Fiber Technology from the Caleta Vitor Archaeological Complex, northern Chile

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Declaration

Unless otherwise acknowledged in the text all work contained therein is the original research of the author

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Dedication

To my partner Vaughn, and my parents; Wanda and Duane, you have been an integral source of support before, during and hopefully after this project.

“You need to set your goals a little out of reach, that way, when you get there, you know you’ve done something.” - D.M.
Abstract

The marine subsistence economy of pre-Hispanic inhabitants of northern Chile's hyper-arid coast was based on the rich fishery created by the upwelling effect of the cold Humboldt Current along South America's Pacific coast. Fiber technology, including fishing nets and lines, were integral to subsistence strategies providing the majority of fish represented in middens at the Caleta Vitor archaeological complex. Recent research suggests that the prominent role fiber technology played at the Caleta Vitor complex was not a unique phenomenon, but that plant fiber cultivation and fiber processing technologies were vital to the initial establishment and later administration of the Andean Civilization.

Despite the burgeoning acknowledgment of the importance of fiber technology in both hunter-gatherer subsistence economies and the development of complex societies, fiber artifacts are frequently ignored by archaeologists. Regions with established pottery and stone tool chronologies usually lack even a basic chronology of fiber types or show any understanding of technological developments, especially in early contexts before the introduction of loom weaving. This is only partly due to the vulnerability of fiber artifacts to diagenetic processes in many archaeological contexts, leaving little direct or indirect evidence of a fiber industry to be thoroughly examined. Given the considerable impediments to the study of this essential component of hunter-gatherer subsistence economies, the fiber-rich archaeological deposits on the hyper-arid Chilean north coast present a rare opportunity to study these often-ignored artifacts.
The papers in this dissertation examine the fiber artifact assemblage excavated from the Caleta Vitor archaeological complex of far northern Chile using textile analysis, stable isotope analysis and historical documents. The work presents the first detailed chronology of fiber technologies, a model for camelid fiber procurement and new information on the presence of the Inka State in the region. The results provide a much-needed clarification of the trajectory of material types in this region. The work spans the Middle and Late Archaic Periods, Early and Late Formative Periods and the Late (Inka) Period.
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Chapter 1. Introduction

1.1 Overview

The first settlers arrived on Chile's northern coast by the Late Pleistocene equipped with "a well-established economic regime able to exploit marine resources" (Carter, 2016: 428). Their exploitation strategies depended on composite implements, including hooks, lines, sinkers, lures, points, and chopes (tools used to pry shellfish from rocks). Although the bone, stone and wooden parts of these composite tools have been subject to archaeological examination since Max Uhle (1922, 1974) began serious scientific archaeological investigations in this region, large numbers of fiber components have escaped scrutiny even though they have been well-preserved in the dry, arid conditions. Composite fiber technologies remained in use along the northern coast through to the early historic period whilst more advanced fiber processing and cloth production technologies were introduced to the region during the Formative Period (ca. 3,000 BP). The advanced textile techniques from the Azapa Valley were analyzed by Ulloa (1981a, 1981b, 2008) and Cassman (1997, 2000a and b; Cassman et al. 2008) who identified a local tradition based on a suite of technical and stylistic attributes but as detailed textile studies are rare outside Azapa Valley, the longevity of the tradition in northern Chile is not known.

Without local data on fiber components, several researchers (Rivera 1991, 2008; Cassman et al. 2008; Carter 2016) have filled the gap with data on archaeological fiber processing from northern Peru where extant remains of cotton textiles appear before ceramics. However, there are important differences in the fibers used in the two regions. Gossypium barbadense (cotton) is native to northern Peru/ southern Ecuador and not unexpectedly, this species
significantly impacted the trajectory of the fiber economy in that region, where cotton processing typically predates the advent of pottery, in what is called the “Cotton Preceramic”. Conversely, cotton first appears on the Peruvian south coast by 4150 cal BP, after the preceramic period (Beresford-Jones et al. 2018) making it unlikely to have been used in the Archaic Period in northern Chile as previously suggested. In contrast, several archaeologists (Standen 1997, 2003; Standen and Santoro 2004) have suggested that camelid and vegetal fibers made up the toolkits of the earliest periods of occupation in northern Chile unlike the earliest periods in northern Peru that are characterized by cotton. To date, no quantitative studies have been conducted to test these divergent views or quantify the materials over time.

