to 3,392 cal BP (Lavallée et al. 2011). The data from Camarones 14 site indicate a colder and wetter period between ca. 7,669 to 7,015 B.P. that progressively became drier, and by 6,641 B.P., dryer conditions already prevailed. This is in accordance with data for the Atacama that also point to warm/moist conditions during the Early Holocene followed by a Middle Holocene marked by severe aridity between 6,000 and 3,800 BP (Vargas and Ortlieb 1998; Grosjean et al. 1997). The data from Camarones 14 documents the change in climate and plant succession, and the transformations this engendered in the landscape.

Radiocarbon Data

The radiocarbon dates obtained for the sites of Camarones 14 and Camarones Sur are presented in this section. It also includes radiocarbon dates from Schiappacasse and Niemeyer (1984) for Camarones 14 and Rivera (1984, 2012 personal communication) and Billings (2001) for Camarones Sur. The chronological data for Huaca Prieta is presented later on in the section about shell analyses[12].

Camarones 14 Radiocarbon Data

In 2007, several samples for radiocarbon date from Camarones 14 were recovered during fieldwork. To avoid contamination, they were collected using tweezers, wrapped in aluminum foil, and put in separate labeled plastic bags. Eight samples related to the Chinchorro occupation were chosen in order to produce a finer chronology. Their contexts in the excavation are:

AA85503 1 - level 13. Sample weight: 3.41 gram; observation: under a shell of *Concholepas concholepas*),

AA99972 – level: 13 D.

AA85504 2 - level 13C. Sample weight: 0.4 gram; observation: closed to a coprolite.

AA85505 3 – level 12. Sample weight: 0.8 gram; observation: from a combustion area.

AA85506 4 – level 9C. Sample weight: 3.1 gram.

AA85507 5 – level 8C. Sample weight: 0.4 gram

AA85508 6 - 7B. Sample weight: 0.5 gram.

AA99973 – layer 10.

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[12] Also, for more information regarding Huaca Prieta chronology and radiocarbon data, see Dillehay 2012b

Possible problems are three fissures in the soil in the excavated area, possibly from earthquakes that could have mixed materials from the superior layers, as well as some disturbed areas as described later in the profile. These were concentrated in sector A3 (subsector C)[13]. Levels 7B and 8C, as well as level 9C, had mixed sediments, but samples were collected from the preserved sections of these levels.

All the selected samples were sent to the Arizona AMS Laboratory–NSF (University of Arizona) for radiocarbon date. They were sent in two sets, the second one was sent later, to refine the chronology. From the second set, one of the samples contained a shell fragment of *Mesodesma* from layer 10. The laboratory report from the Arizona AMS facilities is available in Appendix H. Additionally, Dr. Mario Rivera also sent a cob fragment of *Zea maiz* for radiocarbon dating. Therefore, a total of nine radiocarbon dates were produced for the site.

The following table (Table 5.7) has the radiocarbon dates for the 2007 excavation. Table 5.8 has the data published by Schiappacasse and Niemeyer (1984). For all samples, the respective calibrated data are provided. The results are presented as calibrated dates, as well as conventional 14C ages. The calibration program used was Calib 6.0 using 2-sigma. The marine reservoir effect used for calculation was $\Delta R = 384$ (Ortlieb et al. 2011). Charcoal fragments, plant fiber, and shells composed the samples.

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[13] To have a better control of the excavated area, sectors were subdivided in smaller units of sub-squares A, B, C and D.

Table 5.7: Radiocarbon dates from Camarones 14 (T. Franco)

Laboratory ID.	Sample context		Nature	Radiocarbon	Calib 6.0	Archaeological context
	Layers	Excavation context		Uncal. age BP	Cal. BP	
AA85503 1	16	13B (A3, SQA)	charcoal	7,669 ± 54	8334 - 8543	Flakes, shell artifacts, shell fragments, remains of medium small plants, fish fragments, ashes and charcoal.
AA99972	17	A2-13D	charcoal	7,125 ± 37	7794 - 7973	Small fragments of fishes and crustaceous, forming a thin sheet over the sterile hard sediment below. Charcoal from a heart in area near the heart from layer 13C (A2)
AA85504 2	17/16	13C (A2)	charcoal	6,980 ± 50	7662 - 7924	*Lagenaria* (squash), botanical remains, mollusks, small fish and crustaceous fragments, hearth, lithic point, scrapper,coprolites.
AA85505 3	14	12 (A3, SQ A/B)	charcoal	7,015 ± 50	7680 -7930	Flakes, thin sheet of ash with charcoal, burned shells, and small fish bones fragments, deposited over a thin sheet of sand.
AA85506 4	12	9C (A2, SQA)	charcoal	6,641 ± 49	7424 - 7571	Flakes, string fragments, mollusks, fishes and plant remains. Change in plants, with absence of flowers was observed (in relation to upper

						layers).
AA85507 5	11	8C (A3, SQ C)	plant fiber	6,522 ± 54	7268 - 7474	Shell fishhooks, flakes, scrapper, plants and mollusk remains. Parasites: *E. vermicularis*, *Diphyllobothrium*
AA85508 6	11	7B (A3)	charcoal	6,088 ± 50	6734 - 7148	
AA99973	10		shell	7283 ± 48	7285 - 7533	Predominance of Mesodesma shells, also strings, plants, including flowers, shell fishhooks, lithic points, and flakes.

Camarones 14 - Radiocarbon dates (T. Franco/M. Rivera 2012)

AA84945	11	A2, 8 (81 cm)	1 cob fragment	785 ± 35	574 - 732

Table 5.8: Radiocarbon dates from Camarones 14 (Schiappacasse and Niemeyer 1984)

Laboratory ID.	Sample context		Nature	Radiocarbon	Calib 6.0 (Cal. BP)
	Layers	Excavation context		Uncal. age BP	
I-9816	D		charcoal	6615 ± 390	6564 - 8175
I-9817	D		charcoal	6650 ± 155	7171 - 7747
I-11431	D	mummy nº. 21	mummy tissue	7000 ± 135	7522 - 8018
I-999	D		charcoal	7420 ± 225	7706 - 8594

The samples from Camarones 14 are in chronological sequence in accordance with the stratigraphy. The exception is sample AA85503 1 dated to 7,669 ± 54 BP and sample AA99972 dated to 7,125 ± 37, which show an inversion in the dates. Due to this discrepancy, the oldest data is used only as a general reference for the extension of the period when referring to the uncalibrated data. For example, the radiocarbon dates for the initial Chinchorro occupation of the Camarones 14 site are between 7,669 and 6,088 BP. Charcoal from the first sample (AA85503 1) was found in situ covered by a shell of

Concholepas concholepas. Charcoal from the third sample (AA85504 2) was collected in close association with a single coprolite. The next sample, AA85504 2 dated to 6,980 ± 50, was collected at the beginning of layer 17 and is more related to the upper layer 16. Although it was more recent than sample AA85505 3 from layer 14 (7,015 ± 50 BP), the difference is minimal; the calibrated results show superposition of dates with a time range from 7,680 to 7,973 BP for the Early Chinchorro period.

Two other samples did not return reliable results. The cob fragment returned a later date than expected for the layer. This fragment, however, was close to a disturbed section filled with coprolites and mixed sediments from sector A2. So it is probably linked with layer 5 (mixed sediment). With the shell fragment, it was the opposite and the age was older then expected, and thus should not be considered in the analysis as the age for layer 10.

The full range of occupation at the site was not completely established since no samples from upper layers were dated. The Chinchorro occupation is from 7,669 ± 54 to 6,088 ± 50 BP. The occupation continued after this period until the contact with inland cultures. An isolated data of 785 ± 85 BP was produced for a later period associated with maize cob.

Camarones Sur Radiocarbon Data

In the tables below (Table 5.9 and Table 5.10) four radiocarbon dates for Camarones Sur are listed. They are based on the information provided by Dr. Mario Rivera. Incorporated into the sequence are the radiocarbon dates provided by Billings (2001) for the site. Levels and strata classification from each author are based on different interpretations of the profile and do not resemble each other. Billings data identified years as BC, as reproduced here from her source. For both, Rivera and Billings, Calib. 6.0, and 2-sigma was used to calibrate the years BP.

Table 5.9: Radiocarbon dates from Camarones Sur

Rivera 1984, 1991 and 2012* (data compiled)

Lab. ID.	Radiocarbon Years BP		Cal BP	Nature	Deep (m)	Level	Source
AA-84944	594 ± 35	AMS corrected	511-632	Maize cob	1.20	5	Rivera *
GaK-8644	1050 ± 110	Standard uncorrected	690-1171	Charcoal	1.34	6	Rivera 1984
RL-2055	3060 ± 290	Standard uncorrected	2367-3885	Charcoal	2.70	8/9	Rivera 1991
Gak-8645	5640 ± 160	Standard uncorrected	5998-6728	Charcoal	4.97	17	Rivera 1984, 1991

* personal communication (2012)

Table 5.10: Radiocarbon date from Camarones Sur

Billings 2001 (data compiled)

Strata	Lab. No.	Nature	Correct Date (BP)	1 sigma	Calib BC 1 sigma OxCal V2.0)	Calib BP (2-sigma Calib 6.0)
3	3483	Vegetal fibers	3624	64	2112-1887 BC	3650-4082
5	3488	Ashes and mollusk fragments	4150	73	2872-2617 BC	4432-4825
10	3487	Ashes/hearth	4693	123	3640-3340 BC	4961-5604
10.1	3484	Reeds	4282	95	3032-2696 BC	4445-5039
13	3486	Reeds/charcoal	4082	144	2872-2465 BC	4090-4856
15	3485	Vegetal fibers	4510	67	3338-3100 BC	4876-5295

The Chinchorro occupation dates to 5,640 ± 160 BP, as obtained by Rivera (1984), during the site's initial excavation. Billings produced a more detailed sequence from 3,624 to 4,510 BP. For this research, samples were not sent for radiocarbon date. The chronology here was based on Rivera's data sequence. The only specimen that was submitted to a radicarbon date from this occupation period of the site dated at 760 ± 135 BP (stone number 12).

Conclusion

The radiocarbon dates for the initial Early Chinchorro occupation of the Camarones 14 site are between 7,669 ± 54 BP (AA85503 1) and 7,015 ± 50 BP (AA85505 3). A mummy from this occupational period is radiocarbon dated at 7,000 ± 135 BP (I-11431), mummy n^{o}. 21 (Schiappacasse and Niemeyer 1984). After this period, the area was abandoned for about 400 years. The site was reoccupied from 6,641 ± 49 BP (AA85506 4) to 6,088 ± 50 BP (AA85508 6). The time frame for the Middle Chinchorro could not be established, as the shell sample did not give a reliable date. However, there is still material from this layer that might provide a radiocarbon date. This could be done in the future and could help refine the chronology of the occupation.

Camarones Sur was not radiocarbon dated for this research. The available chronology indicates an occupational period from 5640 ± 160 BP (Gak-8645) to 594 ± 35 BP (AA 84944).[14]. Excavation of this site for this research was not authorized by the Consejo de Monumentos Nacional de Chile.

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[14] The deepest levels were not reached during this research, since the intervention in this site was limited to the open profile to collect *C. concholepas* and through the accompaniment of M. Rivera excavation in a limited area close to the profile that do not reach that deepest levels.

Artifacts

The raw materials used to manufacture artifacts found during the 2007 excavation at Camarones 14 site included shells, lithic materials, plants (thorn, wood and fibers), and animal hair fibers. These materials related to fishing, hunting, cordage confection (textiles), food processing and preparation (e.g. scrapers, knifes), artifacts manufacture (e.g. projectile points, fishhooks). The trend toward a sedentary pattern is accompanied by an increase in artifact diversity (Shott 1986). The main purpose of this thesis is seasonality, so artifacts are a secondary element here. Even so, fishhooks and shell artifacts are studied in more detail, along with lithic artifacts.

This section addresses shell and thorn fishhooks together in one single unit. The fishhook discussion is followed by the analysis of other types of shell artifacts and modified shell fragments. For these, a typology is elaborated to help understand the patterns. Projectile points, scrapers, and a hammerstone, among other pieces, make up the lithic material. Cordage fragments are not subject to intense analysis and are only briefly introduced here. A few wood artifacts from the excavation are described in Garcia's report (Appendix E).

Figure 5.5: Shell fishhook in context at Camarones 14 site; on the left, a fragment of *Choromitylus chorus* (layer 15).

Shell and Thorn Fishhooks

Fishhooks play an important role in the archaeology of the northern coast of Chile. Llagostera (1992) considers them as indicative of the complete adaptation to the marine environment, an indication that local cultures were already exploiting the sea in all its extension. Bird (1943, 1946) believed that fishhooks were first used as the guide artifact for defining the region's cultural chronology. Based on his excavations along the north coast of Chile, he elaborated a periodization scheme based on the initial occurrence of shell fishhooks ("Shell Fishhook Culture") and then on their replacement by cactus thorns fishhooks (Llagostera 1979). These artifacts were characteristic of the First and Second Pre-agricultural periods, respectively, occurring in contexts with specialized fishing toolkits along with some other artifacts[15].

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[15] Besides the shell fishhook, some of the archaeological components of the older occupation of the Quiani I (6170 +- 220 B.P.) site include: composite fishhook (a bone hook fixed to a fusiform weigh), detachable head harpoons to capture marine mammals, and lanceolate and double-ended point (Llagostera 1979).

The focus on fishhooks as a division marker, however, has been challenged by finds at Abtao-1 site (Antofagasta), Punta Pichalo (Pisagua) and Camarones 14. Thorn fishhooks were found in stratigraphic association with shell fishhooks (Llagostera 1979; Shiappacasse and Niemeyer 1984). Besides that, Llagostera (1979) notes a tendency for shell fishhooks to be replaced by bone fishhooks as observed at the Punta Pichalo and Punta Grande (Taltal) sites. In Camarones 14, however, no bone fishhooks were found.

Fishhooks from Camarones 14

The 2007 excavation at Camarones 14 site provided a total of 16 fishhooks (e.g. Figure 5.5). From these, two (2) were made from cactus thorn and fourteen (14) from *Choromytilus chorus* (Figure 5.6) shells. No defined composite fishhooks or bone fishhooks were found at this time, although some were reported by Schiappacasse and Niemeyer (1984) when they excavated the site.

The length, width, and thickness of all fishhooks were measured using a dial digital caliper set to the nearest tenth of a millimeter (0.1 mm); these artifacts were also weighted, described, and some of them photographed[16]. Also recovered were shell debris and pre-formed pieces used to make these artifacts, like shell disks. Table 5.11 shows the distribution of these artifacts and their cultural context in relationship to the excavation of the site.

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[16] They are now in the collection of the Museo de San Miguel de Azapa, where they received a definitive catalog number.

Table 5.11: Fishhooks and some other shell artifact contexts from Camarones 14 site

Cultural context	*I Early Chinchorro*				*Concretion*	*II Middle Chinchorro*				*III Transitional Chinchorro*		*IV Post Chinchorro*	
Final layers	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*3*
Shell fishhook			1				3	8			1		
Thorn fishhook			1	1									
Pre-forms								2					
Disk							5	2					
Hook fragment					1			1			1		
SchNy[1]	d	d	d	d		c	c	c	b	b	b	b	b

One (1) shell fishhook out of layer context, from Profile W/N.

[1] SchNy – Schiappacasse and Niemeyer's (1984) macro stratum

Besides the fishhooks, two (2) pre-forms or unfinished artifacts (already resembling a fishhook), as well as three (3) hook fragments, and seven (7) disks (Figure 5.9) were also found. These disks were at the initial stage in the manufacture of a fishhook as proposed by Schiappacasse and Niemeyer (1984). Hook fragments are defined here as parts of a broken fishhook. Due to their incomplete form, some were classified as part of a composite fishhook.

All shell fishhooks are of the same type: a circular shape with both extremities pointed, but varying in length from about 1.6 to 3.28 cm--all samples have small fractures, generally on the extremities. A fishhook from layer 7 is broken and apparently unfinished or not well elaborated. In general, the artifacts have no signals, marks, or alterations on the edges indicative of string attachments, but some have signs of manufacture.

The investigation done at the site by Schiappacasse and Niemeyer (1984) yielded 17 thorn fishhooks and 95 shell fishhooks. Both types were found together in the same cultural contexts. Composite fishhooks made with cetacean bones (the body part of the artifact) and shells (the hook) were also found. Besides these artifacts, more then a hundred shell fragments, including pre-forms (78 pieces) were recovered and classified into four morphological categories based on the manufacturing stages of the single shell fishhooks. Also recovered were four "*limas*", that is, a fusiform or cylindrical artifact (length between 30 to 50 cm and 8 to 10 cm diameter) and an unspecified number of "*sierras*", which were probably tools used to make shells fishhooks, as described below[17]. This author agrees with Lavallée's (2012) observation that the site could have been a "*taller de fabricación*", or a workshop-like place. This is based on the number of different pieces related to various stage of artifact manufacturing.

a) Shell fishhooks and their manufacture

Choromytilus chorus, a bivalve with a hard and large shell (Figure 5.6), was the main species used in the confection of shell fishhooks in the archaeological sites of the region. At Camarones 14, all shell fishhooks were elaborated on valves of this species, including the ones recovered by Schiappacasse and Niemeyer.

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[17] For more information see Schiappacasse and Niemeyer (1984).

Figure 5.6: Modern shell of *Choromytilus chorus*

Based on the study of 78 pre-form samples, Schiappacasse and Niemeyer (1984) proposed a five-stage manufacturing process (Figure 5.7). First a disk is cut from the shell (Figure 5.7); this matrix form has its margins irregular, although some were polished (number 3, in Figure 5.9). However, as they observed, these polished pieces were not used for the production of fishhooks. The second step is to make a radial cut to the center and amplify it with one or two more cuts nearby (Figure 5.8). The third step is to enlarge the piece with a "*lima*", which is a cylindrical stone artifact. The fourth step is to polish the disk internally in a circular way until it reaches a semi-lunar shape. The pre-form has the internal contour polished and the external contour still irregular, without polishing. Finally the last step is to sharpen the edges and polish the external contour.

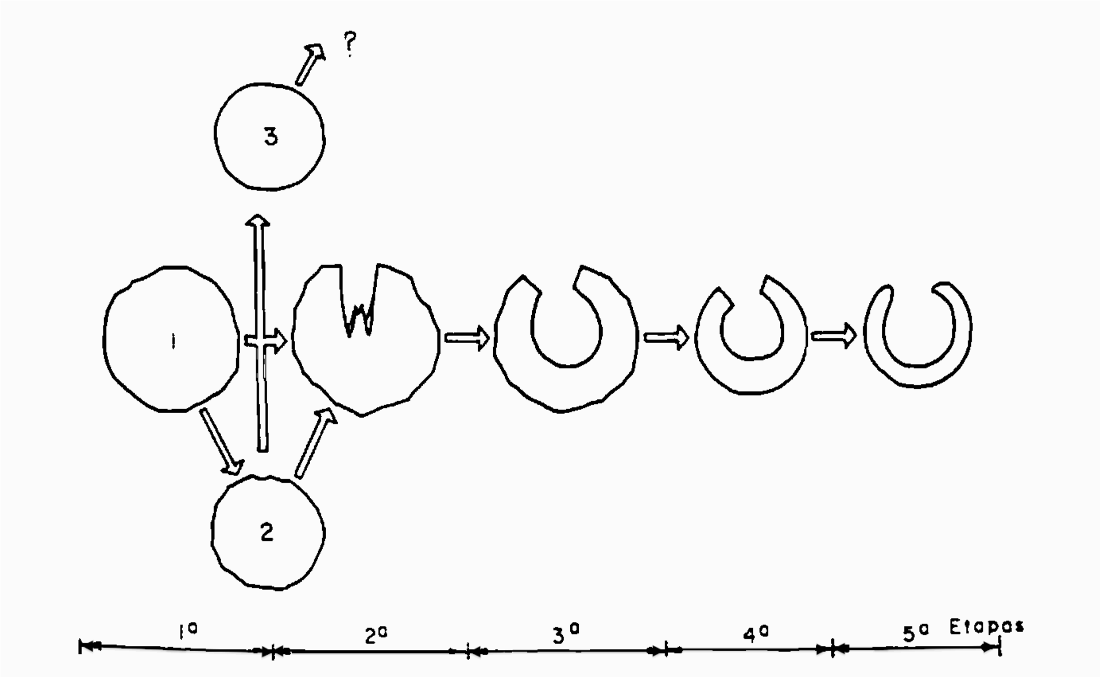

Figure 5.7: Different stages in shell fishhook manufacture as proposed by Schiappacasse and Niemeyer (1984: 29).