Previously, camelid fiber excavated from coastal sites was interpreted as a non-local product, obtained through exchange with highlanders or hunting activities up the quebradas, in local marginal hunting areas in the lomas formations or at higher elevations (Rivera 1991, 2008; Núñez and Santoro 2011) but this procurement strategy has never been quantitatively substantiated using stable isotopic analysis. As Thornton et al. have pointed out, outside the highlands, “prehistoric foddering practices and the locations of pasturelands are not well established” (2011). Historically, camelid herding was restricted to high elevations (>3,000 masl) although it is well documented that colonialism significantly disrupted traditional herding activities and it is inappropriate to equate historic with prehistoric practices. While the origin of the material has not been satisfactorily provenanced, some researchers have recognized the early use of camelid fiber on the coast (Standen 1997, 2003; Standen and Santoro 2004) while others have suggested that so-called “woolen (sic) items” were introduced in the Formative Period (Rivera 1991, 2008; Carter
The socio-political ramifications of obtaining this high-value commodity as a part of the subsistence economy for the production of prestige goods and clothing are significant to the region.

Furthermore, there has been limited and contradictory information on vegetal fiber processing in northern Chile, particularly for the Archaic Period when as stated, composite fiber tools were a significant contributor to the subsistence economy as fishing nets and hafting material. Research has focused primarily on the famous Chinchorro (Archaic) mummy shrouds (Cassman 2008) made of processed reeds (*Schoenoplectus* spp.). These items are touted as the most enduring feature of the Chinchorro culture, yet no detailed regional investigations have been conducted into other applications of the same technologies that went into shroud production. For example, the Chinchorro shrouds are twined with twisted or spun and plied cordage, also used for hafting and a cacophony of other items of material culture, including fishing nets, lines, bags and personal adornment, yet vegetal fiber has not been recognized as an essential part of the local subsistence economy.

In northern Chile, the Formative Period is marked by an influx of people, new subsistence behaviors and technologies from the highlands, not only the backstrap loom, pottery, agriculture, and camelid herding but also a suite of new cultural practices. While pottery and weaving appear to be ubiquitous across the region, there is a considerable variation in the adoption of agriculture and herding with many coastal populations retaining their hunter-gatherer subsistence strategies.
This variation in subsistence strategies continued into the Late Period when the Inka expanded into northern Chile during the reign of Topa Inca Yupanqui (ca. 1471–1493). The region came under the administration of Tambo Belen and Tambo Zapahuira in the Arica highlands and maintained a physical connection to the Empire via the extensive Inka Road network (Zori et al. 2017). While sites (Molle Pampa) of the Lluta/Azapa valleys produce Inka style material culture and evidence of intense agricultural, initial investigations of the Late Period collection from Caleta Vitor revealed little evidence of Inka interest in the site with no evidence for intense agriculture, herding or architecture and limited instances of Inka material culture (Carter 2016).

1.2 Location

Geomorphologically, the south-central Andean region is broken into five sub-areas: the coastal cordillera with an average elevation of 1,500 m, the central depression which is between 1,400 and 3,000 m asl, the pre-Cordillera (3,000-450 m asl), the Cordillera, comprising the high Andean peaks, up to 6,000m asl and the Altiplano or Puna, a high-altitude plateau (Rivera 1991, 2008; Santoro et al. 2005; Carter 2016). The coast is hyper-arid and largely unvegetated, with small populations of plants in lomas formations reliant on coastal fogs (known locally as Camanchaca) and limited vegetation in the bases of Quebrada (canyons) supported by runoff from the high Andes, which is often subterranean.

Five of these deeply (>1,000 m) incised canyons reach Chile's far north coast; Lluta, Acha, Vitor, Camarones, and Tana/Tiliviche, carved through the landscape from the high Andes by pyroclastic flows. The canyons make life along the terrestrially barren coastal cordillera
possible by providing access to the otherwise inaccessible coast, typified by cliffs almost a kilometer high. Extreme changes in elevation and variation in precipitation along this incredibly steep elevational gradient cause significant east/west environmental disparity over relatively small geographical distances and a good deal of variation in the availability of natural resources from one sub-area to another (see detailed environmental description including stable isotope ecology in Chapter 8). Caleta Vitor is set at the coastal end of the Quebrada de Vitor; approximately 25km south of the modern city of Arica, just a few kilometers south of Peru's southern-most border.