Figure 5.8: Fishhook manufacture: disk shell with a cut in the center.

Figure 5.9: Disk of *Choromytilus chorus* placed over a modern valve of a similar shell showing its original area on the shell's valve. In this case, the most external area of the shell was used on the confection of the fishhook that has produced the disk as a result of the manufacture of the artifact.

Unlike Schiappacasse and Niemeyer (1984), this author believes that the externally polished disk is also a pre-form of a fishhook. It would be interesting to check their site context to see if they were from the same strata or different ones. This could reflect a different practice in making fishhooks, in which the disk is first polished externally and then internally polished in a second stage of manufacture. This variation could be a new technique related to early or more recent periods of the site's occupation. The advantage in polishing the external area first is to have a more robust piece with less risk of breakage in the process.

Below are examples of fishhooks from Camarones 14 found during this research. Figure 5.10 is a pre-form from layer 10, where the majority of the fishhooks were found. The next two photos are example of shell fishhook; they have the same provenience as the pre-form, layer 10 (Figure 5.11, and Figure 5.12).

Figure 5.10: Pre-form of a shell fishhook (*Choromytilus chorus*) from layer 10.

Figure 5.11: Shell fishhook (Anz3), 1.9 x 1.18 cm, from layer 10

Figure 5.12: Shell fishhook (Anz1), 1.09 x 0.82 cm, from layer 10

b) Thorn Fishhook and its Manufacture

Besides the shell fishhooks, there were also cactus thorn fishhooks (Familia Cactaceae)[18]. Two fishhooks made from cactus spines associated with the early-middle Chinchorro context were recovered from the initial layers of the excavation at Camarones 14 in 2007. The one from layer 15 is the oldest one (Figure 5.13) and it is very well made indicating perfection of the technique. This fishhook is well-shaped, with a dark coloration. The other fishhook is from layer 14 (Figure 5.14). Unlike the previous one, it is not well finished and is more rustic; clearly, the technique for its manufacture had not acquired the same precision as for the other piece. This unfinished or rustic fishhook resembles the ones illustrated by Schiappacasse and Niemeyer (1984).

At the end of nineteen-century cactus fishhooks were still used by the native Mohave Indians in the North American Southwest (Yates 1899). These artifacts were made with spines from the *Echino cactus*. They used water to soften the thorn, and fire to hardened and mold it. The process of manufacture was described by Yates (1899). First, the spine is left in water for a while to make it pliable, then it is heated, passing the thorn near the fire; the thorn is held close to the fire and twisted; the shape is slowly modeled, rolling the spine between the fingers and, repeatedly, pressing to bend it until the curved shape is obtained; that becomes the distal extremity of the fishhook or the hook. The thorn is then, entirely wrapped with a string, from one edge to the other, to make it keep the modeled form during the drying and cooling.

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[18] Identified in Schippacasse and Niemeyer (1984) as *Trichocerus cuzcoensis,* synonimia *Echinopsis cuzcoensis* (Brako and Zarucchi, 1993). Garcia B. did not identify this species among the plant remains analyzed from the 2007 excavation; the two thorn fishhooks, however, were not among the sampled material sent for analyses.

By its control and precision, it appears that the well-elaborated thorn fishhook (Figure 5.13) recovered from Camarones 14 was made using a similar technique. The dark color along the piece could indicate the use of fire. It was certainly made by someone who had mastered the technique. It is suggested here that the more rustic and unfinished fragment (Figure 5.14) was not worked by the same person or perhaps technique; it turns out to be a common type found by Schiappacasse and Niemeyer (1984) during their excavation[19].

Figure 5.13: Thorn fishhook from the Camarones 14 site, layer 15.

Figure 5.14: Thorn fishhook fragment from the Camarones 14 site, layer 14.

The fact that only a single fishhook was found at the site shows complete mastery of the technique and suggests that this piece could have been obtained by contact with another group, implying networks along the coast. Another possibility is that well-made artifacts were highly valued. If at this time the group was moving seasonally, they would probably take well-made artifacts with them (Andrefsky 1998), especially if they were small and light, like thorn fishhooks. The fact, however, is that the technique seems to

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[19] It was not possible to see the collection of the material collection by Schiappacasse and Niemeyer; however, by the illustrations provided on the publication (1984), the thorn fishhooks have not the same grade of elaboration of the one described here.

have been lost at some point in time, maybe, from one generation to the other, at least at the Camarones 14 site.

Fishhooks: conclusions

Fishhooks were already known and in use by the time of the Early Chinchorro, although apparently not at the very beginning. They first appeared at some point between ~7600 BP and 7,000 BP in layer 15 (Table 5.11)[20]. Above the sterile layer that separates this period from the Middle Chinchorro, fishhooks were not found in the initial layer (layer 12), but only in the subsequent layers (layers 11 and 10). This suggests a re-adaptation when people returned to the area. Shells, however, were worked in this layer; also, some lithic material mostly flakes was found. As already mention, if people were not living at the site in a more permanent way, they probably carried their fishhooks with them.

Shell Artifacts

Schiappacasse and Niemeyer (1984) found shell beads, pendants, and spoons together with discarded parts related to shell fishhook manufacture. Such objects were not found during the 2007 excavation for this dissertation, although shell remains were found and the sorted in the laboratory[21]. These shell artifacts and fragments relate to different stages in the manufacture of fishhooks; these and other artifacts were identified.

The use of the *Choromytilus chorus* shells was intense. They became one of the most important materials used in artifact manufacturing and in the lithic industry. The

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[20] It is not know the oldest sample found during Schiappacasse and Niemeyer work at the site.

[21] However, not all debris was analyzed and a review of the shell fragments is recommended for future quantitative analyses.

Chinchorro adaptation to the marine environment and the complexity of their material culture is also reflected in their shell industry. A tentative typology for patterns on shell fragments was developed to organize and understand this material.

Figure 5.15: Shell no. 15, type B. Arrow shows direction of the cut marks on the sectioned portion of the shell.

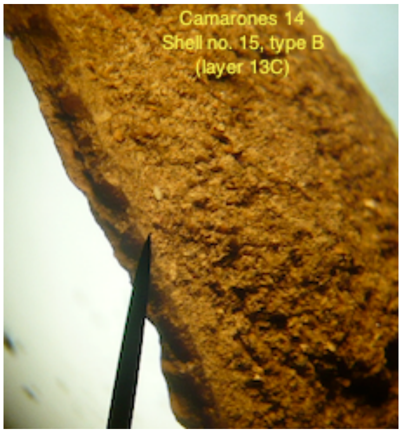

Figure 5.16: Detailed view of the cut marks on binocular microscope (magnification 10X1.5).

Despite the hardness of the *Choromytilus* shells, some fragments could have resulted from natural cleavage in the shells. Lucero (2003) reconstructed shell valves from Isla Santa María and Isla Mocha (south-central Chile) sites. They are similar to some of the patterns found here including their position on the shell. The repetition of forms shows that the breakage of the shells was controlled to generate a desired shape (Figure 5.15 and Figure 5.16). Thus, shell fragments resulted not only from the manufacture process of fishhooks, but also from making other types of shell artifacts, such as the pendants and spoons recovered by Schiappacasse and Niemeyer (1984).

Table (5.12) below shows the distribution of shell artifacts along with shell fragments discarded during the manufacturing procedures. This material was classified by types, as described in the sequence. After these descriptions, a second table (Table 5.13) summarizes the context in which the materials recovered by layers and periods.

Table 5.12: Shell industry types that are not fishhook. Camarones 14 site*

Shell number	Excavation sectors and layers**		Types							
			A	B	C	D	E	F	G	Ha/Hb /Hc/Hd
1	A3	5B					1			
2	A3	5B			1					
3	A3	5B					1			
4	A3	5B				1				
5	A3	5B								
6	A3	5B								
8	A3	5B								
10	A2	9		1(d)						
12	A3	13C				1				
13	A3	13C								1 Hd
14	A3	13C								1 Hd
15	A3	13C		1						
20	A2	5dp3							1	
21	A2	5dp3							1	
22	A2	5dp3							1	
23	A2	5dp3	1							
24	A2	5dp3	1 (w)							
25	A2	5dp3								1 Ha
26	A2	5dp3						1		
27	A2	5dp3								1 Hb
28	A2	5dp3								1 Hb
29	A2	5dp3					1			
31	A2	5dp3					1			

33	A3	7					1			
38	A2	5B(SQA/D)	1							
39	A2	5B(SQA/D)	1							
45	A2	12c		2						
47	A2	13b			1					
--	A2	12c2				7				
--	A2	12c2								6 (Hb)?
49	A2	12c2					1			
50	A2	12c2								3 (Ha)?
51, 52	A2	12c2	2							
53	A2	12c2								1(Hc)
54	A2	12c2				1				
55	A3	11					1			
56a, b, c	A3	11						3		
57	A3	11					1			
58	A3	5dp3								
59	A2	12c					1			
61	A2	12b	1							
62	A3	13	1							
63	A3	13				1				
--	A2	13b				7				
--	A2	13c					1			

Miscellaneous

7	A3	5b	A small fragment of *Choromytilus* shell (1.7X1.5 cm) in a sub-triangular shape, with semi-circular cut. Probably refuse from a fishhook manufacture stage.	1 unit
48	A2	12c2	A small piece of *Choromytilus* shell cut on its sides and in the mesial area, giving the piece a sub-rectangular shape; margin not altered. Red pigment close to the margin area on the internal side. Probably used as a pallet.	1 unit
11	A3	13c	Small *Mesodesma* fragment (3.2x1.9 cm) from the middle of the shell body. It has three semi-circular cuts a long one of this edges. Possible used as an expedite scrapper (Figure 5.25).	1 unit
30	A3	5dp3	Small *Mesodesma* fragment (1.0x1.2 cm) from the middle of the shell body, cut in the lateral areas, with a two opposite cuts in a semi-circular shape.	1 unit
60, 35	A2	12c	Small fragment of *Mesodesma* shell with red pigment; with lateral cuts.	2 unit

Observations:
* Samples collected from the sieve.
** Excavation sectors A2 and A3 and layer descriptions are found in Chapter 3, also, for final layer codes, see Table 3.1 in Chapter 3.

Below, is the type's description of the shell material recovered that is neither fishhooks nor shell disks. The typology is based on the morphology of fragments, *sensu* Lucero (2003), Schiappacasse and Niemeyer (1984), Claassen (1998), and Lima et al. (1986). It generates seven types. Of these, types C, D (some pieces), and types E and G include shell artifacts.

Type A – **Internal semi-circular** cut below or close to the umbo area. The upper part on its mesial area is cut with denticulate sections (d) or no denticulate section (examples: shell number 24 (w) and no. 61).

Type B - **External circular** cut close to the umbo area. The upper part on its mesial area is cut with denticulate sections (d) or no denticulate section (ex.: shells no. 10 (d); shells no. 45 in Figures 5.17 and 5.18; shell no. 15 in Figures 5.15 and 5.16)

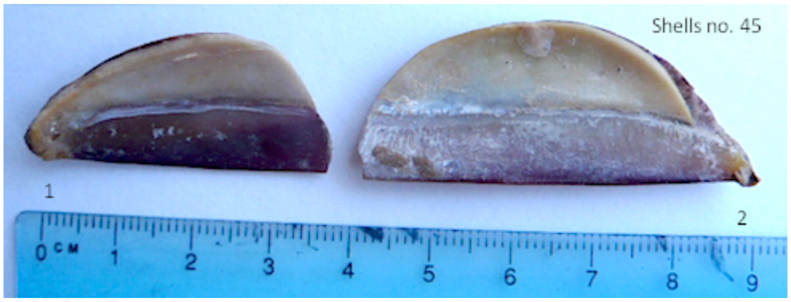

Figure 5.17: Shells no. 45, 1 and 2. Type B; internal view of sectioned shells.

Figure 5.18: Type B, shell 45, 2; external view.

Type C – **Semi-lunar**; sharpen area. This is a small piece made from the mesial portion of the shell. It has a semi-circular area in its distal extremity, typically with polish or used marks in this area. It was probably used for scrapping soft materials (shell no. 2 in Figure 5.19).

Figure 5.19: Shell no. 2, type C; possibly a scraper for soft materials. Shell no. 3, type E; polished on its pointed areas. By its small size, it could be used fixed on a soft material, like wood.

Type D - **Bell shape**/sub triangular. The distal extremity ends in a point and the proximal one in a curve. This gives a bell shape to the piece (Figure 5.20, and Figure 5.21); size varies between 4.0x4.2 cm and 1.9x3.7 cm (ex: 4, 12 and, 54–variation of the type). Some are well define artifacts with use-wear marks on the edges of the point area (ex: shell no. 63 in Figure 5.20).

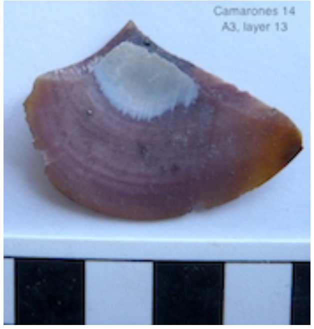

Figure 5.20: Well-defined shell artifact; shell no. 63, type D (excavation context: A3, layer 13)

Figure 5.21: Shell no. 12, bell shape; type D (excavation context: layer 13C)

Type E - Extremity **cut in point** and the opposite extremity or the proximal area is more or less linear; size varies between 1.2x1.6 cm and 2.3x2.5 cm (ex: no. 1; a variation is observed in no. 49 – Figure 5.22).

Figure 5.22: Shell no. 49, variation from type E (excavation context: A2, layer 12C2)

Type F - small fragment with semicircular cut on one side of the shell; cut in a small pointed shape (Figure 5.23, shell no. 26). It is the small version of type E, like a sub-type; size varies between 0.8x0.9 cm and 1.0x1.2 cm (ex: 56a, 56b, 26).

Type G – Shell piece characterized by a narrow pointed shape extremity, suggesting its possibly used as a drill in soft materials (ex: no. 21 in Figure 5.23).

Figure 5.23: Diversity of shell remains from layer 10 (excavation context: level 5 dp 3). No. 26, type F; no. 23, type A; nos. 29, 31, type E; no. 20, 21, 22, type G; n.27, 28 type Hb (refuse).

Shell Refuse Remains

Under the "Refuse" type there is a series of different shell fragments with cut marks. Some are probably stages in fishhook manufacture, as with piece number 7 (see Table 5.12 under the label Miscellaneous). Others are difficult to ascribe to a certain type of artifact. Additional patterns were noted along with more general refuse, described below:

Refuse a (Ha)– Umbo part of the shell; a fragment with a longitudinal cut, long and linear on the lateral area of the valve, below the umbo, which progresses along the middle of the shell or has a cut in the middle. Shell is broken on the middle (ex. numbers 50 and 25).

Refuse b (Hb)– probably discarded material of shell in a sub-quadrangular shape, cut from the central-middle area of the shell (ex. numbers 27 and 28 in Figure 5.23).

Figure 5.24: Shell no. 13 and 14; debris type Hd (excavation context: layer 13C).

Refuse c (Hc) – Fragment of the edge of a *Choromytilus* shell in a pointed shape, with triangular base. Its cut is on the edges and the central portion of the shell, opposing the margin cut area (ex: shell no. 53).

Refuse d (Hd) - Umbo part of the shell; mesial area cut in a denticulate shape; no well defined use-wear marks are visible (ex: shell no. 14 in Figure 5.24).

Fragments of *Mesodesma*

Some pieces of fragmented shell of *Mesodesma* were separated and described in table 5.12 (Figure 5.25)--under the label "Miscellaneous". Such material should be analyzed carefully. The natural fracture of *Mesodesma* shells tends to fragment into pointed or semi-lunar shapes, as observed by this author[22]. Some experimentation is needed to understand this process.

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[22] It was noticed by this author that the act of walking over shells of *Mesodesma* and other shells and stones debris would break some into shapes like those mentioned here.

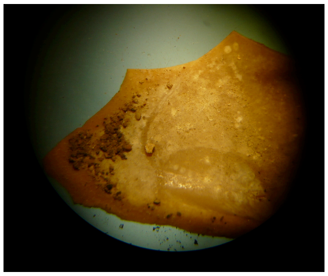

Figure 5.25: Valve fragment of *Mesodesma donacium* cut to form two sharp edges, suggesting its uses as a scraper (shell no. 11).

The Table (5.13) below shows the distribution of shell fragments, including artifacts with signs of having been used in artifact manufacture (e.g. cut marks). They were morphologically classified by the types defined here. The description of the types is found at the end of this section.

Table 5.13 - Shell artifact types from Camarones 14

Cultural context	I Early Chinchorro				Concretion	II Middle Chinchorro				III Transitional Chinchorro		IV Post Chinchorro	
Final layers	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*3*
A			3				1	4					
B	1		1			1							
C								1					
D	1							1					
E	1							4					
F								1					
G								3					
Ha			3					1					
Hb			6					2					
Hc			1										
Hd	2												
SchNy[1]	d	d	d	d		c	c	c	b	b	b	b	b

Observation: Refuse type are the H series listed above (Ha, b, c, and d)

[1] SchNy – Schiappacasse and Niemeyer's (1984) macro stratum

Comparing Table 1 (Table 5.11) with the fishhook distribution and Table 2 (Table 5.13) with the typology of the shell industry and artifacts, the shell industry is more concentrated in layers 15 and layer 10. Layer 17, although it had no fishhooks, the cuts on the shells indicate that this material had already been worked. Fishhooks were possibly already in use but not discarded. The analysis of the context by Schiappacasse and Niemeyer (1984) may provide future data for this possibility.

Shell Materials: conclusions

The Chinchorro people exploited a diversity of marine resources; of these, mollusks were one of the most important sources available along the Camarones seashore. They were both a dietary staple and a raw material used to make different artifacts. Along with shell fishhooks, a variety of other shell artifacts were identified. The Chinchorro culture was oriented to a marine environment, which was reinforced by a rich shell industry. This is shown by the varied artifacts and other shell remains, along with discarded pieces related to shell artifact manufacture. Schiappacasse and Niemeyer (1984) noted this with respect to fishhook manufacturing. The shell industry illustrates the complexity of Chinchorro material culture as well as its strong connection with and knowledge of the marine environment.