1.3 Caleta Vitor Archaeological Complex

Arica is Chile's northern-most city, situated at the coastal end of the Azapa Valley - an archaeologically rich and well-studied geological feature, slowly being subsumed by urbanization and modern farming (Rivera 1977). Despite Vitor Bay’s close proximity to Arica, this region had received limited attention prior to Chris Carter’s 2008-2010 landmark excavations. Although the bay is popular with local fishers and host to some modern farming activities, it has experienced far less modern occupation than Azapa with some disturbance from Armada activities (for a detailed history of excavation see Roberts et al. 2013; Carter, 2016; Bland et al. 2017).

Carter divided the Caleta Vitor complex concentrated in the southern portion of the bay into seven zones labeled CV1 through CV7 comprising middens, occupation areas, burials, and rock art. Zones CV1, CV2, CV4, CV6, and CV7 (Trenches CV1/2, CV2/1, CV1/3, CV6/1, CV7/1 and CV4/1) produced fiber artifacts appropriate for this study, covering the Middle and Late
Archaic, Formative Periods and Late Period (Figure 1). There were no fiber artifacts from securely dated Middle Horizon or Late Intermediate layers.

Figure 1. Map of Caleta Vitor showing approximate trench locations within each sector (numbered in red). Drawn: C. Carter (2016).

CV1 is the largest of the seven zones; identified as a preceramic midden and occupation area with several burials. Carter concluded that material culture in this area was Chinchorro in origin, with one reed wrapped burial from CV1/3, an extension buried with the remains of
bird skin and feather embellishments. Radiocarbon dates concur with Carter’s assessment, spanning the Archaic and Early Formative Periods. CV2 had both ceramic and preceramic layers, well-defined stratigraphy and was identified as an occupation area and midden, also containing burials.

Dates from CV2 fall between the Early and Late Formative Periods. This area was profoundly disturbed by military activities and looting and is separated from CV4 by a road on the northern boundary. CV4 is also a midden deposit containing ceramics, seeds, and camelid dung as well as some human burials. CV6 is described as a midden deposit with some preceramic but mostly ceramic layers containing a potential animal enclosure near a rock shelter (See Carter 2016:212). CV7 is the northern-most zone, described as a low-density midden; several burials were also found in this zone and were reburied at the time of excavation (see Carter 2016). Materials from CV7 are dated to the Late Archaic Period.

- Trench CV1/2 was excavated to a depth of 1170 mm into well defined stratigraphy and produced shell, fish and marine mammal bone as well as reed matting.

- Trench CV1/3 was excavated to a depth of 3200 mm, and included human burials, shell, bone, ash and plant materials. The trench displayed evidence of rodent bioturbation (see chapter 5 for further details).

- Trench CV2/1 was also excavated to 3200 mm and produced shell, bone, textiles, lithics, feathers, ceramic, plants and charcoal lenses.

- Trench CV4/1 was excavated 800 mm into a dense midden deposit that contained plant material, reed, camelid dung, shell and bone.
• Trench CV6/1 was excavated to a depth of 1200 mm including post-Colonial materials, dense layers of vegetal, reed matting, maize stalks and cobs as well as ceramics, shell and bone.

• Trench CV7/1 was excavated to a depth of 800 mm through low density midden deposits that contained shell, bone, lithics and fiber items.

For a detailed accounting of materials recovered from these trenches see Carter (2016).

Since Carter’s excavations, Roberts et al.’s (2013) isotopic analysis of human remains from the site showed a heavy reliance on marine resources throughout occupation with limited adoption of domesticates. Swift et al. (2015) have looked at skeletal arsenic in human remains, concluding that contaminated drinking water was likely the cause of arseniasis among inhabitants between c. 3,867 to 474 cal BP. Bland et al. (2017) have completed activated neutron analysis on pottery from 2,000 to 476 cal BP, indicating continuity in clay sourcing for everyday pottery. Data from Caleta Vitor have also been used in a large scale project by Latorre et al. (2017) looking at coastal upwelling across northern Chile, and Disspain et al. (2017) have used fish otoliths from Camarones Punta Norte and Caleta Vitor to track the distribution of fish species over time.

Between 1893 and 1903, more than a century before Carter’s archaeological investigations, Adolfo Bandelier led an expedition on behalf of the American Museum of Natural History (AMNH) to collect materials from Caleta Vitor and other sites in Peru, Chile and Bolivia, for the museum’s collection (for an accounting of these materials see Carter 2016, citing Mead 1946:13). Max Uhle (1919, 1922) and Junius Bird (1943) then began to construct a chronology of the occupation of northern Chile, estimating initial colonization to have

1.4 Project Aims

The impressive collection of fiber artifacts from northern Chile's Caleta Vitor archaeological complex provides a unique opportunity to address gaps in the archaeological record of the site and broader region while drawing attention to the potential for fiber artifacts in answering archaeological questions. The detailed analyses of material composition and morphology as well as the stable light isotope analysis (C and N) of camelid fiber artifacts from securely dated archaeological strata provides new insights into these questions.

The aims of the thesis are five-fold:

1. To establish the fiber processing and cloth production technologies;

2. To identify material types in use at the site;

3. To contextualize the textile style;

4. To establish the influence of external pressures (cultural, political and economic) on the fiber industry and textiles at the site;
5. To test previous theories regarding the procurement of camelid fiber using stable light isotope analysis.

1.5 Organization of the Dissertation

The dissertation is presented in nine chapters, including an introduction, regional background, introductions to fiber technology and isotope analysis in archaeology followed by four published papers and a conclusion. Chapter 2 provides a detailed regional archaeological background and Chapter 3 introduces fiber processing technologies while Chapter 4 introduces the key concepts underpinning stable isotope analysis in archaeology. Chapter 5 presents a detailed study of fiber artifacts, processing and material types from Middle, Late Archaic and Formative Period contexts of Caleta Vitor. Chapter 6 explores the nature of Inka interaction in northern Chile and presents the results of our analysis of fiber artifacts from Late Period deposits at the site. Chapter 7 focuses on the Inka unku recovered from the site. Finally, chapter 8 addresses the question of fiber procurement in the region using stable light isotope signatures. The camelid fiber artifacts from the site are geographically contextualized based on previously established ecological isotopic distribution and camelid dietary niches. Dates provided in this thesis are reported as cal BP, unless otherwise stated. All photographs were taken by the author, unless otherwise stated.
Chapter 2. Regional Background

Investigations of archaeological textiles from northern Chilean coastal sites in the Azapa Valley focus mainly on the famous Chinchorro mummy shrouds (Cassman et al. 2008), tunics, and other wearable textiles from the Formative through the Late Periods (Cassman 1997; Agüero Piwonka 2000a, 2000b; Agüero Piwonka and Cases 2004; Berenguer 2007; Ulloa 2008; Horta Tricallotis 2009) of the Azapa Valley. These studies have established the antiquity and expertise involved with Chinchorro twining techniques and point out their role as ethnic expressions in burials in a shared textile tradition stretching between the Azapa Valley and the Rio Loa beginning in the Formative Period.

2.1 The Archaic Period

Vitor Bay was occupied by the early Holocene by marine hunter-gatherers known as the Chinchorro, famous for the development of sophisticated mummification techniques beginning as early as 7500 BP through to the Formative Period (Bittmann and Munizaga 1976; Arriaza 1995, 2008; Marquet et al. 2012). The Chinchorro developed a somewhat sedentary mobility pattern due to the reliability of marine foodstuffs on which they relied and the inhospitable surrounding Atacama Desert. Isotopic research and archaeological evidence from the immense shell middens characteristic of coastal sites indicate a continued dependency on marine proteins into the Late Period while also indicating a limited number of terrestrial resources were also exploited for food and craft production (Aufderheide et al. 1988; Tieszen and Chapman 1992; Rivera 2008; Santoro et al. 2012, 2017b; Poulson et al. 2013; Roberts et al. 2013; Castro 2014). Both the marine subsistence and craft economy are described as "stable and local"; with inhabitants exploiting the same...
locally available, raw resources for both food and pottery production over an extended time period (Roberts et al. 2013; Carter 2016; Bland et al. 2017).

Chinchorro fiber processing technologies are described as simple, vegetal fiber mats, cotton fishing lines and nets as well as camelid fiber yarns and threads, used to make string skirts, adornments and more practical items such as bags (Bird 1943; Rivera 1991, 2008; Cassman et al. 2008; Carter 2016). Rivera's (1991) synthesis of the archaeology of the region identified fiber items such as nets, lines, basketry and cotton textiles appearing as early as the Middle Archaic (6550 BP). Rivera (1991) and Carter (2016) argued that cotton was the first fiber used in the region and that camelid fiber was introduced later, along with the backstrap loom and other highland technologies like agriculture and pottery. This technological progression mirrors the north and center of Peru, nearer the native habitat of cotton that is indigenous to north-western Peru and south-western Ecuador.