Fishhooks suggest specialization and adaptation to the coastal environment (Llagostera 1992). Shell and thorn fishhooks were found at the Camarones 14 site context during this research, confirming the data presented by Schiappacasse and Niemeyer (1984). However, composite fishhooks and stone weights were not found in Camarones 14. In fact, stone weights were found at Camarones Sur only during the post-Chinchorro period (LRD – Late Regional Development)[23]. The context for fishhooks was not clear from former excavation at Camarones 14 (Schiappacasse and Niemeyer 1984). For the present excavation, however, the thorn fishhooks came from an earlier period of the site's occupation. The single thorn fishhook found shows a complete mastery of the manufacturing technique. It is possible that this piece was obtained by contact with another group. If so, it implies horizontal networks. Also people probably carried small artifacts as part of their basic tool kits. It seems reasonable to suppose that these movements and contacts included an exchange of knowledge. Even so, it is unclear how widespread these contacts were and whether they involved small groups or an entire group, perhaps through intermarriage.

Lithic Artifacts

A great variety of stone artifacts were recovered during Schiappacasse and Niemeyer's (1984) excavation. Among these are metates ("morteros") for plant processing, different types of worked pebbles, scrapers, retouched flakes, debitage debris, and projectile points[24]. Among the points were: double points (bi-points) manufactured in chalcedony (18 points and 31 fragments), including 5 unfinished pieces (in stages of artifact manufacture or pre-forms); points of larger dimensions, made from basalt, as well as foliaceous points. Most raw materials for lithic artifacts were available locally (quartzite, andesite, and basalt), but chalcedony probably came from Angostura de Conanoxa, 40 km inland. Also, the presence in the site of debitage would indicate that raw materials were brought to the site to be worked there. Besides these, there are also

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[23] For figure of this artifact see Fig. 3.22 and 3.23 in Chapter 3.

[24] For a detailed description of all classes of artifacts, see Schiappacasse and Niemeyer, 1984.

pebbles attached to plant fibers, which were possibly used as fishing plumbs. Also found were "*limas*" and "*serras*", which, as already mentioned in the "Shell Artifacts" section, were used in the manufacture of shell fishhooks (Schiappacasse and Niemeyer 1984). Tables 5.14 and 5.15, below, have the list of artifacts analyzed[25].

The main material recovered for this research includes projectile points, flakes, debitage, scrapers, hammerstones, and a mano. The classification system used to define the lithic artifacts was based on Emperaire (1967), Andrefsky (1998); and Jacques Tixier (Workshop, Rio de Janeiro, 1980).

Table 5.14 - Distribution of lithic material per excavated levels

		Samples from bucket		Dimensions* (in between "&"; LxW)		
Excavation levels	Sector	Piece	Amount	Size (cm):	Grams	Notes
Surface	A2	Small flakes	12	1.8 & 0.5	3.2	
1D	A2	Small flakes	2	1.8 & 2.6	1.58	
1D	A2	Micro-flake	1	0.8	0.05	
1E	A2	Micro flakes	3	0.7 & 0.8	0.54	
1E	A2	Small flake	1	1.4		
2	A2	Micro-flake	7	0.8 & 1.2	7.1	
2	A2	Medium flake	1	4		
2	A2	Large flake	1	5.1 X 4.1	47.71	
2	A2	Core	1	5.0 X 4.5	160.67	Orthogonal
3	A2	Micro-flake	3	0.8 & 1.1	2.86	
3	A2	Medium flake	2	2.1 & 2.4		
3	A2	Large flake	1	4.5 X 4.9	12.4	Burned
4	A2	Micro-flake	3	1.1 & 1.3	0.77	
4 dpd2	A2	Micro-flake	7	0.6 & 1.1	1.28	
5 dpd2	A2	Micro-flake	1	0.07 X 0.05	0.05	
5 dpd2	A2	Small flake	1	1.5		
5 dpd3	A2	Small flake	2	0.6	3.287	
5 dpd3	A2	Medium flake	3	1.3 & 1.7		
5 dpd3	A2	Big flake	1	3.6		
5 B	A2	Micro flakes	6	0.5 & 1.2	0.94	

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[25] Materials collected during the excavation were almost entirely analyzed or systematized, but one bag with general material remains unanalyzed.

5 B	A2	Scraper ?	1	3.5 X 2.3	5.54	Flake fragment, unifacial, with debitage marks in its left margin regarding the percussion plane. Right margin lowered possibly for the haft (fig. 5.33)
9 C	A2	Micro & small flakes	6	0.6 & 1.4	0.64	
9 C	A2	Medium flakes	2	3.5 & 3.0	6.11	
9 C	A2	Pebble: signs of tying	1	1.5	3.67	Small pebble with signals of been tied.
12	A2	Small flake	1	1.2 & 0.6	0.25	
13 B	A2	Micro-flake	2	0.9 & 0.5	0.15	
13 C	A2	Micro-flake	5	0.7 & 1.2	3.43	
13 C	A2	Big flake	1	2.9		

Table 5.15 – Lithic - Selective collection

Layers	Sector	Piece	Amount	Size (cm):	Grams	Notes
3	A3	Small flake		1.7X0.95	0.34	Well define, sharp margin, green color.
5 dpd1	A3	Scraper	1		14.13	Bifacial, sub-triangular shape, with margin retouched of about 3.7 cm (fig. 5.34).
5 dpd2	A2	Medium flake		3.2X2.3	1.96	Well define, bulb and talon, very thin, white color; chalcedony.
5 dpd3	A3	Projectile point	1	3.2X2.0	3.82	Bilateral retouch in both margins. “Tipo serrilhado”; Chalcedony. Fragmented in its mesial portion (figs. 5.26 and 5.27).
12	A2	Flakes and debris	6	2.2&1.4	5.07	
12	A2	Flake	1	5.6X4.3	30.78	
12 B	A3	Flake	1	3.0X2.1	3.45	Expedite flake
12 B - grieta temblor	A2	Hammer-stone (Chancador) (frag)	1	4.75X4.9	37.71	Sub-quadrangular, dark grey color. Active tip with signals of use. (From a mixed area). From an earthquake (?) fissure.
12 B - grieta temblor	A3	Large flake	1	4.1X4.0	11.02	Dark color, bulb. Sharp sides. (From a mixed area). From a earthquake fissure.
12 C	A2	Medium flake/used	1	2.35X2.2	3.23	With part of the cortex. One side in semi-lunar shape (light) probably by use. One side rounded. Red with white points.
12 C - 2	A2	Mano stone	1	5.0X4.3	117.6	Fragment of mano, with used marks, sub-triangular shape.
12 C - 2	A3	Flake	1	3.9X2.5	12	Fragment
12 C - 2	A2	Small pebble	1	1.7X1.12	1.98	
7	A3	Projectile Point	1	2.2X1.9	2.86	Fragment. Bilateral retouch on the distal portion. Broken in its middle portion. White with blue veins

						color. Chalcedony (fig. 5.31)
7	A3	Scrapper	1	5.0X2.2	8.83	Bifacial, chalcedony. Retouched in the right margin and in the apical area (fig. 5.32).
7B	A3	Small/ medium flakes	1	0.8&2.8	4.97	1 small and 2 medium flakes; chalcedony
7B	A3	Core	1	3.3	19.17	1 small core totally used
9 B	A2	Medium flake	1	2.5X1.95	1.72	Bulb and talon well defined. White color; chalcedony. Broken in semi-lunar shape in 2 parts at the distal portion.
9 B	A2	Small flake	1	1.45X1.0	0.42	Flake with bulb and talon well defined; sharp edge. Light grey, translucent.
10	A3	Projectile point	1	5.8X2.98	34.2	Unilateral retouch “Tipo serrilhado” on both margins. Broken in both side (base and tip).
6	A2	Bipolar flake	1	4.9X5.6	10.52	Burned.
14	A3	Flake	1	2.1X1.4	1.44	Flake fragment
14	A3	Small flake	1	1.3X0.15	0.11	Well defined
14	A2	Large Flake	1	5.2X4.3	39.16	Patina; possible retouch on the right side
14	A2	Flake	1	3.0X1.4	2.09	Fragment; possible secondary chipping on the external surface close to the talon
12	A2	Small flake	1	1.3X0.9	0.26	Well defined, sub-triangular shape
13	-	Hammer-stone fragment	1	5.0X3.0	23.96	Flake, part of a hammerstone
13C	A2	Projectile point	1	2.9X2.2	5.53	Distal fragment of a projectile point. Bifacial retouches, apparently worn by use (fig. 5.30)
13B	A3	Small flake	1	1.4X1.0	0.33	
13B	A2	Large flake	1	2.8X2.7	5.85	Broken at its half height; used marks on the internal margin, on the right side.
13B	A2	Small flake	1	---	0.49	
1 dpd2	A2	Large flake	1	4.3X3.3	5.1	Fragment; well defined flake
13C	A2	Small flake	1	2.05X1.3	0.72	Sharp edge
13C	A2	Rejects fragments	6	2.7 & 1.1	14.03	Chipping rejects.
13C	A3-SQB	Small flake	1	1.1X0.7	0.8	Well defined
13C	A3-SQB	Scrape - flake	1	4.0X2.9	10.32	Medium white flake with red spots. Semi-lunar entry with small retouches on the edge. Probably used as a scrape
13C	A3	Medium flake	1	4.2X2.3	4.26	Possible used as a hammer; black color
Profile cleaning	--	Medium flake;	1	4.2X-	9.1	Possible retouch on the right side; black color
Profile cleaning	--	Small flake	1	1.8X1.51	0.86	Sub-triangular shape; red color
4	A2	Small flake	1	2.05X1.1	0.55	Sub-triangular shape; white color
4	A2	Small flake	1	1.4X1.2	0.37	Sub-quadrangular shape; dark

						brown color
5	A3	Projectile point (?)	1	3.4X--	7.01	Chalcedony; bulb and talon well defined; bifacial, retouch on the edges; white color; broken in the mesial portion (fig. 5.29)
5 (Shells layer)	A3-SQC	Projectile point (?)	1	5.1X2.9	13.74	Sub-diamond shape. Unifacial retouch, oblique break in one of the extremities; light brown color with white spots.
5 dpd1	A3	Hammer-stone	1	9.2X7.0	350	A large fragment of hammerstone, burned
5 dpd3	A2	Projectile point	1	3.8X1.4	4.42	Fragment, broken in the middle; bifacial; long distal tip; light brown color (fig. 5.28)
5 dpd2	A3	Hammer-stone	1	12X11	1,180	
5 (coprolites area)	A3	"Quebra-coco"	1	10X11.5	1,490	Stone with a depression in the center of the block
5 dpd1	A3	Large flakes	3	4.2 & 2.2	--	
5 dpd1	A3	Small flake	1	1	--	
5 dpd3	A3	Large flake	1	7.3X3.5	39.65	Gneiss (?); with a secondary chipping; probably used
5 dpd3	A3	Knife (?)	1	4.2X2.9	15.2	Large flake with bulb and percussion plane well defined, sharp margin possible used to cut. Use marks.
5 dpd3	A3	Scraper (?)	1	3.2X1.5	3.01	Medium flake with the margin in half moon shape. Scraper (?)
8	A2	Small flakes	2	0.9 & 1.4	0.5	
5B	A2	Small flake	1	1.5X--	3.86	
5B	A2	Large flake	1	3.4X--		
8	A3	Small flake	1	0.9X1.3	42.63	
8	A3	Medium flake	1	1.5X2.0		
8	A3	Large flake	1	2.2X3.5		
8	A3	Small (?) flake	1	--	0.49	
8	A2	Large flake	1	3.48X3.3	10.9	From chalcedony
8	A2	Flake	1	4.2X2.5	21.8	Flake from the core; chalcedony
8B	A3	Small flakes	4	0.7&1.4	19.02	
8B	A3	Medium flake	5	1.5&1.9		
8B	A3	Large flake	6	2.0&3.4		
8C	A3	Small flake	1	1.3	1	
8C	A3	Debris	1	1.9		
9	A2	Medium flakes/debris	4	3.74	2.2&2.5	2 flakes (2.2&2.5) and 2 debris
12	A3	Small flake	1	1.1X--	0.54	
12	A3	Medium flake	1	2.3X--	2.3	
13	A3	Flakes	2 ?	0.85X3.2	3.87	Small and large flakes
Bucket samples						

1 C	A3	Small flakes	16			
1C	A3	Large flake	1			
2	A2	Small flakes	7	0.8&1.2	189.2	
2	A2	Large flakes	1	5.1X4.1	47.71	
2	A2	Core	1	5.0X4.5	160.67	Orthogonal shape
5C	A3	Large flake	1	4.6X3.2	8.42	Chalcedony, burned signals
5C	A3	Small flake	1	1.7X1.8	1.66	Chalcedony, burned signals
Obs: * when “&” means measurement of the bigger & smaller samples; when “X” means length x width						

Table 5.16 - Lithic artifacts and their cultural contexts

Cultural context	*I Early Chinchorro*				*Concretion*	*II Middle Chinchorro*				*III Transitional Chinchorro*		*IV Post Chinchorro*	
Final layers	*17*	*16*	*15*	*14*	*13*	*12*	*11*	*10*	*9*	*8*	*7*	*6*	*3*
Projectile point	1				1		1	4					
Scrapers	1						1	3					
Knife (?)								1					
Small flake	8	4	1	3		7	10	11		10	4	7	
Medium flake	2		1	1		4	8	4			2	1	
Large flake	3	1	2	1			8	5			1	1	
Hammerstone			1					2					
Bipolar flake									1				
Mano			1										
Reject/debris	6			6		1	1						
Expedite flake				1									
Pebble (tie signals)						1							
Core							1					1	
“Quebra coco"								1					

Table 5.16 shows that lithic artifacts were present in all four cultural periods, mainly different flake sizes. It is during the “Middle Chinchorro”, however, that a wider diversity of artifacts is observed and in greater numbers, with the occurrence of projectile points, scrapers, hammerstones, “quebra-coco[26]”, and the only bipolar flake found among the analyzed material. This suggests that although this technique was known, although

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[26] It is a lithic artifact with a flat base used as a support base to hit hard seeds or in the manufacture of another lithic artifact . A small depression in the surface is characteristic of this artifact.

other types of direct percussion techniques, like hard hammer percussion were preferable. Such diversity drops dramatically in the next period, during which flakes, mainly the small size pieces, and a lithic core are present. During the Early Chinchorro period, projectile points were uncovered for the initial occupation of the site in layer 17, as along with flakes and a scraper. The only other formal artifacts found in subsequent layers of this period were a flake fragment from a hammerstone and a mano. The absence of formal artifacts would probably be more characteristic of sedentary societies (Andrefsky 1998). On the other hand, greater diversity in artifact types in the assemblage would be expected (Shott 1986). For this study, artifacts of the early period of the site's occupation are more in line with maritime hunter-gatherers that maintain a certain grade of mobility. An isolated artifact, part of a point or a spearing tool (Figure 5.30) was found in layer 13, a very compact and practically sterile layer that divided the Early and Middle Chinchorro for a ~350-400 year interval. Photos of some of the artifacts are provided at the end of this section.

Lithic material: conclusions

A lithic industry is evidenced by a variety of fragments that occur throughout the Early and Middle Chinchorro period of maritime forager occupation at the site. It is in the middle of the occupation (Middle Chinchorro) that the diversity in artifact types increases. Given the variety of remains, including flakes and debris, it seems that the artifacts were manufactured at lithic workshops. A study by Shott (1986), based on ethnographic data, demonstrated an inverse relationship between artifact diversity and residential mobility. As artifact diversity increases, residential mobility decreases.

According to this model, the early Chinchorro people were relatively mobile marine foragers, while during the middle period of the occupation, the group was established in more sedentary basis. The Transitional Chinchorro and post-Chinchorro periods shows a possible shift back towards mobility.

Photos of Lithic Material from Camarones 14 Site

Below is a series of photos of projectile points from the Camarones 14 site, along with other lithic fragments, probably scrapers. The fragment illustrated in Figure 5.30 is the only artifact found in the compact layer characterized by the absence of occupation. As already explained, this sterile layer seems to mark the division between the Middle and the Transitional Chinchorro.

Figure 5.26: Projectile point fragment in situ during the excavation of layer 10.

Figure 5.27: Detaille photo of the same point from layer 10.

Figure 5.28: Projectile point from layer 10

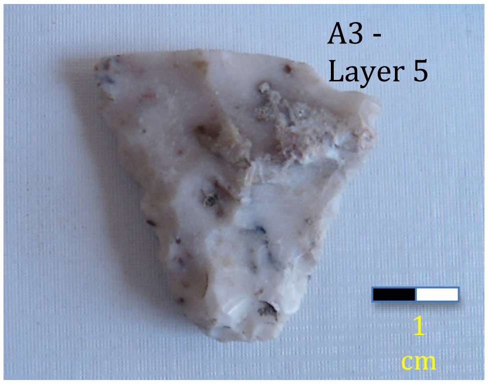

Figure 5.29: Possible point fragment from layer 10 (excavation context: A3, layer 5)

Figure 5.30: Fragment of a lithic artifact found isolated in layer 13, a compact sterile layer

Figure 5.31: Point fragment from layer 11

Figure 5.32: Possible scraper from layer 11

Figure 5.33: Flake with signs of use, possibly a scraper, from layer 10

Figure 5.34: Flake fragment, distal margin retouched (in down possition in the photo). Possibly used as a scraper, from layer 10

Bone and String Remains

Below are described some additional elements found in the excavation, basically bone and string. Some small fragments of wood with signs of use are described in the report on macro-botanical remains presented by Garcia (Appendix E).

Among bone remains, a small deteriorated fragment, probably avian, was recovered. With one of its sides slightly resembling a point, it could be a fragment of a projectile point (Figure 5.35). However, this fragment has no worked marks to confirm this.

Figure 5.35: Small bone point (?) fragment, very deteriorated, from layer 14.
Dimensions: 2.85 X 0.9 cm (length and width). Layer 14 (Sector A2 level 12B)
Weight: 1.33 grams.

A variety of string fragments were found in different layers. They were twisted into Z or S shapes, some with knots. Almost all were made with vegetal fiber, and only one was made with animal or human hair. They were found throughout the occupation. Human hair appears in layer 10 (Figure 5.36). These materials are not the object of intensive analysis here.

Figure 5.36: Variety of string fragments found in the site (sector A3, layer 5 dp1).

Invertebrate Remains

A detailed analysis of invertebrate remains is beyond the scope of this investigation. Introduced here is a brief overview of this material. This category has mostly mollusk shells along with fragments of cypripediums, crabs, sea urchins, and river shrimps. Shell remains were identified by this author based on the comparative collections from the Museo de San Miguel de Azapa (Azapa) and the Museo de Conchas (Arica). The specific literature was also consulted, mainly Guzman et al. (1998) and Romero (2002). The list of invertebrates identified is presented below in table 5.17.