Archaeologists have noted an increase in cotton at northern Peruvian sites by ca. 5,000 BP (Pearsall 2008) and identified cultivated cotton in Peru by 5,490 BP (Dillehay et al. 2007). It is unlikely that cotton was used as far south as Chile before it was used in its native habitat. More recent work on the coast of northern Chile indicates no archaeological evidence of cotton use in either domestic and ceremonial contexts during the Early Archaic, it has been suggested that camelid fiber was used instead, however, no detailed study has been conducted to illustrate the chronology of these vital fiber materials (Standen 1997, 2003; Standen and Santoro 2004).
Vegetal fiber artifacts have received little archaeological attention in northern Chile apart from the famous Chinchorro mummies wrapped in twined burial shrouds made from locally abundant sedges belonging to the family *Cyperaceae*, most likely *Schoenoplectus* sp. At Acha-2, burial mats have been dated to 9,000 BP. They remained unchanged over thousands of years to the final stages of the decline of the Chinchorro Culture in the Early Formative Period (ca. 3,600 BP), despite many other changes in mortuary practices (Aufderheide et al. 1993; Arriaza 1995; Santoro et al. 2005; Cassman et al. 2008). These were made using a technique called twining (Doyon-Bernard 1990; Cassman et al. 2008). The twining technique was not limited to burial shrouds but as Cassman et al. (2008) point out the expert execution of this technique in burial contexts as indicative of a consistently practiced craft and suggests that mats were also used as architectural features like windbreaks and roofing material. Recent research in Peru has drawn attention to the importance of vegetal fiber in marine exploitation strategies, as fishing nets and other items which provisioned these early populations. It has even been argued that these technologies were so central to life that vegetal fiber should be considered the basis for the development of Andean Civilization (Beresford-Jones et al. 2018).

Camelid fiber artifacts are common at Archaic sites across Chile’s northern coast despite the scarcity of terrestrial life in the area. These items are thus identified as trade item from high altitude pastoralists beginning in the Formative Period and ascribed to hunting during the Archaic Period (Murra 1956; Núñez and Dillehay 1979; Santoro et al. 2005; Rivera 2008). This remains the dominant paradigm despite reports that some members of the camelid family occasionally ranged as far as the coast. Some sites produce camelid faunal materials and skins while others, as at Caleta Vitor produce none (Carter 2016). The question of
camelid product procurement is complicated by the seeming lack of dietary contribution from the animals in coastal populations (Roberts et al. 2013; Valenzuela et al. 2015; Carter 2016). Essentially, the current procurement model appears to be less than satisfactory in the face of recent evidence, especially considering the importance of fiber items to these marine economies.

There is some disagreement regarding the origin of fiber processing technology in the Americas though the discussion has not received much recent attention. Adovasio and Maslowski (1980) argue that cordage production was brought to the Americas by the earliest pioneers, citing evidence of cordage dating back to the beginning of the Holocene and terminal Pleistocene from Danger Cave (Jennings 1957) and Guitarrero Cave (Adovasio and Maslowski 1980; Jolie et al. 2011). By no means disproving this theory, new dates in excess of 18,000 BP have now been obtained for occupation in southern Chile (Dillehay et al. 2015). On the other hand, Bird (1979) presents a broad overview of cordage production in the Andes citing the simplicity of basic cordage production as evidence that the technology was an independent invention by groups of people all over the world. It must be noted that Bird (1979) was under the impression that the earliest processed fiber items were just 6,000 BP, incidentally, from Chile's north coast. Archaeologists have now established that fishing technology was in use along the Peruvian coast from the late Pleistocene/early Holocene, probably introduced by the earliest migrants to northern Chile more than 10,000 years BP (Sandweiss et al. 1998; Carter 2016; Santoro et al. 2017a) and as early as the late Pleistocene when the Andean coast (Keefer et al. 1998; Santoro et al. 2005)


2.2 The Formative Period

The Formative Period (4,000-1,500 BP) is described as the “first stage of Andean tradition in northern Chile” (Rivera 1991:21), with the arrival of trade goods and people from the highlands (Ulloa 2008; Rothhammer and Dillehay 2009; Núñez and Santoro 2011; McRostie 2014; Muñoz et al. 2016; McRostie et al. 2017). These new technologies and migrants were not evenly distributed or adopted across the region. Some sites retained their marine focused hunter-gatherer economies while others adopted pastoral and agricultural subsistence strategies, as at Caleta Vitor (Roberts et al. 2013; Carter 2016; Santana-sagredo et al. 2015; Valenzuela et al. 2015; Santoro et al. 2017b).

The Formative Period is divided into two parts comprising the Late Chinchorro (4,000-3,600 BP) that is marked by the appearance of pottery (c. 3,000 BP), agricultural goods, textiles, changes in burial practices as well as other non-local trade items (Rivera 1991; 2008; Roberts et al. 2013; Carter 2016). Considered a period of decline for the Chinchorro, some aspects of their material culture remain common into this period despite an influx of trade goods and people from the highlands and perhaps the Loa region. These trade networks were possible because of highland camelid caravans that facilitated the movement goods to the coast and vice versa. According to Rivera (1991) the backstrap loom and blended cotton/wool textiles were introduced to the region during this period. Ulloa (2008) describes textiles of this period as simpler, mostly vegetal fiber with some twined wool items, others were made using the looping technique, and sprang. Sprang refers to a technique that D’Harcourt (1962) and Emery (1980) define as frame-braiding/plaiting made using without tools, on a frame or at least two fixed points.
The following, phase (2500-1500 BP), features a plethora of advanced textile techniques and stylistic changes. Loom technology was improved by the introduction of heddles and new motifs and clothing types are reported (Ulloa 1981b). These new techniques include slit and interlocking tapestry, ‘lost warp’ (discontinuous warp), supplementary warp, and threads dyed in yellow, blue and red. New clothing styles include tunics, the first garments of this type worn in the area (Rivera 1991:22; Ulloa 2008). Horta (2004) and Ulloa (2008) believe these tunic styles are an expression of local textile tradition which spans Azapa through to the Loa region. The textile tradition is based mostly on textiles from the Azapa 70 site, characterized by tunics and other plain warp-faced structures, the co-occurrence of 1:1 tabby weaves and warp stripes as well as a decline in highland influence. However, some highland influence is noted, Tiwanaku elements are noted and there is an increase in the use of wool fiber at coastal sites in the Azapa Valley.

Isotopic research shows a continued reliance on marine foodstuffs into the Late Period (Roberts et al. 2013) exchanged for a limited range of terrestrial resources and craft products (Aufderheide et al. 1988; Tieszen and Chapman 1992; Rivera 2008; Santoro et al. 2012; Poulson et al. 2013; Roberts et al. 2013; Castro 2014; King et al. 2018).

2.3 The Middle Horizon

Highland influence, first observed in the Formative Period, continues and intensifies into the Middle Horizon (1,500-1,000 BP) and the influence from the Tiwanaku Empire becomes evident in an array of material culture (Torres-Rouff 2008). Broadly there is a trend toward urbanization, more substantial, healthier populations who continued to exploit the
abundant marine resources alongside intense, irrigated agriculture (Torres-Rouff 2008; Roberts et al. 2013). Craft technologies and materials also change during the Middle Horizon marked by the incorporation of gold and silver in addition to advanced weaving techniques such as tapestry (Rivera 1991; Ulloa 1981b). Ulloa (1981b) also identified stylistic influence from highland weavers during this time, typified by anthropomorphic warrior motifs, geometric forms and the “Tiwanaku split eye”.

At Caleta Vitor, there is a notable change in burial practice during this time and evidence of domesticated plants such as maize and animals including camelids. Carter (2016) concluded that these domesticates were not a primary dietary source for the people living at the site and found no evidence of intensive agriculture or camelid herding/consumption. Unfortunately, no fiber artifacts in the collection from Caleta Vitor have thus far been dated to this period.

2.4 The Late Intermediate Period

The Late Intermediate Period (1,000-660 BP), falls between the end of Tiwanaku influence which characterizes the Middle Horizon and the beginning of Inca influence in the area (Late Period). Tiwanaku influence remained strong through many parts of the Atacama and migration from the Altiplano continued over the Late Intermediate Period (Rivera 1991; Torres-Rouff 2008). This period is characterized by the continued development and use of irrigation infrastructure, intensification of agriculture and the appearance of fortified villages called Pukaras, commonly thought to indicate intergroup tensions, juxtaposed by
evidence for long distance inter-group trade, accommodated by large llama caravans that indicate the existence of a complex economic system (Rivera 1991; Roberts et al. 2013).