Table 5.17: Invertebrates from Camarones 14

Phylum MOLLUSCA				
Class / Subclass	Family / Superfamily	Taxon	Common name in Spanish	Obs.
POLYPLACOPHORA	CHITONIDAE	*Chiton* sp	"Apretador"	
GASTROPODA	MURICIDAE	*Concholepas concholepas* (Bruguière, 1789)	"Loco"	
	FISSURELLIDAE	*Fissurella* spp.	"Lapa"	
	CALYPTRAIDAE	*Crepidula dilatata* (Lamarck 1822)		
	LOTTIOIDEA	*Acmea* sp.		
		Scurria sp.		
	TROCHIDAE	*Tegula atra* (Lesson, 1830)	"Caracol negro"	
		Tegula tridentata (Potiez & Michaud, 1838)		
		Tegula ssp.		
	TURBINIDAE	Prisogaster niger (Wood 1828)	"Caracol negro"	
	STROMBIDAE	*Strombus* sp.		
BIVALVIA	MESODESMATIDAE	*Mesodesma donacium* (Lamarck, 1818)	"Macha"	
	MYTILIDAE	*Aulocomya ater* (Molina 1782)	"Cholga"	
		Choromytilus chorus (Molina, 1782)	"Choro zapato"	
		Perumytilus purpuratus (Lamarck, 1819)	"Chorito maico"	
		Semimytilus algosus (Gould, 1850)	"Chorito" / "Chorito negro"	
	VENERIDAE	*Eurhomalea lenticularis* (Sowerby, 1835)		
Phylum ARTHROPODA				
CRUSTACEA / CIRRIPEDIA	BALANIDAE	*Balanus* sp.	"Picoroco"	
CRUSTACEA	PORTUNIDAE	*Taliepus* sp.	"Jaiba"	
	HIPPIDAE	*Emerita analoga* (Stimpson 1857)	"Pulga del Mar"	Sand crab
MALACOSTRACA	PALAEMONIDAE	*Cryophiops caementarius* (Molina, 1762)	"Camarón de río"	River shrimp
Phylum ECHINODERMATA				
	ECHINIDAE	*Loxechinus albus* (Molina, 1782)	"Erizo rojo"	Red urchin

The distribution of the shells found at the site is presented in Table 5.18. Only the remains from the layers related to the Middle and Early Chinchorro are presented. The rest of this material may be the object of a future investigation, since it is known that changes in shellfish composition are related to changes in foraging culture (Meehan's 1982; Bird and Bird 1997, 2000). Ethnographic studies show that children also have a tendency to diversify the species collected introducing variability to the samples. Also, some shellfish can be processed immediately after collection. Consequently, certain shells will be underrepresented at the site if only the edible flesh will be brought to the site (Bird and Bird 1997, 2000). For the purpose here, the evidence of the river shrimp (*Cryophiops caementarius*) suggests seasonal exploitation of this resource.

Table 5.18: Occurrence (presence/absence) of mean species of invertebrates per level in Camarones 14 site. Samples from sector A3.

		TAXA												
Level (excavation)	LAYER	*Concholepas concholepas*	*Choromytilus chorus*	*Mesodesma donacium*	*Perumytilus purpuratus*	*Semimytilus algosus* (?)	*Chiton* sp.	*Crepidula dilatate*	CIRRIPEDIA (*Picorocos*)	*Fissurela* spp.	*Aulocomya ater*	Crustacean	Shrimp	Cultural context
5	10	*	*	*	*	*	*		*	*		*		II Middle Chinchorro Less than 6,000 to 6,700 BP
5b	10	*	*	*	*		*		*			*		
5c	10	*	*	*		*	*				*	*	*	
7	11		*	*	*	*						*		
7b	11	*	*	*	*	*	*	*	*			*		
8	11	*	*	*	*	*	*		*			*	*	
8b	11	*	*	*	*	*	*		*			*	*	
8c	11	*	*	*	*	*	*		*	*		*		
9a	12		*	*			*	*	*			*	*	
9b	12	*	*	*		*		*	*	*		*	*	
9c	12		*	*				*	*			*	*	
10	13		*	*										
12	14	*	*		*		*	*	*			*		I - Early Chinchorro ~7,000 to 7,700 BP
13	15	*	*	*			*	*	*	*	*	*	*	
13c	17	*	*	*		*	*	*	*	*		*		
14	18	*	*	*	*	*	*		*			*	*	

Fragments of shrimp were found at the base of the site and in layer 15. For the Middle Chinchorro, shrimp occurred in layers 12, 11 and 10. Shrimp are more available from January to March when they migrate to the river's mouth for reproduction (Viacava et al. 1978). As stated in Chapter 2, they are found in the lagoon close to the site. Depending on the environmental conditions of any particular year, shrimp can be found in December and April too. In terms of seasonality, they are available from the middle summer to the beginning of fall.

Fish Remains

Fish analysis focused on otolith remains recovered for this research from the excavation of Camarones 14. Otoliths from the deepest layers related to the Early Chinchorro strata were selected and prepared for growth ring analyses. The preparation of the otoliths was done by this author at the facilities of the Universidad Arturo Pratt (Iquique, Chile) in the laboratory of Prof. Miguel Araya. It was performed with the assistance and supervision of Jessica Peñailillo who also identified the prepared otoliths. Using specialized literature, mainly Garcia-Godos (1996), some otoliths were also identified by this author[27].

In some species, the sequence of growth rings, formed by a single hyaline followed by a single opaque ring, is not straightforward. Double or multiple rings can form the growth ring sequence (Araya et al. 2001). This is the case of the Chilean jack mackerel, *Trachurus symmetricus murphyi* (Nichols) (Araya et al. 2001), a species sampled here. This complicates the analysis since the determination of the seasons in

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[27] Any mistakes in the identification of mollusks and fishes remains are responsibility of this author.

which the fish was collected is based on the correct identification of the growth increments. Also, a comparative seasonal collection of otoliths from modern fish species from the Camarones area does not exist. Because of these factors, the analysis of growth rings in otoliths was not performed. The study of the growth rings as well as the application of isotopic analyses for seasonal inferences can be applied in the future, once a comparative collection for this type of research is prepared for the area. Table 5.19 has a list of fish species identified from Camarones 14 and their distribution by layers.

Table 5.19 - Fish remains from Camarones 14 based on otoliths remains

Cultural context	*I Early Chinchorro*				*Concretion*	*II Middle Chinchorro*				*III Transitional Chinchorro*		*IV Post Chinchorro*	
Final layers	17	16	15	14	13	12	11	10	9	8	7	6	3
Trachurus simetricus (*jurel*)	*		*			*	*					*	
Isacia conceptionis (*cabinza*)	*					*	*	*					
Sciaena deliciosa (*covinilla*?)	*						*	*					
Cilus gilberti (*corvina*)	*		*			*	*	*				*	
Paralabrax humeralis (*cabrilla*)						*	*						
Not determined	*	*	*	*		*	*	*		*	*	*	
Total otoliths	39	27	136	18	0	42	97	60	0	5	26	7	0

Trachurus symmetricus is a migratory fish sensitive to water variations and El Niño; it is present during the summer months close to the beach or in brackish water (Llagostera 1979; Sielfeld et al. 2002; Núñez E., et al. 2004; Thiel, et al. 2007). *Paralabrax humeralis* is an occasional fish found in bottom rocks. Local non-migratory fish include *Isacia conceptionis, Sciaena deliciosa* and *Cilus gilberti* (Sielfeld et al. 2002). Although the identification of fish species is incomplete, otoliths were abundant in layer 15 with 136 units, suggesting intense fishing activity, as well as in layer 11 with 97 pieces.

Results from Table 5.19 suggest summer activity for layers 17, 15 (Early Chinchorro) and layers 12 and 11 (Middle Chinchorro).

Parasitology

Parasitological evidence from human coprolites found in archaeological sites can provide information about human migration, diet, health, and the surrounding environment (Araujo et al. 2008; Reinhard and Bryant 2008; Reinhard et al. 2013). Coprolites found in Camarones 14 were sent for analysis to obtain indirect data on sedentism versus mobility. The premise is that a sedentary life style makes people more vulnerable to the spread of disease. Evidence of worm infestation could indicate that people were living and sharing spaces in the same area at a more sedentary base (Cohen 1989). Mobility, by contrast, can interrupt the life cycle of some parasites as it reduces the proportion of worms that can successfully re-infect people (Cohen 1989). A parasite that has part of its life cycle in the soil would not be able to complete it if people move to another area before the parasite's offspring can mature and re-infect people.

In Camarones 14, coprolites were found dispersed at different levels. Some of them were concentrated in a pit structure[28] along with fragments of *Zea maiz*. This was located between sectors A2 and A3 both about 20 cm deep. The pit cut the sediment matrix, reaching level 5 (layer 10). Other levels sampled were: level 3a (layer 5), level 5-

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[28] A description of this pit can be found in Chapter 3.

2 (layer 10), level 7 (layer 11), level 8 (layer 11), level 8b (layer 11), and level 12 (layer 14). Dr. Adauto Araujo and Mônica Vieira de Souza from the Escola Nacional de Saúde Pública, Fundação Osvaldo Cruz (Rio de Janeiro, Brazil) studied these materials (see Appendix I for the table results).

The analyses indicated the presence of *Diphyllobothrium pacificum* and *Enterobius vermicularis* in samples from a context date from about 6,000 BP. In the samples from about 700 BP and associated with maize, the results show the presence of *Diphyllobothrium pacificum*, and possibly starch of *Zea maiz* (Figure 5.37). Unidentified starch and phytolith remains, as well as fish, insect fragments, and pollen were also found in the samples.

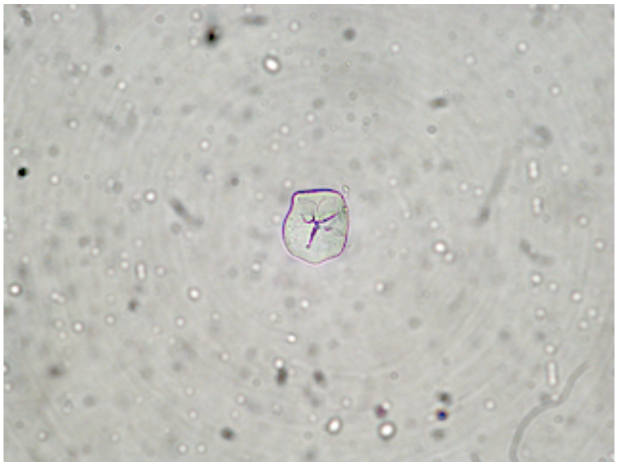

Figure 5.37: *Zea maiz* (?) starch from a coprolite sample from about 700 BP (Source: Adauto Araujo and Monica Vieira; suplementary data from Appendix I)

Diphyllobothrium pacificum is a parasite found in fish and marine animals like the sea lion. It is common along the Peruvian and Chilean coasts. Marine mammals are the final host and cannot infect people. Humans are infected through the ingestion of contaminated raw or not well-cooked fish (Reinhard and Urban 2003). The occurrence of this parasite in Chinchorro contexts has already been described (Reinhard and Urban 2003). *Diphyllobothrium pacificum* was also reported for the Tiliviche site (Ferreira et al. 1984). Ferreira and co-workers analyzed samples from two units (I and II) of this site dating from about 7,900 to 6,110 BP[29] and from about 6,110 to 3,950 BP, respectively. Eggs of *Diphyllobothrium pacificum* were only found in the later samples from unit II, reinforcing the indication of contact between the coast and this inland site for about 7,000 BP. *Diphyllobothrium* was also reported at the Huaca Prieta site in northern Peru from a context dating to ~4,500 BP (Callen and Cameron 1960 in Le Bailly and Bouchet 2013). The results found here for the Camarones 14 site confirm the presence of *Diphyllobothrium pacificum* in Chinchorro populations for ~6,000 BP during the Middle Chinchorro period of this site.

At this point, no conclusion can be made about sedentism. *Diphyllobothrium pacificum* is a parasite with part of its life cycle in fish and not in the soil. Infections in human are not dependent upon soil conditions but on the type of food. The parasite indicates a marine diet and a life close to the coast. Concerning *Enterobius vermicularis*, infection can occur in different forms through contaminated water, soil, hands or through the air. It does not depend on soil or climate conditions. *Enterobius vermicularis* is a pinworm that co-evolves with humans and can infect people immediately after the female worm releases her eggs (Araujo et al. 2008).

In summary, *Diphyllobothrium pacificum* and *Enterobius vermicularis* were identified at the Chinchorro site for about 6,000 BP. Also a fish-based diet is suggested by the presence in this sample of fish flesh and scales. *Diphyllobothrium pacificum* was

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[29] 5,900 B.C. to 4,110 B.C. and 4,110 B.C. to 1,950 B.C (Ferreira et al. 1984)

found in a much later context of about 700 BP, with indications that included domesticated crops. This is suggested by a possible starch grain of *Zea maiz* and by the absence of fish remains in the samples from this context. Sedentism cannot be inferred from the present data.

Sedimentology

To indentify paleoenvironmental events that took place in the area, soil samples from selected levels of Camarones 14 were sent to Dr. Mario Piño from Universidad de Valdivia (Chile) to be analyzed. The levels analyzed correspond to layers 12, 13 and 14 (see Chapter 3, Figure 3.6). These levels were selected because they are related to a period right before (layer 14) and right after (layer 12) the site was abandoned. A sterile layer (layer 13) separated the two layers. As described in Chapter 3, this layer has sand with salt, a combination created by the dry air, which creates a hard concretion, sometimes 25 centimeters thick. Archaeologically, it is a sterile layer dividing the matrix of the site and could represent a change in environmental conditions. This event took place during the Early/Middle Holocene period of the site's occupation. Below is the list of the samples sent for analysis with the soil description (Table 5.20). The report presented by Dr. Mario Piño with the results appears in Appendix J.

Table 5.20: Soil samples for sedimentology studies

Sector	Level (final layer)	Weight (grams)	General description	Sampling date	Laboratory letter code
A3	9b/c (12)	242 g	Brown sediment; concretion; with organic material encrusted - mainly crustacean.	Nov. 05. 2007	EA$_3$
A2	9 (12)	201.66 g	Sand sediment with silt, reddish brown, with organic material - some charcoal, tiny plant and fish fragments; small shell fragments, almost absent (about 0.5%).	Nov. 01. 2007	EA$_2$
A2	10 (13)	240.58 g	Light brown sediment. Very hard concretion. Shell fragments encrusted (about 0.1%) and small stones.	Nov. 11. 2007	D
A2	12 dpd1 (14)	225.49 g	Sand sediment with silt, light grey, friable; with organic material - charcoal, tiny fragments of shells, plants, fishes and crustaceans.	Nov. 12. 2007	CA$_2$
A2	12 (14)	218.94 g	Silt sediment, grey (ashes), friable, with organic material – tiny fragments of shrimp and some other crustaceans, fishes and plants; one shell fragment of *Choromytilus* and a fragment of wood.	Nov. 07. 2007	CA$_3$

Final Conclusions

Fishhooks appeared at some point between ~7,600 and 7,000 BP in layer 15 (Table 5.11). This artifact is in the initial layers of the occupation[30]; these artifacts were already known and in use by the time of the Early Chinchorro context, although, apparently, not during its initial moments. The site was abandoned (layer 13) between the Early and the Middle Chinchorro periods. After humans returned to the site (registered in layer 12), fishhooks were not found nor were shells intensively worked. This suggests that when people returned to this area, they possibly had to "re-evaluate" options and

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[30] The date of the oldest sample found during Schiappacasse and Niemeyer work at the site is not known.

regain cultural and cognitive knowledge about the landscape. Lithic artifacts were the raw material most intensively worked at this moment of the occupation, but mainly flakes and debris. No special artifacts were found to suggest their use to process plants. This layer was probably occupied on a seasonal basis. Another possibility, already mentioned, is that if people were mobile and not living at a permanent base, they may not have carried fishhooks with them. The subsequent layer (Layer 11) is characterized by its diverse lithic artifacts. This intensifies in layer 10 with its shell industry, which suggests an intensive occupation, possible year around[31]. Layer 9 has a thin sheet of botanical material and features in a sack-shaped also filled with plant remains. This could represent a specific moment of the site's occupation and use of space, or maybe it was just a storage area with a protective thin cover over the shell layer below. In this case, the lack of artifacts does not mean the site has abandoned.

Shells and lithic artifacts had been worked in the site area. This shows that the domestic area of the site was also used as a workshop space where people were manufacturing lithic and shell artifacts. Following Shott's (1986) model, the analysis of lithic material associated with shell assemblages indicates that marine hunter-gatherers were more mobile during the initial period of the site's occupation (Early Chinchorro) with the possible exception of the layer 15 (certain grade of sedentism). This changed during the Middle Chinchorro period to a more sedentary pattern after a certain initial mobility (layer 12). The possibility of a shift back towards mobility is found during the

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[31] Although marked by a diversity of artifact remains, this layer (10) is characterized by the accumulation of shells, mainly Mesodesma deposited in this section of the site as the result of an intentional cut trespassing other layers (confer profile description in Chapter 3).

Transitional Chinchorro and Post-Chinchorro periods, as the diversity in artifacts type decreases relative to preceding periods[32].

The analysis of fish otoliths indicates summer activity in layer 17 and layer 15 during the Early Chinchorro, and in layer 12 and layer 11 during the Middle Chinchorro. The otolith data combined with shells from the site indicate a certain degree of seasonality for the period corresponding to layers 17 and 15, and again for layer 12, suggesting that the site was occupied during the summer season. This is in line with shrimp remains from these layers, with the exception of layer 17.

Coprolite analysis indicates that *Diphyllobothrium pacificum* and *Enterobius vermicularis* infected people living at the Camarones 14 site about 6,000 BP during the Middle Chinchorro occupation. No evidence of crop domesticates were found. The diet was based on fish and other marine resources. *Diphyllobothrium pacificum*, from a later sample about 700 BP, indicates the consumption of *Zea maiz* and an absence of fish. The evidence for *Diphyllobothrium pacificum* suggests that people were living or spending great deal of time at coastal bases.

Between about 7,600 to 6,000 BP, there was a change from wetter to more arid conditions. Artifact analysis, mainly lithic, indicates a more stable, possibly year round occupation during the middle Chinchorro. The remains of *Leucocoryne sp.* (*Zephira elegans*) throughout the Chinchorro periods indicate the exploitation of inland *lomas*. Hunter-gatherer incursions for the exploitation of this bioma should have occurred between August to September and maybe November. The occurrence of those remains in the Middle Chinchorro, when pollen analysis indicates a drier period, suggests the

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[32] As a reminder, these two periods had layers compromised by mixed material which does not entered in the analysis here.

maintenance of humidity in certain areas inside the valley that human foragers exploited. Maize is not registered for the Chinchorro occupation, it is associated with the post-Chinchorro occupation about 700 BP.

In Chapter 6, archaeological evidence for sedentism and cultural complexity in the coastal area of the Central Andes is revisited and the results of the analysis are integrated into the cultural landscape for the period. Finally, a comparative view between Huaca Prieta and the Chinchorro sites is presented.

CHAPTER 6

CULTURAL INTERACTIONS

Chapter 1 presented a brief overview of previous archaeological research on early coastal societies. This chapter focuses on the wider implications of these findings for the major sites. It details the adaptations of forager hunter-gatherers to the marine environment of northern Chile, seasonal strategies, and the impact they had on cultural complexity and the transition to sedentism. It presents an overview of coastal hunter-gatherers along the central Andean coast from the early and middle Holocene, with a focus on those societies that started developing a more sedentary pattern. This provides a broader context in which to view the target sites of Camarones 14 and Camarones Sur, both located in the north section of the Atacama Desert coast, and the Huaca Prieta site located in the north section of the Peruvian desert coast.

These coastal societies were part of a long process in the cultural history of the Central Andean coast that took shape in the river valleys against the background of a desert landscape. These sites were part of an occupation scenario that began as early as 12,000 to 11,000 years ago (Stothert 1988; Keefer et al., 1998; Dillehay 2003; Dillehay et al. 2012a) at the end of the late Pleistocene. Beyond the coast caves were already occupied in the central highlands of Peru that date around to 10,500 BP. In addition, caves and open-air sites were occupied in southern Peru and northern Chile that date to about 11,000 BP (Dillehay et al 2004, Nuñez and Santoro 2011).