Cassman (1997, 2000a, 2000b) conducted an extensive study of 950 garments associated with 436 from mummies from three sites in the Azapa Valley (Azapa-140, Azapa-71 and Playa Miller-9). The Late Intermediate Period mummy burials showed little variation in ethnic expression although some status differences were noted; men had more decorated shirts than women whilst women had better quality (finer) shirts at the coastal site (Playa Miller-9). Overall, mummies had better quality and more grave goods than their inland, agricultural neighbors.

2.5 The Late Period

The Late Period is characterized by Inka dominion. In the Atacama, the Empire adopted a highly varied policy which has been likened to their approach to the Chimu in northern Peru (D’Altroy 2003). Economic and political interactions were conducted through Tambos in the Arica highlands, situated with access to the Inka Road system (Santoro and Uribe 2018). According to Murra (1962) and Hughes (2010), the successful expansion and the administration of the Inca can be attributed to the production and regulation of textiles which were central to Inka socioeconomics. Textiles and clothing were such powerful symbols that wearing qombi (fine, tapestry woven textiles), for example, was restricted to the royal family and could only be worn by others if gifted to them by the Inka. Such gifts were usually political, as in the case of local officials in the creation of a sort of reciprocal
arrangement wherein the local leaders would gain status for their connection to the Inka.

Gifts of *qombi* were also made to distinguished military commanders (D’Altroy 2003).

By the Late Period, the subsistence economy of Caleta Vitor had diverged from that of the neighboring inland population of the Azapa/Lluta Valleys where intensive maize agriculture was underway, and where isotopic research indicates a coinciding reduction in marine resource consumption (King *et al.* 2018). Maize and other domesticates occur in the archaeological record of Caleta Vitor; however, no evidence of intensive agriculture was identified (Carter 2016). Instead, “the economy remained clearly focussed on the sea. Indeed, if anything, the exploitation of marine resources increased – both to satisfy local demand and for trade. Deposition rates, based on dates from the Late Period (CV4/1, CV6) increased substantially” (Carter 2016:449) coinciding with increased population and high pottery discard rates (Carter 2016; Bland *et al.* 2017). Similarly, the remains of camelids and evidence of camelid consumption appear at Lluta valley sites such as Molle Pampa, whereas no such evidence was identified at Caleta Vitor. Evidence of camelids at the site is limited to camelid faecal pellets which appear in the Formative Period and increase in abundance during the Late Period (CV2/1, CV4/1, CV4/6, CV6/1, CV6/2, and CV6/3), evidenced by fiber and rock art depicting camelids (Valenzuela *et al.* 2015; Carter 2016).

Inka style artifacts are also sparse at Caleta Vitor, with just a single pucu dish (Carter 2016) and an Inka *unku*, discovered at the site following a looting incident. Based on this limited evidence Carter (2016:431) concluded that there was “little direct control led by the presence of an administrative body” during the Late Period.
Chapter 3. Introduction to Fiber Processing Technology

The following technologies are pertinent in subsequent chapters. For a detailed description of fiber processing technology see Emery (1980), Jolie et al. (2011), Adovasio (1977) and Barber (1995).

3.1 Spinning, Splicing or Twisting

As with many fiber processing and cloth production techniques, there are a dizzying array of terms used to describe yarn production executed without tools (unaided). The simplest yarn production techniques involve simply rolling vegetal or animal fibers between the palms or along the thigh. The term splicing widely used to describe rope construction in maritime technology (Day 1953), has recently been borrowed to describe this simple method of twisting thread in textile studies. Tiedemann et al. (2006) use splicing in two different ways- (1) following Samuel (1985), thigh-spinning is defined as a type of splicing and (2) to describe a technique to lengthen yarns during thigh splicing, noting that the technique can be done with bast, cotton or animal fiber. The term end to end splicing is also used by Barber (1995) to describe flax preparation for spinning in her discussion of fiber processing and cloth production activities depicted in an Egyptian Middle Kingdom tomb from the early second millennium B.C. Recently, Gleba and Harris (2018) and Beresford-Jones et al. (2018) have argued that unaided vegetal fiber yarn construction methods can be more accurately distinguished by the two types - continuous splicing and end-to-end splicing - depending on how fiber is added to the growing yarn. A more detailed tabulated inventory of the use of the term splicing in the literature is given in Gleba and Harris (2018: Table 3).
In this dissertation, direction of twist is used for vegetal yarns prepared from long, lengths of lightly processed fiber (probably thigh-spun - unaided) and spun and plied is used where it appears much finer, more heavily prepared fibers have been drawn out (see spinning below).