The panorama of early occupations in coastal areas, however, is incomplete. This is due to the postglacial transgression that occurred after the Late Pleistocene (Richardson 1981; 1998; Rademaker et al 2013). Rising ocean waters during the last sea transgression would have covered coastal sites from this period, which are now under the submerged continental shelf (Anderson et al. 2007; Núñez et al. 2010; Dillehay et al. 2012)[1]. The sea level fluctuations stabilized at its current level around 6,000 BP, during the middle-Holocene (Llagostera 1992; Núñez et al. 2010; Dillehay et al. 2012). Consequently, there are many more sites preserved from this period (Grosjean et al. 2007; Sandweiss et al. 2007). Despite this fragmentary picture, the data that emerges from the remaining sites allows us to depict relevant aspects of the cultures that occupied the region in the distant past (Moseley 1975; Lavallée 2000; Dillehay 2008).

The point here is to posit the sites of Camarones 14, Camarones Sur, and Huaca Prieta in this ample scenario to help to understand how their economic and cultural systems were integrated in the context of the region during the early to middle Holocene. Specifically, these sites can contribute to our understanding of subsequent cultural developments, in particular how the early Maritime Foundation Hypothesis had its basis in these early periods

Maritime Interaction: Exploiting the Sea and Coastline

Along the coast of the central Andes, the early-middle Holocene, in a period between 7,000 and 4,000 years ago, was marked by great adaptive diversity expressed through subsistence strategies and technology (Muscio 2001). During this time, coastal

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[1] However, from southern Peru to northern Chile, the shelf is narrow, about 10 to 15 km (Thiel 2007), which increases the potential preservation of sites from the Late Pleistocene and Early Holocene in the region.

populations were increasing (a peak was reached about 6,000 BP) (Marquet et al. 2012), and maritime foragers were already established in the region exploiting and interacting with the marine environment (Reitz, 1988; Llagostera 1992; Dillehay et al. 2012).

Llagostera (1992) perceives the coastal adaptation in two different technological stages[2]: that of maritime gatherers initiated about 12,500 BP (e.g. Quebrada Tachuay site) and that of Archaic fisherman, which was marked by the introduction of fishhooks. Based on Tiliviche and the Camarones 14 sites, this took place about 8,000-7,500 BP. These sites have some of the oldest records of fishhooks on the Pacific coast of South America. Recently, however, the discovery of fishhooks at the Acha sites in north Chile pushed this date to 9,000 BP (Muñoz and Chacama 1993; Rodríguez and Muñoz O. 2001; Standen and Santoro 2004).

The first stage, that of the maritime gatherers, is related to the exploitation of the sea in its "longitudinal dimension" (Llagostera 1982, 1992) and without the use of fishhooks. It embraces mollusk gathering and the capture of fish mainly in the intertidal zone, tidal pools, coves and lagoons using fishing traps. On the shore, sea lions were hunted while terrestrial mammals were captured in the river valleys, the *lomas* and in the coastal cordillera (Llagostera 1992). The second stage, that of the Archaic fisherman, envisioned the sea exploitation in its vertical form been related to the capture of marine fauna from the neritic zone. In this stage, the fishhook is the artifact that opened access to deep sea resources. The result was not only a greater diversity in species but also larger fish (Llagostera 1992). Hunter-gatherer foragers were already exploiting the seashore in the first stage, while in a second stage, specialized maritime foragers with a technology

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[2] Although the idea of stages has an evolutionary perspective, in this thesis this aspect is not totally embraced, as it is understood that cultures have their own specificities and do not follow the same linear patterns of development.

focused on the exploitation of the sea created a way of life oriented to the maritime environment. Some of these societies became sedentary and adopted a broad-spectrum economy that included the introduction or an initial exploitation of cultigens.

The next section describes some of the principal site occupations related to early marine forager economies in the Central Andean coast. This is followed by some of the first sites associated with a more sedentary way of life. They were not strictly divided chronologically, since certain economic systems can persist through time and be contemporaneous with more recent innovations.

Early Maritime Foragers (12,500 to 9,000 BP)

During the late Pleistocene/early Holocene, maritime foragers already occupied several sites along the Central Pacific coast. Among the oldest are the Early Las Vegas phase (Las Vegas complex in southern Ecuador dated from 10,000 to 8,000 BP (Stothert 1988); the Amotape complex dated about 11,200 and 8,125 BP (Lavallée, 2000 quoting Richardson 1978); the earliest sites from the Paiján complex 11,000 to 8,500 BP in northern Peru dated to between 11,000 and 10,000 BP (Dillehay et al 2003; Dillehay 2008), and the pre-mound evidences at Huaca Prieta dated between ~12,500 and 11,700 BP (14,200 and 13,300 cal yr BP) (Dillehay et al. 2012a). Still further south in Peru are the Quebrada Jaguay site dating to between 11,100 and 10,000 BP (Sandweiss 1998); Quebrada Tacahuay dated to around 10,700 BP (12,700 cal. years BP.) (Keefer et al., 1998); the Ring site dated to about 10,575[3] (Sandweiss et al. 1989), and Quebrada de los Burros dated to between 10,000 and 6,000 BP (Lavallée et al., 1999; 2011; 2012). In

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[3] Sandweiss et al. (1998; Sandweiss, 2008) observe that the early dates obtained for Amotape and Ring Shell are maybe unreliable since they were performed from marine shells and the reservoir efected was not applied for correction (et al. 1998; Sandweiss, 2008).

Chile from this period are the Huentelauquén complex and the Quebrada Las Conchas site (currently Las Chimbas site) dated to about 9,700 BP (Llagostera, 1979), and the Acha complex (Acha 2 and Acha 3 sites), dating to around 9,000 B.P. (Muñoz O., 1993; Rodríguez and Muñoz O. 2001; Standen and Santoro 2004).

With the exception of Huaca Prieta, all sites cited above had lithic hunting-related artifacts made using bifacial (e.g. Paiján) and unifacial debitage techniques. At these sites, people also exploited the maritime environment as attested by their subsistence resources (e.g. marine fish and shellfishes); some had already started using fishhooks (e.g. the composite fishhook from Acha 3) and developing a more specialized maritime economy in some areas.

The Paiján culture is one of the earliest of the north and central coast of Peru. The Paiján sites are strung out from Cuspinique in the north to the Chillón valley near Lima, and they are spread out between the coast and the Andean foothills up to 1,500 m. This gave them access to a mosaic of diverse of environments and resources (Dillehay et al. 2003; Dillehay, 2004, 2008). The sites are dated to between 11,000 and 8,500 BP, being divided in to an early and a late phase (Dillehay 2008). Associated with generalized hunter-gatherers, the tool kit from the Paiján sites is composed of bifacial artifacts, Paiján points[4], unifacial scrapers, perforators, hammers, gridding stones, bones, and shell tools (op. cit.). Bodies were buried in a flexed position lying on the side (Lagostera 1992). Circular stone structures with thick occupational floors varying from 5 to 15 cm are associated with the late phase (Dillehay 2004). The hunter-gatherer economy was oriented to the seasonal exploitation of a variety of habitats, as reflected in the

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[4] Dillehay (2008: 38) describes Paiján points as “long needle nose-like projectile points”.

distribution of the sites and subsistence resources. As studies realized by Dillehay and collaborators (2003) indicate, mobility decreased between the early and late Paiján phases. In this late phase (10,000 to 8,500 BP) the forager hunter-gatherer economy including the exploitation of plants persisted. During this period, people started aggregating and settling down at sites located in the middle distance between the coast and the hillside (Dillehay, 2004, 2008). Even so, despite the semi-sedentary pattern, no evidence of plant domestication was found (Dillehay 2008).

The Amotape complex on the north coast of Peru is composed of small campsites (12 sites) that date to between 11,200 and 8,125 BP. In addition, there are two other complexes, the Siches and Honda, which date to between 8,000-5,000 BP and 5,000-4,000 BP, respectively (Llagostera 1992). A diversity of local plants and animals were exploited, along with mangroves, mainly at Siches and Amotape. By the time the Honda Complex sites were occupied, the mangroves had already retreated further north, as attested by the absence of mangrove species among the marine resources found associated with the sites of this complex. The communities at the Honda Complex also utilized gourds like (*Lagenaria*). Their tool kit consisted of unifacial artifacts that also included ground stones, T-shaped axes, stone bowls, and at Siches sites cup-shaped mortars.

The Quebrada Tacahuay (Keefer et al. 1998; DeFrance 2009) site is located in southern Peru, close to Ilo city. With two occupations, it dates between 10,700 and 9,000 BP (12,960 to 10,150 cal BP). The earliest occupation is characterized as a specialized coastal station. The main subsistence activity was the processing of marine fowl, plus some fish, mollusks, and marine mammals. No signs of residential structures such as post molds were found. However, DeFrance (2009) observes that the absence of outside material and the grade of specialization with respect to maritime resources suggest a “model of coastal residence”; more empirical data, however, is necessary to assess mobility patterns. This deposit was sealed by flooding followed by the natural accumulation of sand sediments. The reoccupation of the site occurred around 10,000 to 9,000 BP based on a more diverse subsistence, mainly fish and mollusks.

The Quebrada Jaguay site (Sandweiss et al. 1998; Sandweiss 1998), also in southern Peru, was a domestic center characterized by the presence of houses, possibly rectangular, and abundant marine remains, mainly drum fish and wedge clams. Only flakes constituted the toolkit. Raw material was mainly local with some obsidian from the highlands about 165 km away. The houses were constantly modified, suggesting periods of abandonment. Also the occurrence of obsidian and cactus seeds (prickly pear), which grows at elevations of 1,000 meters or higher, suggests that the early phase, dated to between 11,400 and 10,000 (ca 13,000 – 11,400 cal BP), corresponded to a seasonally based camp from which people exploited the adjacent mountains and nearby rivers (Sandweiss 2008). The Ring site near the Moquequa River is similar to the Quebrada Jaquay and Quebrada Tacahuay sites. The earliest occupation is dated to about 10,575 BP followed by a sequence of dates from ~9,100 to 5,850 BP (Sandweiss 2008). The site is characterized as a “semi-permanent base camp” occupied by groups living a “nomadic way of life” (Santoro et al. s/d). Unlike Quebrada Jaguay, there is no evidence of connections between the coast and the highlands.

A change in the pattern of the coastal resources exploitation but without specialized artifacts is found at the Quebrada de Los Burros site, which shows evidence of cultigens. Worked by Danièle Lavallée and collaborators the site is located in southern Peru and shares some characteristics with the sites from the coast along the Atacama in northern Chile (Lavallée et al. 2012). The site was occupied from 10,000 to 6,000 BP (Lavallée et al., 1999; 2011; 2012). Plant cultivation appears for the period between ~8,875, and ~6,985 BP, and includes *Lagenaria siceraria* (gourds), *Canna indica* L. (edible canna), and possibly *Zea mays* L. (corn). The site also has some of the earliest evidence for *Phaseolus* sp. (beans), and *Manihot esculenta* (manioc) registered in Peru (Chevalier 2012). Evidence for year around occupation was not corroborated by the analyses performed on *Mesodesma* shells and fish otolith (*Sciaena deliciosa*). In fact, both results indicate an absence of such remains between February and June (Lavallée et al. 2012), suggesting a seasonal exploitation. This site, together with the sites of Villa del Mar, Yara (Rasmussen 1998), and Kilometro 4 (Wise 1999), show connections with the Chinchorro tradition in northern Chile, mainly by its funerary aspects with burials in extended position and bodies wrapped in mats (Rasmussen 1998; Lavallée et al. 2012). The last three sites are all located north of the city of Ilo in southern Peru. Besides that, thorn fishhooks, lithic artifacts such as projectile points, flakes, manos, metates, plus bone artifacts, notably fishing weights for net line fishing and a type of drill, were also recovered at these sites (Lavallée, 2012). Yara is dated to between 7,800 and 5,000 BP, Kilómetro 4 is about 8000 BP., and Vila del Mar is between 7,800 ± 110 and 6,280 ± 60 BP (Lavallée 2012: 41).

In the northern Chilean coast, one of the oldest occupations is Quebrada Las Conchas (Antofagasta, Chile) worked by Llagostera (1992), which is characterized as a shell midden site located around 3 km from the actual coast. The site dated in 9,400 ±

160 BP and 9,680 ± 160 BP (P-2702) (Llagostera 1992) was occupied by forager-hunter gatherer with a subsistence based on marine resources constituted by fishes (24 species), mollusks (mainly *Concholepas concholepas*, and *Fissurela spp*.), sea lions (Otaridae), and dolphins (Delphinidae). Among these remains, were birds and bones from guanaco (*Lama guanicoe*) indicating exploitation of the terrestrial biota. Their tool kit consisted of a variety of lithic artifacts, such as scrappers, knives, various types (different shapes) of projectile points, and "ellipsoidal plummets". Bone manufacture was restricted to artifacts used to dig mollusks (choppers). Some peculiarities of this site were a series of geometric, discoidal, and polygonal stones, similar to the ones from Huentelauquen, and seeds with harmine, a hallucinogenic substance derived from some plants[5]. Also found were some burned human bones mixed in with refuses from the site, an unusual (Llagostera 1992). Standen and Santoro (2004) note that these sites have distinctive characteristics such as polygonal stones and projectile points with "*pedúnculo ojival*" that are not found in the extreme north of Chile or southern Peru. They may have a different origin, possibly from the south-central Andean hunter-gatherer forager's tradition.

In the extreme north of Chile, the Acha 2 and 3 sites are located in the Azapa Valley about 7 kilometers inland from the actual coastline. These are considered pre-Chinchorro sites. This is based on burial patterns, such as the natural mummification of human bodies, the funerary wrap around the bodies, and multiple burials as well as a marine based subsistence and technology (e.g. composite fishhooks) (Rodríguez and Ovalle 2001; Standen and Santoro 2004). They are dated to about 9,000 B.P. (Standen and Santoro 2004) when the local environment was more humid than today, a fact

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[5] One of these plants is *Banisteriopsis caapi* know as "*ayahuasca*," a liana from the Amazon forest used in hallucinogenic rituals.

attested to by the remains of Ciperacea and Graminae plants (Rodríguez and Ovalle 2001). In Acha 2, Rodríguez and Ovalle (2001) noted the temporary nature of house structures at the site, and a subsistence economy based on both marine resources from the coast and flora and fauna from the valley. To them, this indicated a semi-sedentary pattern in which forager-hunter-gatherer moved from one area to the other.

Tiliviche-1 is part of a complex of mounds and hearths located about 40 km away from the coast in the Tiliviche Quebrada[6] highlands (Núñez and Hall 1982; Núñez 1983). It is situated about 950 meters above sea level in an inland riverine oasis area (Figure 6.1). Although not a coastal site, the archaeological material associated with it points to a mixed economy that exploited resources and used technological implements related both to the coast (55% of the food) and to the local highland environment (42% of plants and 3% of mammals) (Núñez 1983). Shells of *Mesodesma donacium* and *Choromytilus chorus*, plus bones from marine birds, crustaceans, some fish, and marine mammals reinforce this connection with the coast. Remains of llamas (*Llama* sp.) and small mammals (*Cavia* sp) indicate the exploitation of the surroundings areas of the site. As to the plants, *Scirpus californicus* ("*totora*"), seeds of *Prosopis chilensis* ("*algarrobo*"), *Prosopis tamarugo* ("*tamarugo*") and *Equisetum* sp. (horsetail) show the use of the riverine and inland areas. Maize was found in the late occupation at 3,900 ± 100 BP (N-3772) (Núñez 1983).

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[6] That is, gulch or ravine.

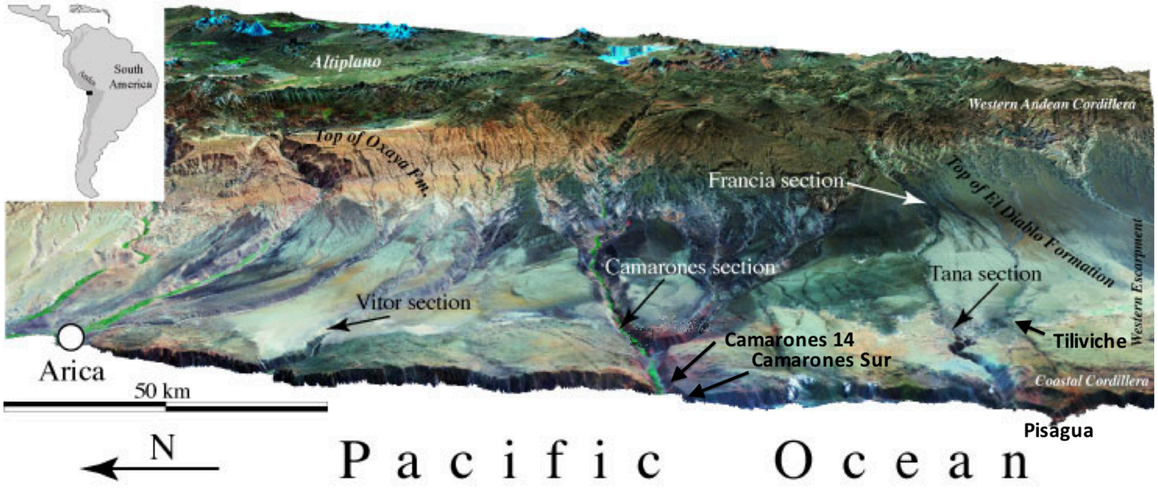

Figure 6.1: Location of Tiliviche site in relation with the sites of Camarones 14, Camarones Sur and the coast of Pisaguas (adapted from Rotz 2005).

About eight huts with a semi circular structure in shallow depressions with posts supporting the roofs were found at the site. The early occupation of the site is put in the early-middle Holocene, between 9,760 ± 365 BP. (SI-3116) and 7,850 ± 280 BP. (Gak-6052), and 6,060 ± (SI-3114) (Núñez 1983: 181). Diversified lithic artifacts with bifacial projectile points were found, mainly in a lanceolate shape, along with knifes, scrapers, drills and grinding stones. Shell fishhooks manufactured from *Choromytilus chorus*, as well as parts of composite fishhooks (hooks and weights in bone and shell), were associated with the intermediate period (~7,850 BP) of the site's occupation (Núñez 1983). Although Tiliviche is an intermittent river that dries up during the winter, there are small springs at certain points along the ravine (Morales J. s/d) that could supply a small group of people with water. During the time of the occupation, however, more humid conditions prevailed that provided enough water (Núñez 1983). After about 6,000 – 2,000

BP the increases of aridity and the consequent reduction of freshwater gradually restricted the group's movement and the use of coastal resources (Núñez 1983).

The Transhumance Pattern in Northern Chile

According to Núñez (1983), the early occupation of the Tilivicehe-1 site from about 9,750 to 6,050 BP represents a transhumance pattern by a small population with seasonal movement between the coast and the inland oasis, as reflected by the coastal components associated with the occupation. The site is seen as a "transitory logistic camp" where groups went to collect subsistence items, such as raw lithic material, plants and reed fiber, and to hunt small preys (Santoro et al. 2004 - Final Proof). Camarones 14 would represent a site that complemented the coastal circuit along with other coastal sites located at Pisaguas, that is the coastal end of the Tiliviche River. As already noted, this inland connection with the coast gradually diminished between 6,000 and 2,000 years BP (Núñez 1983).

Another site similar to Tiliviche is Aragón. It is located in the Jazpampa Quebrada distant 34 km from the coast at an elevation of about 1,100 m. The local habitat was less productive than at Tiliviche. Coastal resources predominated as the food supply (Núñez 1983). The site's early period is dated to about of 8,660 ± 230 BP (Gak-5966) and has bifacial projectile points (lanceolate type), scrapers, knifes, and grinding stones (e.g. mortars, manos) (Núñez 1983). Consumption of marine products increased in the period between 5,170 ± 200 BP (Gak-5965) and 4,480 ± 170 BP (Gak-5967). Aragón 1 artifacts are similar to those found at the Camarones site (Núñez and Zlatar 1976 in Núñez 1983: 184).

Many sites located in the lower part of the Tarapacá Quebrada show a similar pattern of inland-coast connections, as for example the Tarapacá 14A at 1,400 meter and dated to between ~6,800 and 4,700 BP (Núñez 1983). Shells and marine fishes attest to contacts with the coast, while the lithic industry resembles "Tiliviche and the Shell Fishhook Culture sites of Pisaguas and Arica" (Núñez 1983: 185).

The Conanoxa site complex is part of this circuit, although it is more recent, dated to between ~4,000 and 3,700 BP (Schiappacasse and Niemeyer 1975). It is located in the Camarones Quebrada, about 40 km inland. The site had a lithic industry similar to the coastal sites; subsistence remains include marine resources, river shrimps, plus guanaco and viscacha from the inland highlands (Schiappacasse and Niemeyer 1975). The evidence suggests the periodic movement of coastal groups to the site to hunting local animals and to search for raw material (chalcedony) (Schiappacasse and Niemeyer 1975; Núñez 1983).

In summary, the Tiliviche and Tarapacá complexes, as well as the Aragón and Conanoxa sites were part of an articulated system of exploitation between the inland valleys (Quiñua, Tiliviche, and Aragón oasis) and the coast (between Lluta and Camarones delta valleys). This pattern was established between 10,000 and 8,000 BP (Núñez and Santoro 2011). It persisted at the Conanoxa site until about 3,700 BP (Núñez 1983).

These sites, including Acha, form a mosaic based on the exploitation of resources from both the coast and the valley. The Acha site was based in the contact zone, closer to the coast then Tiliviche. For its part, Tiliviche was based on transhumance. A similar contact model applies to Quebrada de Los Burros, with the exploitation of both lomas and the coast in a seasonal circuit of exploitation.

Early Sedentary Coastal Cores (8,000 BP to 3,500 BP)

A more sedentary life began to appear around 8,000 BP (Lavallée, 2000). It was anchored to a diversified economy that exploited marine and land resources – e.g. mangrove, river valleys, *lomas* - associated with initial forms of plant cultivation. Some coastal settlements, like Las Vegas and La Paloma, became permanent fishing villages, (Stothert 1985; 1988; Benfer 1990; Pearsall 2008). These sites, together with Huaca Prieta, are highlighted in this section. The first sedentary core started to appear around 8,000 BP on the south coast of Ecuador. It is associated with the Preceramic complex of Las Vegas culture.

Las Vegas

The Las Vegas complex includes 34 known sites located on the semiarid coast of Santa Elena peninsula, in south Ecuador (Stothert 1985; 1988; Piperno and Stothert, 2003). Although three phases were described for this site complex, namely pre-Las Vegas (10,800-10,000 BP), Earlier Las Vegas (10,000-8,000 BP), and Later Las Vegas (8,000-6,600 BP) (Stothert 1985; 1988), this culture is defined by its last two phases that present one of the strongest evidences of early sedentariness along the north portion of the Andean central coast.

Las Vegas 80 (OGES-80) was excavated by Karen Stothert (1985; 1988) and is located about 4 km from the bay of Santa Elena; it has a late terminal Pleistocene occupation (pre-Las Vegas). The two subsequent phases that are characterized by a broad-spectrum economy provides evidence for sedentary occupations from about 10,000 to 6,600 BP. Small communities living in perishable circular huts exploited a diversified environment that had the potential to support permanent or semi-permanent groups of hunter-gatherers (Stothert 1985). The surrounding areas consisted of a zone of ecological contact, with estuaries, mangroves and semi-arid savannas. This gave people access to a varied of resources, such as plants and mammals (deer, peccaries, foxes, and rabbits), including fish and mollusks available throughout the entire year (Stothert 1985). The Vegas cultural technology included bone artifacts (spatulas and pointed bones), pigments, shell containers, flakes, plus polished and flaked stone axes among other artifacts. Deer provided an important item of the peoples diet, along with fish and mollusks from the mangrove areas. No definitive evidences of fishhooks, lithic projectile points, or other bifacial artifacts were found (Stothert 1985). Plants were also important; the first indications of plants domestications in South America come from Las Vegas culture. *Cucurbita* (squash) fruit phytoliths from Las Vegas-80 site and site 67, indicate that domesticated forms of *Cucurbita* had been planted since the initial periods of the Las Vegas culture ca. 10,000 BP[7]. *Lagenaria siceraria* (bottle gourd) and *Calathea allouia* (lleren), a root crop still used today in the area,,turn up at the sites from around 9,300 BP. (Piperno and Stothert 2003). A variety of wild plants were used since the early Las Vegas phase, including a wild form of *Cucurbita ecuadorensis*, also found with a pre-Las Vegas occupation (Piperno and Stothert 2003). An intensive occupation is found during the Later Las Vegas phase, with subsistence redirected toward both wild and cultivated

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[7] The appearance of domesticate *Cucurbita* in the context of Las Vegas culture was dated between 10,100 and 9,300 BP (Piperno and Stothert 2003)

plants. A cemetery with 192 human burials dated between 8,250 and 6,600 BP was also found related to a "pre-intensive-agricultural" population. The area was abandoned about 6,600 BP (Stothert 1985).

La Paloma and Chilca I

A second core of sedentariness was registered on the Central coast of Peru at the Chilca valley from about 7,800 to 4,800 BP (Benfer 1990: 288). It is related with La Paloma site worked by Robert Benfer (1982; 1984; 1990; Reitz 1988; Quilter, 1989). The site's initial occupation, between 7,800 and 7,000 BP was seasonal with people mobility regulated by the lomas dry season, which occurs from November to December. During this period people moved from the seashore to the inland valley or to other seasonal camps on the beach (Benfer 1982). From about 7,000 to 4,800 BP, the site became a sedentary village with a hundred of semi-circular shaped small houses constructed with reeds; roofs were covered with grass or rushes (Benfer 1990; Lavallée 2000). About a thousand burials were found under these houses. The corpses were lying on their sides wrapped in mats of woven reeds. They had their hands protecting their faces or pelvis and their legs were bent. The analysis of 201 skeletons indicated a decrease in stress over time. An ear infection of the auditory canal (external auditory exostosis[8]) was found on eight skeletons. Apparently, only men were affected by this lesion, which suggests intense activity and exposure to the cold waters of the Pacific, probably diving for seashells and other marine resources (Benfer 1982; 1990; Quilter 1989). The analysis of faunal remains show that the diet was based mainly on small fishes (anchovies and

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[8] An osseous proliferation located at the entrance of the auditory canal characteristic of people who dives frequently in cold waters (Sanden et al. 1997).

sardines) along with marine mammals and shellfish (Reitz 1988). Benfer (1990) observes that a shift toward marine resources seems to have occurred by the Encanto period (~5,300 BP) and that it also includes the predation of marine mammals and other marine invertebrates. Over 500 storage pits were found, some with fishmeal probably indicating anchovy storage (Benfer 1982; 1990). Although this economy was strongly oriented to marine resources, terrestrial plants were also exploited, but in lesser degree. Besides plants from the nearby lomas, people from La Paloma also practiced incipient horticulture. The following cultigens were utilized: gourd, guava (*Psidium quayba*), squash (*Cucurbita*), and beans (*Phaseolus*) (Pearsall 2008). Plants were most common from 5,100 to 5,300 BP (Level 300, Encanto Temprano phase). Strontium analysis realized on human bones indicates a higher consumption of plants by women (Benfer 1990: 308).

Chilca I (Engel 1964), dated between 5,500 and 4,500 BP (Lavallée 2000) is situated about 8.5 km inland. The site has cultural similarities to La Paloma (Benfer 1982). Squash, gourd, and beans were also cultivated, as well as achira, jicama, and jack bean (Pearsall 2008). Although a minor dietary complement, horticulture activities were practiced in later periods when people were settled in more sedentary bases and living in seashore villages with conical huts of wood tied at the top and covered with rushes (Lavallée 2000).

Huaca Prieta

As already noted in Chapter 1, the Huaca Prieta Preceramic mound is about 138 m long, 62 m wide and 32 m high (Dillehay et al. 2012a). It is located on the delta of the

Chicama River (Chicama Valley) on the north coast of Peru. Huaca Prieta is a flat-topped mound first excavated by Junius Bird in the 1940s. Bird interpreted it as domestic site, a fishing village occupied by a sedentary coastal population of maritime and plant foragers with an incipient agriculture of squash, lima beans, jack beans, cotton, peppers, and gourds. People lived in subterranean houses and had a well developed textile industry (Bird et al. 1985).

This interpretation was changed by the work done by Tom Dillehay, Duccio Bonavia and collaborators initiated in 2006 (Dillehay et al 2012a; 2012b; 2012b online supplement). Their work brought new insights to the "rise of early complexity" along the northern coast of Peru (Dillehay 2012). The data that emerged from this investigation posit Huaca Prieta not as a domestic residential site, but as a ceremonial mound that was part of a larger complex of sites (Dillehay at al. 2012b; 2012b online supplement). Besides the mound itself, the site area includes 38 domestic sites, the majority of which date to between 5,300 and 3,500 BP (6,000 - 4,000 cal BP) (~phase III to V). Also found were "raised agricultural platforms"[9] dated to about 4,200 BP (4,800 cal BP). Based on phytolith analysis, cultivated crops included beans, squash, and chili pepper (Dillehay at al. 2012b online supplement).

The sequence began in the late Pleistocene, extents through the periods of mound building, and ended with the use of the mound by later ceramic cultures[10]. Dillehay and collaborators (2012a) had reached the initial base of the site's occupation, which was

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[9] Actually, these platforms were found in ancient wetlands buried about 1.5 m bellow the present day surface (Dillehay at al. 2012b, online supplement).

[10] Recent investigation done by Dillehay has added a new period in the history of the site, as a continuity of its uses and the deconstruction of the monument as it was interpreted in modern times, adding here the physical transformation of the site trough excavation to reveals its original meanings and history. The site is also, in modern times a monument under conservation policies.

placed about 3 to 6 m bellow the actual surface of the original marine terrace (Sangamon terrace). The radiocarbon dating from these deep pre-mound levels yielded results of between ~12,500 and 11,700 BP (~14,200 – 13,300 cal yr BP) (Late Pleistocene). There followed a period during which the site was abandoned between ~10,500 and 9,200 BP (~12,000 and 10,500 cal yr BP) (Dillehay et al. 2012a). The initial time span for Huaca Prieta is contemporary with other sites located along the Peruvian and Chilean coasts during the late Pleistocene. It is earlier than sites in the Andean foothills between 25 and 50 km of Huaca Prieta (Dillehay et al. 2012a). This earlier period had some stone flake artifacts ("unifacial edge-trimmed"), mollusks, crabs, sharks and some other fragments of faunal remains (sea lions, deer, and birds) found among thin lenses of charcoal and ashes. No bifacial artifacts were found associated with the pre-mound or the mound occupation (Dillehay et al. 2012a).

A pre-mound (*Phase I*) period dated to between ~7,900 BP and ~6,600 BP (~9,000-7,500 cal BP) during the early to middle Holocene (Dillehay et al. 2012b) is associated with maritime foragers and incipient horticulturalists (op. cit.). This period is followed by the mound building constructive phases (*Phase II* to *IV*)[11] (~7,572 to 4,107 cal BP) which lasted over 3,000, from about 6,650 to 3,600 BP (~7,572 to 4,107 cal BP), and from ~3,600 BP to 3,000 BP (4,107 to 3,455 cal BP) (*Phase V*), which marks the end of the Preceramic phase (Dillehay et al. 2012b). As Dillehay (et al. 2012b) points out, since the beginning (*Phase II*), the mound structures were the result of intentional and planned action since. They were not the result of a gradual accumulation during the

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[11] *Phase II* dates between ~7,572 – 6,538 cal BP; *Phase III* is between ~6,538 – 5,308 cal BP; *Phase IV* is between ~5,308 – 4,107 cal BP; *Phase V* is between ~4,107 and 3,455 cal BP (Dillehay et al. 2012b: 63-65)

period of the site's use. Some of the mound structures include small "pit-houses", retaining walls, and later, a sunken plaza (Bird et al. 1985; Dillehay et al. 2012b, online supplement).

Textile manufacture was elaborate with the use of varied techniques such as weaving, twining, looping, and knotting (Bird et al. 1985). Fishnets of different sizes were also found, as along with bottle gourd fruits, which were used as fishnet floats. Such artifacts formed the majority of the netted implements recovered at the site, which reveals the importance of fishing in daily life (Bird et al. 1985). Fishhooks, by comparison, were rare and only three pieces were identified, one shell fragment, whose classification as a fishhook is questionable, and two hooks of thorn[12] (Bird et al. 1985). Also recovered at Bird's excavation were sandals, a thorn needle with cotton yarn, wooden artifacts, bone artifacts (no point was found), and ornaments made from shells, gourds, and coral.

A Comparative View

During the early-middle Holocene the process of sedentariness and cultural complexity followed different lines along the north-central coast of the Peruvian desert and along the north coast of the Atacama. In the Peruvian case, fish abundance combined with agricultural zones in the river deltas lead to a complex material culture and ideological culture that assumed monumental proportions through time. This can be seem at Huaca Prieta (Dillehay et al. 2012b). It is a process in which landscape was incorporated and transformed through social and economic activity, integration and disintegration, often in tandem with conflictive territoriality. In the Atacama, by

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[12] On page 224 (Bird et al. 1985), the photo of a shell fragment classified as a fishhook is questionable. Also, the two thorn fishhooks are morphologically different from the samples from Camarones 14 site.

comparison, these processes also embraced maritime specialization and mummification of human bodies.

[13]. For the Chinchorro, mortuary rituals and mummification practices created a spiritual bond between living people, their ancestors, and their deities (Arriaza and Standen 2002). Mummification might have guaranteed cultural continuity and group cohesion, reinforcing self-identity and perpetuating collective memory (Santoro et al. 2005). Cemeteries were integrated into the landscape instead of being detached from it through monumental constructions, as occurred in the north-central coast of Peru[14]. Thus, for the Chinchorro, their belief system was manifested through the mummification of human bodies rather than architectural monumentality.

In the case of Camarones 14, from about 7,600 to 7,000 BP, groups circulated through the landscape in a pattern of seasonality that brought them back to the site. During such periods of "soft-territorialty" (senso Schiappacasse and Niemeyer 1984) cultural memories were constructed and solidified. The resource-rich coastline and tidal flats, the rivers and streams, the sources of food and raw materials, the hunting grounds, neighboring territories, and external contacts, all these were mapped and kept alive in the cultural memory of the group. Animal remains from the highlands found at Camarones 14 attest to these connections. About 7,000 BP, it is possible that a change occurred to year-around occupation of the site. If this was the case, sedentism and mummification were parallel developments at Camarones 14. For it is to this period that the first

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[14] Other examples in which cemeteries are landscape markers are the shell mounds in Brazil (4,000 to 2,000 BP) (Gaspar et al. 2008) and in less scale, the Formative period tombs (2,500 to 1,700 BP) in the Azapa valley (Núñez and Santoro 2011: 510).

mummies were dated (Schiappacasse and Niemeyer 1984). Most likely, at this point, mummification and burial strenghted territoriality.

In the pre-Chinchorro site at Acha-3, burials were placed in the periphery of the settlement (Standen and Santoro 2004). At Camarones 14, by contrast, the Chinchorro interred their ancestors under the house, a pattern also found at other Chinchorro coastal sites (Rivera 1991 quoting Zlatar 1983). Cemeteries were later transferred outside to the nearby slopes, as at Camarones 15 D (Rivera and Aufderheide 1998) and Morro 1 (Standen 2003) sites to a public space represented by a transposed landscape. By doing so, the external landscape was symbolically transformed into a sacred space through its use as a shared cemetery. Such cemeteries created a kind of a sacred form of sedentism (Dillehay s/d, In Press); they have to be understood as more then just territorial markers. In the case of the Chinchorro, cemeteries were places of return, both physically for mummified bodies, and in a spiritual and religious sense for the community. This connection brought people back to the site repeatedly, thereby reinforcing a sedentary or semi-sedentary life style in the region[15]. Thus, environmental and physical factors were not the only forces that had the potential to drive people to adopt a sedentary life style. Belief systems and the creation of sacred spaces can be just as important. For the Chinchorro, this identification with place was reinforced by mummies left behind buried under the houses.

At Huaca Prieta the meaning attached to the site followed a different path. The monumentally constructed environment increased detachement from the natural landscape. By the end of the period of the site's construction, an open sunken plaza suggests the intensification or initiation of public rituals (Dillehay et al. 2012b). Also, the

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[15] In this sense, the cemetery is not necessarily an indication of sedentism, but a driving force to bring people back.

organized effort that went into the constructions, including a mobilized labor force suggests a divergence from the Chinchorro pattern of a more private involvement with the local comunity. By contrast, almost from the start, the Huaca Prieta site took a more centralized and public approach. Huaca Prieta was constructed to be detached from the landscape and to be seem by the people from a distance. The Chinchorro cemeteries, in opposite, were integrated in to the landscape, not detached from it. They were small and burials were horizontally distributed and more in a vertical succession, although they were densely occupied (Arriaza 1995).

Conclusions

On the Andean coast, the richness of marine resources played a pivotal role in creating the basis of sedentary societies of considerable social complexity as postulated by the "Maritime Foundations of the Andean Civilization" hypothesis (Moseley 1975). It argues that the richness of the marine environment along the Central Andean coast had the potential to sustain sedentary communities. This in turn, lead to population growth and the development of social complexity as manifested by the monumental architecture of the period between 5,000 and 4,000 BP (3,000 and 2,000 a. C.).

This process, however, started much earlier than Moseley predicted. Human groups were already established along the desert seashores of the central Andes as early as 12,500-10,000 BP; they exploited maritime resources and there is evidence for the early adoption of cultigens (Stothert et al. 2003; Dillehay et al. 2012; Lavallée et. al 2012). The high productivity of the maritime environment leveraged by the upwelling currents, attracted early forager-hunter-gatherers to the coast. They also exploited the adjacent landscapes, possibly in a more seasonal pattern. The archaeological evidence shows that the groups who occupied these sites developed an economic and technological system focused on the exploitation of marine resources. This can be seen in the early introduction of fishhooks (e.g. Acha 2, Tiliviche, Quebrada de Los Burros), which expanded the range of fish caught. The manufacture of nets to harvest schooling fishes like anchovy and sardines, further extended their subsistence options. This advance, which took place around 5,000 BP, was based on the use of cotton in the manufacture of fishing nets and by the use of gourds as floats.

There are some earlier sites along the coast dated between 12,500 to 8,500 BP that also show signs of a diversified economy in which forager hunter-gatherer were exploiting many aspects of the surrounding environment (Dillehay 2004, 2008). Besides marine resources, they drew upon a diverse set of plants and animals from the lomas and surrounding areas (Lavallée et al 2012). They also made sporadically distant journeys to the highlands to obtain obsidian and some other resources (e.g. Quebrada Jaguay) (Sandweiss 2008).

During the same period, inland groups were circulating through the landscape more intensively, developing a more seasonal and generalized economy. Hunter-gatherers associated with Paiján sites (11,000 to 8,500 BP), for example, connected the coast and the interior slopes in a vast area of North and Central Peru, taking advantage of the seasonal cycles of nature. At the end of the period mobility decreased with groups aggregating between the coast and the highlands (Dillehay 2004, 2008). A pattern of semi-sedentism is also found to sites in northern Chile, for example, at the Acha sites located between the littoral (about 7 km, today) and the inland valleys (Rodríguez and Ovalle 2001; Standen and Santoro 2004). Additional permanent or semi-permanet sites as for example the sites came later, such as those at Las Vegas (Stother 1985) in Ecuador, La Paloma (Benfer 1990) in northern Peru, and further south, at the Quebrada de Los Burros site (Lavallée 2012).

There were adaptive differences between the north and the south-central coast of the Andes. Along the northern coast the numerous rivers that cut through the desert coastal plains created microclimates that stimulated a more diversified economy and it promoted patterns of seasonal mobility for exploitation of the inland areas. This led to the establishment of gardens and the use of domesticated plants that supplemented coastal resources. In these conditions, more stable settlements as Huaca Prieta, Las Vegas and La Paloma sites start to appear. Contacts between neighboring communities was also more intense.

Conditions along the south-central coast, by contrast, were very different. Extending from southern Peru to the northern portion of the Atacama coast, the region has poor river drainage; the coastal plains are narrow or totally absent. The result is less environmental diversity. Settlements are possible only a few river deltas with more permanent water supply. Unlike the seasonal mobility of the Paiján hunter-gatherer that spread to wide areas of north and central Peru, the seasonal mobility or transhumance of early hunter-gatherer along the north coast of Chile was restricted to inland oases located at mid distance between the coast and the highlands (e.g. Tiliviche site) (Núñez 2000). In this way, transhumance was more oriented to the verticality of the displacements between the coast and the inland oases, although horizontal connections to other points along the coast were also possible (Santoro et al. 2011).

In the case of the central Andean coast, early groups developed an economy focused on marine resources and with a certain degree of mobility (Quebrada Jaquay, Quebrada Tacahuay, Ring site). Later, about 9,000-8,000 years ago, a specialized maritime tool kit, such as fishhooks, was developed (e.g. Acha 2, Tiliviche, Camarones 14, Quebrada de Los Burros).

Within this scenario, Huaca Prieta located along the northern coast of Peru and the Chinchorro in the northern coast of Chile represent two very different societies from the early/middle-Holocene, a period of intense social and cultural change in the Central Andes (Dillehay et al. 2004). This period was marked by economic and cultural diversity. Regional societies became more diversified, mainly between 8,000 to 6,000 BP (Rivera and Rohhammer 1991; Dillehay et al. 2004). This process in early cultural complexity manifests itself in economic and social systems, ideology and in technology. It was also a period of population expansion (Muscio 2001; Marquet et al. 2012) and differentiation in which self-identity became more visible, as seen in the uniqueness of the Chinchorro mummies (Arriaza 1995) and the elaborate burial rituals at the Las Vegas and La Paloma sites. As Stothert (2003) observes, burial ceremonialism suggests an increase in "community social activities". This intensification is also indicated by the constructive phases of Huaca Prieta and by the strong belief system the elaborate textiles found at the site portray. All these factors point to an emergent social intensification and economic complexity of the period in which Huaca Prieta and the Chinchorro sites were immerse (Stothert et al. 2003; Rivera and Rohhammer 1991; Dillehay et al. 2004).

A sedentary life style transformed the social structure of hunter-gatherer groups (Hitchcock 1987). As Hitchcock points out, some of these alterations included changes from a band to a family system, possibly with a reduction in community's size. Labor activities demanded more time with periods of intense activity as during the harvest period. Cooperative labor and occupational specialization increased. Skills became significant and an important factor for defining a group's social division, linking the rise of specialists with "the rising complexity of activities in sedentary" contexts (Hitchcock 1987: 395).

At Huaca Prieta, besides a diversified economy and the early introduction of cultigens, this is highlighted by the site's monumentality and specialized construction skills, as well as by the elaborate and intricate textile techniques (Bird et a. 1985; Dillehay 2012b) in which specialization and labor skills were required. Huaca Prieta was part of a large complex of sites. In this case, social aggregation is suggested, possibly with the attraction of outlying groups to the site in certain periods of the year.

At Camarones 14, maritime specialization was the key to the Chinchorro culture. It was embed in its technology, economy and belief system. The Chinchorro sites show a highly successfully adaptation to a challenging coastal environment. Artificial mummification denotes a high grade of specialization that underscores Chinchorro cultural complexity. Even so, despite the highly elaborated mortuary patterns, there are no strong indications of social stratification in the wake of Chinchorro social complexity among the Chinchorro (Arriaza et al. 2005). Yet, the link between complex activities and sedentariness (Hitchcock 1987) may still apply to Camarones 14. As suggested by this research, the beginning of artificial mummification about 7,000 BP preceded a period of semi-sedentism.

Huaca Prieta as a huge constructed mound with a diversified economy, and Camarones 14 as a specialized maritime economy marked by mummification patterns, followed different paths to cultural complexity. Along the Peruvian north coast of the

Central Andes, this was later leveraged by the sites monumentality (from 4,500 and 3,800 BP), which was supported by a maritime economy and the integration of industrial crops, mainly cotton and squash (Moseley 1975; 1992). Both sites express the great cultural diversification of the cultural systems that developed between 8,000 and 4,500 BP, a period in which sedentism and seasonal mobility were important elements in these early developments.

CHAPTER VII

FINAL CONSIDERATIONS

During the early to middle Holocene, the intense exploitation of a changing marine environment contributed to the adaptation of sedentism and an increase in social complexity (e.g., Moseley 1975, 1988; Yesner 1980; Rowley-Conway 2001; Erlandson and Jones 2002; Arnold 2004). For the central Andes, Moseley's Maritime Hypothesis considers the richness of marine resources, especially anchovy shoals, to be the key element that promoted sedentism and social complexity on the north coast of Peru (Moseley 1975, 1992). In its analysis of the emergence of sedentism and early cultural complexity among hunter-gatherers societies, this dissertation is partially grounded in the Maritime Hypothesis. It is focused on the earlier maritime societies that once lived in the circumscribed environments of river deltas in the arid central-north of the Pacific coast during the early to middle Holocene (~8,000 to 2,500 BP). It investigates whether similar environmental conditions found further south in northern Chile, had the same impact as at Huaca Prieta. Did they lead early maritime foragers to live in permanent settlements on the coast of the Atacama Desert? And if so, how did these conditions structure cultural complexity in the way it was developed there by the Chinchorro society? Also investigated is the Huaca Prieta mound on the north coast of Peru, which presents a different grade of complexity. Results from both studies are briefly compared as they contribute to understanding the differences in the emergency of complexity along the north and the central Andean coast.

In its study of seasonal resource exploitation and mobility patterns, this thesis takes a paleoecological approach. The main focus is the interplay between seasonality and sedentism. The working hypothesis states that during the middle Holocene, sedentism in selected small, circumscribed river deltas fostered cultural complexity. This was stimulated by the need to manage subsistence resources year-round, and to develop an advanced maritime technology.

At Camarones 14 (Schiappacasse and Niemeyer 1989) and Camarones Sur, sites (Rivera 1984) related to Chinchorro forager hunter-gatherers from northern Chile were subjected to seasonality studies carried out on marine shells. Also investigated were marine clams from Huaca Prieta, a ceremonial mound in northern Peru associated with Preceramic horticulturalists and marine foragers (Bird et al. 1985; Dillehay at al 2012). At the two Chilean sites, the studies were carried out on shells from the gastropod *Concholepas concholepas*; for Huaca Prieta the analysis was performed on shells from the bivalve *Semele* sp. This chapter summarizes the results of this research; it highlights some of the problems found in its execution and makes suggestions for future research.

For all species, shell growth line studies were performed. For *Concholepas concholepas* from the Camarones 14 site, oxygen isotopic analyses was also applied. The analysis of shell growth patterns focused on the distribution of the internal growth lines or growth bands seen in cross-cut sections of the shells. In modern shells, internal growth bands present certain patterns, possibly related to the seasons of the year. The periodicity of growth band formation has being applied to estimate the season of in which the shells were harvested at archaeological sites (Jones 1980; Claassen 1986; 1998; Quitmyer et al. 1997; Andrus 2012; Clark 1979; Quitmyer and Jones 2012). Thus, morphological data and statistic analyses were applied to look for these seasonal patterns (Quitmyer et al. 1997; Quitmyer and Jones 2012). The seasonal markers observed in the shells of *Semele* sp. were white (opaque) and dark (translucent) bands. In *Concholepas concholepas* they were defined by the angle of the growth lines and the space between those lines closest to the tip of the shell. These patterns were then used to study archaeological shells from all three sites, in order to check the seasonality of shell harvesting and, indirectly, to access the period in which the sites were occupied. The study of the direction of the angle formation of the growth lines as seasonal markers in shells of *Concholepas concholepas* is a new methodological approach developed in this thesis.

For the Camarones 14 site, plant remains were tentativelly included to supplemment data from shells regarding seasonality. Data from plants indicated site activity during summer, fall (early fall), and winter[1]. Some plants, like *Scirpus* or *Typha*, can be available and harvested all year. Although seeds indicate the harvesting time, they can also be stored. The presence of other types of remains (e.g., stems) does not necessarily indicate the season in which they were collected[2]. For this reason, shell data was considered the key factor for the interpreting of the results. These are summarized below for each site.

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[1] There is no seasonal marker for spring. Although flowers of Compositae were found, it is not possible to identify the genera or species, to confirm blooming period.

[2] For example, although *Scirpus*' seeds have a marked seasonal cycle (late summer and early fall), this plant is available during the entire year. However, stem fragments, a non seasonal marker was also found. Based on the seeds it is possible to infer, in part, when foragers collected *Scirpus*, but they could be collected in other seasons, too.

Camarones 14 Site

Based on the data from the shell analysis, the initial occupation of the site (Early Chinchorro Period) around 7,700 BP was possibly seasonal, mainly during the spring and/or summer, and/or maybe even winter. For the same period, the plant remains point to the summer, early fall, and winter, including the fall season that was not register for the shells from this early period. Plants, however, are not a reliable indicator of seasonality, although it offers a certain base for the analysis (Scarry and Hollenbach 2012). The base of the excavation, which represents the initial occupation of the site, had semi-circular holes, maybe postholes; one of them was framed by stones. This is indicative of a light type of structure, possible a residential one (see figure 3.8 in Chapter 3). Schiappacasse and Niemeyer (1984) also found evidence of a hut structure at the base of the site. Although this suggests of a certain period of permanence in the site, it does not necessarily indicate of a permanent occupation.

At the end of the early Chinchorro Period, a change in this pattern is observed and sedentism is possible around 7,000 BP. At this time, plant remains reinforce the possible occupation of the site for summer, early fall, and winter. However, very thin successive sheets of ashes and brown sand with organic material constitute the stratigraphy for the respective layer suggesting its intermittent use. Additional work is needed to evaluate this data.

After 7,000 BP, the site was abandoned at some point for about 400 years. This is marked by a sterile layer of compact sediment that practically sealed the layers below[3]. About 6,600 BP (Middle Chinchorro Period), forager hunter-gatherers returned to the

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[3] Parts of it, however, were cut by later antropogenic activities (see stratigraphy in Chapter 3).

area possibly on a seasonal basis. The macro-botanical data indicates summer, early fall, and winter, for this period. However, there are no shells from this specific period that mark the reoccupation of the site. The seasonality of the site's occupation at this time is suggested by the stratigraphy of the correspondent layer (layer 12), which is characterized by the superposition of thin sheets of soft sand sediment with organic material intercalated by hard sand conglomerate maybe indicative of successive moments of site abandonment and reoccupation. However, no strong assumption can be made at this point. This period has about a 100-year time span. This fine chronology is based on the radiocarbon date for this layer at 6,641 ± 49 (AA85506 4) and a sample from the bottom of the subsequent layer (layer 11) dated for 6,522 ± 54 (AA85507 5).

After that, from about 6,500 to 6,000 BP, shells were possibly harvested during all seasons, which could mean year-round occupation. This is reinforced by the macro-botanical data that points to plants exploitation during the summer, early fall, and winter seasons. This layer is composed of loose sediment mixed with organic material.

After this period, no radiocarbon dates are available; however, shell analysis from the subsequent layer shows a return to a seasonal pattern of exploitation. Macro-botanical remains corroborate this evidence. Seasonal occupation is also registered for the last occupational period, the Terminal Chinchorro.

In general terms, the periods related to seasonality of the site's occupation are marked by a lack of shells from the fall period[4]. Shells from the fall season are only found, when sedentism is possible otherwise they are absent. The implication of these results is that sedentism is possibly coincident with the first occurrence of artificial mummification dated to ~7,000 BP, as registered for Camarones 14 (Schiappacasse and

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[4] As already noted, the indication from macro-plant remains is for early fall only.

Niemeyer 1984; Arriaza 2008). Hence, residential sedentism could be one of the background factors in the beginnings of the long-term Chinchorro's funerary tradition, as proposed by Arriaza (1995).

The analysis of the initial occupation of the site during the early Chinchorro Period indicates of a seasonal occupation, mainly during the summer, spring, and maybe winter. This corroborates the "soft-territoriality" model proposed by Schiappacasse and Niemeyer (1984). In this model, the territory was exploited by short incursions to other ecological areas in search for resources and/or to establish or reinforce social networks. Some resources, although available during the entire year, are more abundant in certain seasons, as for example, the river shrimp that are found in larger numbers at the river mouth from about December to March/April, for reproduction. They migrate up stream during the fall. It is also in winter that resources from *lomas* are available. Evidence of these resources was found in Camarones 14. Thus, the soft-territoriality would be partly, based on a seasonal pattern of exploitation with the displacement of the group or part of it to other areas to establish short-term camps during fall/winter. In this fashion, they could exploit additional resources and contact further groups inland, as for example, at the Tiliviche site situated 40 km from the coast of Pisagua (Núñez and Hall 1982; Núñez 1983). Movement along the coastline was also possible between 8,000 to 7,000 BP, a period (Santoro et al. 2012) that corresponds in part to the early occupation of Camarones 14.

Camarones Sur

For Camarones Sur, sedentism is indicated for ~3,000 BP, during the Terminal Chinchorro Period as represented by the contact between the Chinchorro and horticulturalist societies (Regional Development Alto Ramirez period). However, this should be viewed with caution given the small number of shells for this period (five shells). Consequently, no strong conclusion can be drawn at this point.

For the late periods, which are representative of post-Chinchorro occupations, the analysis shows a seasonal use of the site during spring/summer for about 1,000 BP and winter/summer for around 600 BP (Late Regional Development). Results for the burial area of Camarones Sur, which is possibly associated with the Late Regional Development Period, indicates at least the possibility of a semi-permanent occupation during the spring, summer and winter seasons, and maybe fall. However, since soil was removed and then replaced for burial purposes, shells from different contexts could have been mixed together. Because of that, whether the results indicate sedentism for the late periods remains in question. For this site, as already noted for Camarones 14, seasonality is marked by a lack of shells from the fall season. By contrast, summer is the most recurrent season, indicating the site's constant use, often combined with the spring and/or winter.

Overexploitation

It is possible that prehistoric societies living permanently in circumscribed areas had to manage local resources carefully to avoid overexploitation and the need to change locations in search of new resources in other areas. To test the overexploitation hypothesis, an examination was performed on shells of *Concholepas concholepas* from Camarones 14 and Camarones Sur.

The Camarones 14 data shows a slight trend towards an increase in the size of the shells collected through time. This is the opposite expected for overexploitation. Hence, in this case, no overexploitation is indicated. Likewise, data from Camarones Sur does not point to overexploitation. There is no data to suggest that the mollusk banks of *Concholepas concholepas* were exhaustively exploited. In conclusion, although this study was based on a single species, there is no indication of resource stress that could have led local human population to move outside of the area.

Considerations about the Transhumance and Soft Territoriality Models

The transhumance model applied to Camarones 14 during the Early Chinchorro Period shows a coast/inland movement different from what might be expected. In the transhumance movement, as applied to the northern Chile area, hunter-gatherer populations would be exploiting the inland oasis during the spring/summer season and the littoral during the fall/winter (Nuñez 1983). However, shell and plant analysis suggests that the Chinchorro occupied the coastal area during the spring/summer and possibly the winter and were not inside the valley.

In the soft territoriality model (Schiappacasse and Niemeyer 1984), groups of foragers move from one point to another, exploiting different areas of the valley and returning to the Camarones River delta, where the site of Camarones 14 is located. During these incursions, to inland areas they acquired raw materials for artifacts, food, and exchange items. In the process, they established or reinforced social networks with inland populations. The results found here are in line with the soft territoriality model. In addition, Santoro and collaborators (2012) point out that movement along the coast was possible between 8,000 to 7,000 BP, due to low sea levels. With a lower sea level, the present-day narrow marine platform and other spaces would be exposed, opening a coastal route to nearby delta valleys (Santoro et al. 2012). Thus, during that time, this track was feasible, unlike the present-day situation in which high coastal cliffs block the passage from one valley to another following a littoral route. Lautaro and Santoro (2011) note that the early maritime societies located between Arica and Pisaguas were articulated with each other. However, Chinchorro sites are found in the Camiña delta valley (Pisaguas) in the south, but not in the Vitor Valley in the north, even though a perennial fresh water source is available there. As Santoro and collaborators (2012) observe, a location-bias in the research conducted so far may explain the lack of sites in the Vitor Valley. If this is correct, the movement of people during the early periods of Camarones 14 could be both along the coast and/or towards the interior valley.

Huaca Prieta Mound

The shell analysis of *Semele* sp. did not suggest continuity in the use of the shells at the Huaca Prieta site. The site may have been permanent as a constructed structure, but not used continuously, what reinforces its ceremonial aspect. Seasonality is indicated by the absence of shells from summer for all phases of site-use analyzed. Shells were collected mainly during fall, winter, and possibly middle spring, a period in which the clams are not at their height of the reproductive phase (fall to winter). The shells were found in direct association with human burials or in empty chamber tombs; so there is a direct link to funerary rituals. They could also be associated with rituals with a seasonal cycle. Although shells of Semele are not as fragile as some other bivalves, like *Mesodesma donacium*, all the analyzed shells were broken. This could result from opening the shells and removing the mollusk, by people walking in those areas, or from trampling during rituals (Dillehay, personal communication, 2014). Another possibility is that shells were deliberately broken for some unknown reason, related to rituals or for construction purposes, such as a fill in building walls and other structures. However, if the shells were used in construction, they would be found aggregated within the walls and, as already mentioned, they came from human entombment and not from building contexts.

Comparisons between Camarones 14 and the Huaca Prieta Site

In general terms, the physical settings of both sites are similar. They are characterized as circumscribed environments surrounded by desert dunes in the delta of the rivers. However, unlike the mouth of the Camarones River near Camarones 14, the Chicama river delta close to Huaca Prieta with extensive wetlands was more suited to agriculture and supported early agriculture developments (Dillehay et al. 2012b). Both sites represent by specialized coastal economies, and in both cases, there is an association between maritime resource abundance, sedentism and early cultural complexity.

Regarding the Chinchorro, this research demonstrates a gradual change from seasonal occupation or soft territoriality (Schiappacasse and Niemeyer 1984) to possible sedentism about 7,000 years ago. At Camarones 14 this appears to be connected to the development of early artificial mummification. Another period of possible sedentism was between 6,500 and 6,000 BP, perhaps followed by a return to a seasonal mobility.

Unlike the Chicama River delta, the Camarones delta, incrusted between high mountain cliffs, is inappropriate for agriculture mainly due to the high salinity of the soil. Although maize was found at Camarones 14, as well as at Camarones Sur, it was probably related to later periods of post-Chinchorro occupations and came from cultures further inland.

The Chinchorro did not develop the monumentality or social complexity found at Huaca Prieta (Arriaza 2005; Dillehay et al. 2012b). Chinchorro cultural complexity is revealed by the artificial mummification of human bodies, which requires specialized knowledge of human anatomy (Arriaza 2003; Arriaza et al. 2005; Arriaza et al. 2008).

Huaca Prieta followed a different pattern from the one showed by the Chinchorro sites. The mound is constructed in an open space near the river delta, an area rich in marine and wetland resources but also with agricultural potential. Sedentism there is marked by the site's monumentality and its ceremonial structures, which indicate social complexity, and by the introduction of agricultural elements (Bird et al. 1985; Dillehay at al 2012). The analyses of the shells performed here, however, did not demonstrate a year-round use of the site. Instead, it is suggested a seasonal pattern based on shell harvesting. As already discussed, this apparent dichotomy in *Semele* harvesting is probably related to a complex of events that took place at the site, events not related to periods of occupation at neighboring sites but to ceremonies. This, in fact, reinforces the ceremonial aspect of the site.

Huaca Prieta had permanently constructed structures designed for public ceremonial activities. Camarones 14 had a more ephemeral structure, designed as residential and private space, and related perhaps to family lineages. Sacred spaces shared the residential structure in the sense that human remains were buried under the residential floor, as seem in the earlier occupation of Camarones 14 (Schiappacasse and Niemeyer 1984). It was some time later that the Chinchorro cemeteries were formally arranged on the nearby slopes close to the ocean with a horizontal distribution (Standen 2003, Arriaza et al. 2005). At this time around 5,500-4,000 BP cemeteries are larger (Rivera 1991), they were integrated into the landscape and not intentionally detached from it.

Living in a circumscribed environment surrounded by the arid desert and territorially marked by public cemeteries (*sensu* Rowley-Conwey 2001) horizontally arranged on nearby slopes close to the ocean (Ariaza 1995; Standen 2003; Arriaza et al. 2005), the Chinchorro did not show the verticality of Huaca Prieta mound. It is possible that Chinchorro mobility in its initial period is enlaced by burial sedentism (Dillehay sd_mimeo) with the revisiting of the living to the dead, possible integrated in the seasonal cycle of movement of the soft-territoriality. As a ceremonial site, Huaca Prieta is clearly planned and intentionally structured to be detached from the landscape so it could be seen at a distance, possible not as a territorial marker, but to radiate out religious influence. Both societies, however, show strong signs of cultural identity. For the Chinchorro, this was marked by funerary traditions. At Huaca Prieta, this is seen not only by the ceremonial center, but also by the elaborate textile patterns the culture created (Dillehay personal communication 2012).

Cultural and Social Complexity

Chinchorro society consisted of small groups of marine forager hunter-gatherers arranged in a social equalitarian system. Characterized as a Preceramic fishing society, it had its earlier development in a period that predates agriculture as well as social-political complexity (Arriaza et al 2008). With a long duration of about four thousand years, its emergent complexity is mainly manifested through its ideological system marked by the elaborate mortuary patterns of artificial mummification (Arriaza et al. 2005; Arriaza et al 2008). Although artificial and natural mummification were selectively applied, there is no strong evidence for social inequality (Arriaza et al. 2005). Differences in mummification styles (e.g. black, red, mud-coated) and variations are in general interpreted as cultural variations and the reuse of space over time (Arriaza et al. 2005).

Huaca Prieta's monumentality shows signs of corporative labor, and its emergence as a religious center suggests the realization of public ceremonies and rituals, possibly with the participation of outlying groups. Chinchorro ceremonies, by contrast, seem more focused on social integration; rituals were possibly oriented to family members and lineages, thus reinforcing a sense of belonging. Mummies, for example, were possibly representative of family lineages, and were included in multiple ceremonies. In later times, cemeteries could have functioned as pilgrimage sites, a kind of an attractive force that brought people back and reinforced lineage bounds. In this case, Chinchorro society would perhaps be constituted by kin groups. Chinchorro sedentism is possible around 7,000 BP in connection with the rise of artificial mummification.

As already mentioned, social complexity at the Huaca Prieta site is marked by layered construction phases that imply collaborative labor and the use of the site for rituals and as ceremonial space. Also, human burials at Huaca Prieta associated with offerings suggest social stratification (Bird et al 1985). Complexity was also expressed by the intersection between sedentism, expressed by the site itself, and by seasonality, expressed by the periodical use of the site in certain seasons of the year.

Revisiting the Research Objectives:

1) A relationship between the shell's growth rings and the seasons of the year was observed in modern shells of *Concholepas concholepas*.
2) Those patterns were applied to shells from the sites of Camarones 14 and Camarones Sur and the results allowed us to assess the seasonality of shells harvest and to infer periods of site occupation during the Middle Holocene.
3) A relationship between the shell's growth rings and the seasons of the year was observed in modern shells of *Semele* sp.
4) Those patterns were applied to shells from the site of Huaca Prieta and the results allowed an assessment of the seasonality of shell harvest and to infer periods of the use of the site during the Middle Holocene.
5) The results give a better understanding of the mobility patterns of the societies investigated here and their intersections with early cultural complexity.

The basic question whether the Chinchorro culture was sedentary and to what extent sedentism fostered cultural complexity was answered for the Camarones 14 and Camarones Sur sites. Periods of soft-territoriality were interchangeable with periods of more stable occupation, maybe year-round. Early mummification from the site of

Camarones 14, ~7,000 BP, is perhaps connected with a period of prolonged occupation, suggesting a possible connection between early cultural complexity and sedentism. Also, the comparison between the Chinchorro society and the ceremonial site of Huaca Prieta highlights the intersection and difference between cultural complexity and mobility patterns.

Problems, Achievements, and Suggestions for Future Research

The oxygen isotopic analysis on shells of *Concholepas concholepas* brought unreliable results. This confirms Labonne and Hilaire-Marcel's (2000) finding that archaeological shells of this species do not serve as a good paleoenvironmental proxy. Although the modern sample used to check the shell's potential for seasonal analyses seemed promising, seasonal data from shell profiles from the archaeological samples generated ambivalent results. In the case of archaeological samples, in which mollusk banks were close from the river deltas, the increase of water discharge from the rivers during the summer months maybe impacts the results, mainly due increase in water turbidity, changes in water temperature and salinity. This suggests that further studies are needed regarding the use of isotopic analysis to access seasonality on *Concholepas concholepas* (Falabella et al. 1991; Gúzman et al. 2004; Lazareth et. al. 2005; Gúzman et al. 2007).

As mention, *Concholepas concholepas* is one of the most recurrent species found at archaeological sites in northern Chile (Billings 2001). Therefore, the search for a morphological pattern that can be used as seasonal marker would be especially helpful for future research. The analysis performed here was experimental. It attempted to discover the seasons in which the shells were collected so as to understand the dynamic of the occupation and exploitation of the area by early hunter-gatherer foragers. In this sense, this thesis has identified some possible seasonal markers and explored other potential ones. An example is the morphology of the edge of the shell as seen in a cross-section (the shape of the shell's tip), a result of the external ornamentation of the shell that was briefly introduced in this thesis (see Chapter 4). This included a typology correlating the stages of the tip's formation with the seasons of the year.

An analysis based on the angle formation of internal growth lines was developed and successfully applied in the samples studied in this thesis. However, as it is a new approach, it needs to be tested with more samples and then compared to other seasonal indicators. In this way, its potential can be fully checked. Growth-line analysis is a simple methodology that does not require any expensive equipment. Although the sample preparation can be time-consuming, depending on the volume of the material, the analysis is not complex. Conversely, the observation of the angles can be challenging if the lines are not well marked and visible at the internal surface of the shell. Even in well-polished samples, lines can be blurred making it difficult to observe changes in angle direction. This author carried out all the analysis of the shell growth lines of *Concholepas concholepas* personally. A review by a second trained researcher as a blind test to confirm the results from each shell is preferable. Despite that, the methodology is simple.

The analysis of *Semele* shells, although requiring some preparation of the samples, is straightforward and bands are in general well marked on the internal surface of the prepared area. This material can be compared in the future with the results of oxygen isotopic analyses performed by Dillehay's research group. Also, future research with

Semele shells at Huaca Prieta needs to address broken shells and study the morphology of the fragments to verify if there is a pattern in how they were broken. Another possibility is to develop an experimental study with people walking over in an area covered with these shells. By comparing the type of fractures left, it might help establish if shells at the site were unintentionally broken. Fragmented shells could also be used as evidence for the long term use of the site. In this case, the degree of fragmentation could be tentatively used as an indirect indicator of long term occupation.

This thesis made pollen and botanical data available for the Camarones valley. In this way, it contributes to the paleoclimate record of the region that was lacking for the Atacama coast (Sandweiss 2003; Arriaza 2008).

In its broadest aspect this thesis evaluated a new way to study seasonality by using *Concholepas concholepas*, a gastropod abundantly present at Holocene sites. The approach used here shows its potential as a seasonal indicator, although it needs more testing. This is because oxygen isotopic analysis could not be used to check the results of the visual analysis of the angles of the growth lines.

Final Considerations

This research confirmed and reinforced the differences between the north coast of Peru and the north coast of Chile regarding seasonality and early complexity. This research had shown that the occupation at Camarones 14 and Camarones Sur by maritime hunter-gatherer was a dynamic process. As discussed earlier, periods in which sedentism was possible were intercalated by periods of a seasonal pattern in site occupation, as follow:

1) The initial occupation of the Camarones 14 site between 7,700-7,000 BP was possible seasonal, mainly during the spring and summer. At the base of the occupation, winter was also possible. This goes in line with the soft-territoriality model proposed by Schiappacasse and Niemeyer (1984). People would be possible travelling to inland or nearby coastal valleys during the fall/winter seasons.

2) Sedentism was possible ~7,000 BP with shells possibly collected during all seasons. After that the site was abandoned or sparsely used for about 400 years.

3) Around 6,600 BP the site was re-activated possible in seasonal basis as suggested by the stratigraphy, but there are no shells for this period and more data is necessary.

4) A change to sedentism maybe occurred between ~6,000 and 6,500 BP with shells possibly collected during all seasons.

5) After 6,000 BP another change in mobility is suggested and seasonal occupation is indicated with lack of data for the fall season. Although seasonal, the site has been activated during the major part of the year (spring, summer and maybe winter).

6) Shells from Camarones Sur site show that around 3,000 BP (end of the Chinchorro period) a shift back to sedentism is possible.

7) After 3,000 BP to about 600 BP, occupation in seasonal basis is indicated by a lack of shells from the fall season in both sites.

Camarones 14 represents the onset of a funerary tradition marked by the mummification of human bodies about 7,000 BP. This early manifestation of cultural complexity is possibly associated with a period of sedentism that maybe had occurred about the same time. The connection between sedentism and cultural complexity for Chinchorro has been suggested by others (Arriaza, 1995; Arriaza and Standen, 2002; Arriaza et al. 2008). Sedentism, however, has yet to be proved (Billings 2001; Rasmussen

1998). This research contributes some hard data that points in this direction but not for both sites via all time. And it adds a new element to the discussion: a dynamic, in which mobility patterns were interchangeable. Groups were moving from sedentism to seasonal mobility and vice-versa over long periods of time. Thus, in response to changing conditions, such as environmental stress or social conflicts, sedentism had a degree of permeability that facilitated people to return to a seasonal pattern of mobility, when this was necessary. Soft-territoriality, the model of circulation through the territory proposed by Schiappacasse and Niemeyer (1984), is reinforced here by the seasonal pattern of mobility observed for certain periods of the occupation of the site. This circulation through the territory probably gave the Chinchorro a deep insight about the landscape and how to move from one point to another, and the periods of the year in which such movement was easiest. This knowledge was not lost. It was part of the Chinchorro's cultural memory, kept alive by the maintenance of the circuit made by small groups of people articulating the contacts with inland areas. The point here is that a return to a seasonal pattern was facilitated by the circulation of the group or part of it that was still active and in the "memory" of the group. This is a strategy that could be triggered in periods of stress, such as scarcity of food, a drought, hostile groups, or a disruptive El Niño. It enables the entire group to move to a different area or to return to a pattern of soft-territoriality. Possible contacts with inland sites such as Tilviliche and Conanoxa are indirect evidence for this living memory and how it was maintained. In the case of Camarones 14, it could have facilitated abandoning the site and then returning to the area about 400 years later. Also, recall that plant species from the inland *lomas* are registered in almost all layers of the Camarones 14 site. This suggests that the circulation of groups through the area was always active. Bone fragments from llama, guanaco and vicuña, which are found in all strata of Camarones 14 site reinforce this evidence[5].

Regarding seasonality, the absence of data from at least one season for the majority of the layers analyzed opens a second window of interpretation. The absence of shells of *Concholepas concholepas* from fall or winter for the period between ~7,700 and around 7,000 BP, suggests that part of the group of maritime hunter-foragers from Camarones 14 traveled to other areas. Although such data needs to be corroborated by other seasonal indicators, this somehow impacted the *Concholepas concholepas* foraging. One possible interpretation is that a majority of the group traveled at that time. During the fall, the river shrimp migrate upstream and the river course still has enough water as well as the spring waters to make the journey inland possible. In this scenario, Tiliviche-1 possibly marked the limit between territories. Hunter-gatherer groups living in the puna or in some other areas may have traveled to this nodal point during the same period to meet with maritime coastal groups for feasting, exchange, and other social network interactions. In this exchange, products from the puna were probably brought to the coast. As mentioned before, the remains of animals from the puna, - vicuña (Vicugna vicugna), guanaco (Lama guanicoe), and vizcacha (Lagidium viscacia) – are associated with the Chinchorro layers at Camarones 14, and attest to contact between both areas (Schiappacasse and Niemeyer 1984). Also, the high number of *Scirpus* remains and at least one seed found in Tiliviche indicate that the site was activated in the fall season. In colonial times, for example, the Tupinamba Indians from Brasil, traveled to the limits of their territory to exchange items with enemy tribes, who did the same, keeping a pact of non-aggression on these occasions (Fernandes 1963). It is possible that a similar system

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[5] Bones data are from Schiappacasse and Niemeyer (1984) excavation.

of an earlier exchange between the coast and the highlands in northern Chile could be starting been developed.

Conclusions

The Maritime Hypothesis (Moseley 1975) posits a maritime economy as central for sedentism and social complexity in the Central Andean area for the period from 4,500-3,000 BP. Although it does not project far back in time, coastal resources was in the basis of early economies of some societies at the central coast. In this case this may apply to the Chinchorro and their coastal technology, especially about 7,000 BP and during the middle period of occupation when sedentism is possible and maybe in connection with artificial mummification. Huaca Prieta, however, is different. With a mixed economy it relied on horticulture products in addition to the marine resources. In this case, the Maritime Hypothesis is not the only explanation for the site's early complexity. The use of the site was maybe seasonally regulated, and rituals would be cyclical and held during fall and winter, that is, during the wet season.

Although following different paths, socio-cultural changes in the northern coast of Peru and northern coast of Chile, as exemplified by Huaca Prieta and Camarones 14 and Camarones Sur sites, were part of a long process of transformation and adaptation observed along the Andean Central coast during the early-middle Holocene. Huaca Prieta's early complexity pre-dates the social cultural complexity represented by monumental architecture that appears from about 7,000 to 4,500 BP (Dillehay et al. 2004). Although Huaca Prieta is in a context of sedentariness, the use of the site may have had had a seasonal component from time to time as suggested by the shell analysis.

Additional markers, along with the complexity of the site itself, suggest it was a place for seasonal activities, such as funerary rituals with a seasonal cycle held mainly during the wet season (fall and winter). Seasonal rituals and sedentism were complementary at Huaca Prieta; it was part of the site's emergent complexity.

At the Chinchorro sites, a transition to year-round occupation was marked by a pattern of soft-territoriality. As proposed by Schiappacasse and Niemeyer (1984), this mobility allowed not only for the maintenance of the territory and its routes but also functioned as a cultural strategy. It created social memory that could be triggered in periods of stress when it was necessary to leave the area. This required cultural knowledge of where water springs were located, or the periods of the year in which certain resources were available (e.g. freshwater shrimps, resource from *lomas*).

Early steps in Chinchorro emergent complexity possibly included the adoption of a sedentary pattern in conjunction with elaborate funerary patterns and artificial mummification. This took place in an environment circumscribed by the delta river valley, the ocean, and the high cliffs of the coastal Cordillera. As suggested by shell analysis, sedentariness in the Camarones Valley was maybe contemporary with the development of mummification techniques. Changes in Chinchorro cultural complexity was the result of an intricate mosaic that included contact with distant places as well as changes in private and public space as burials were moved from residential areas to nearby slopes. Also, different from Huaca Prieta, the Chinchorro did not develop monumental architecture. However, the number of Chinchorro sites rose with time, indicating a population increase and the successful adaptation of their culture and technology to the river valleys of the arid Atacama coast (Santoro et al. 2012).

In sum, as suggests in this research, sedentism and early complexity in circumscribed areas followed different paths as seen at Huaca Prieta and in Camarones 14 and Camarones Sur. In Huaca Prieta, the site had a permanent character as a monumental building structure; the site's possible cyclical use was marked by the dry and wet seasons, as suggested by shell analysis. At Camarones 14 and maybe in Camarones Sur, the interpolation between seasonality and year-round occupation proved to be a significant element in Chinchorro society. In this case, residential flexibility and territoriality, inherited from a period of seasonal mobility, were an integral part of their cultural memory and preserved the dynamic of territorial exploitation. The whole meaning of the occupations during the life span of the sites history and the Chinchorro society can not be entirely recover, however, besides the small portion of site excavation, the results presented here associated with Schiappacasse and Niemeyer (1984) data for the site, seems to well translate the history of the site's occupation, in which mobility and sedentism were interchangeable. The main point here is the dynamic of the process that interconnects seasonality and sedentism in the challenge environment of the desert coast of the Atacama. The same is expected for Huaca Prieta, although only a fraction of the data was studied the results encourage the interpretation and should contribute to sheds light in its ceremonial aspects.

Huaca Prieta and the Chinchorro represent the cultural diversity that characterized the middle Holocene Period. Early complexity at both sites occurred in a period of significant social-cultural changes in Central Andean coastal societies. This is seen in burial patterns, technology, architectural structures, and symbolism (Dillehay et al. 2004). This research has shown that sedentism and seasonality were significant parts of this process. Nonetheless, was a combination of cultural adaptiveness, choices, and practices, in addition to resource richness, that forged the emergence of early complexity.