### 3.2 Elements of limited length, Twisting and Direction of Twist

Twisting (splicing), spinning, plying, and knotting are fundamental techniques in marine hunter-gatherer toolkits. These techniques are required to make lines attached to fishhooks and net weights and to produce basketry containers for fish and other marine resources. The simplest form of cordage is the single-strand-of-limited-length, including shredded vegetal strands and lengths of sinew or leather which can be knotted together to create additional length. Such elements may require no proprietary tools to produce and can also be twisted together to form stronger, longer yarns (Emery 1980).

Twist is also used to refer to yarns produced without the use of a spindle or whorl in the thigh twisted (thigh spinning) technique where fibers are rolled along between the thigh (or cheek) and palm of the hand (Barber 1995; Cameron 2002; Tiedemann and Jakes 2006) while direction of twist is used to refer to the direction in which a yarn was made (twisted clockwise or anticlockwise) regardless of the production method (Emery 1980).
3.3 Spinning

Spinning involves ‘drawing out’ prepared fibers, to a spindle (a straight stick – usually wood) that is rotated either on a support such as a bowl or the ground or by dropping the spinning spindle. Regardless of the method, the action turns the fibers and creates a continuous thread which is then gathered up and turned onto the spindle to be kept while the spindle remains in use. Spindles can be used alone or with a spindle whorl – a flywheel which maintains the rotation speed and duration of the action. The yarn can be used after the initial spin as a single yarn (Emery 1980) (common in Peruvian weaving), though depending on the tightness of twist, they tend to twist up on themselves. To avoid unwanted twisting and create a very strong yarn, these are doubled and plied (twisted) together in the opposite direction of spin. Of course, yarns can be produced of any number of single yarns or plies. When plied yarns are twisted together, they are referred to as replied (Emery 1980).

Depending on the direction the spindle is turned, yarns will have a resulting S-twist or Z-twist (Emery 1980). As stated, yarns initially spun in the S direction will usually be plied in the Z direction and vice versa, such yarns are described as S/Z. The direction of twist can be easily discerned by holding the yarn vertically and noting the angle at which the fibers spiral, either up to the left (S) or up to the right (Z) corresponding to the angle of the middle of each letter: S=\ and Z=/ (Emery 1980:11 Diagram 1). For a comprehensive description of spinning see Barber (1995:34-37) and for a thorough description of terms see Emery (1980).
3.4 Textile and Basketry Production Techniques

3.4.1 Twining

Twining has been called the “ancestor of loom weaving […], require[ing] the perpendicular crossing of two separate sets of elements” (Doyon-Bernard 1990:69) distinguishing it from looping or netting techniques which typically only use a single element. In twining, a set of semi-rigid elements is arranged parallel to one another in a row- constituting the passive element (warp). The active element (weft), which comprises a set of two yarns usually more pliable than the passive element are passed around each other and passive element(s) at right angles. This technique requires no tools and can be done with very closely or tightly spaced wefts. Active elements can be turned to the right or left during construction resulting in a Z-twine or S-twine. As with yarns, the twining direction can be determined by slant of the element - up to the right is Z-twine and up to the left is S-twine, similar to the direction of twist in yarns described above.

3.4.2 Interlacing

The interlacing technique has been described as “the most straightforward way of interworking elements, inasmuch as each element simply passes under or over elements that cross its path” (Emery, 1980:62). In the case of woven fabrics, the warp (passive element) is kept under tension while the weft (active element) is worked through openings made in the warp called sheds. For example, in plain weave (tabby weave) comprised of 10 yarns, the first pick (to create a shed) would lift yarns 1, 3, 5, 7 and 9 and the second pick two would lift yarns 2, 4, 6, 8 and 10, continuing between the two picks. This simple picking
pattern can be used to create considerable variety depending on the amount of warp and weft visible in the finished product (warp or weft facing or balanced) and the use of multiple wefts or warp grouping (for a detailed description of variants see Emery 1980:76-78).

Weaving usually requires a loom to maintain tension and order in the warp and some method of opening sheds (spaces) in the warp. Sheds can be made using heddles, a shedding stick or by hand. There is virtually no limit to the variations possible in interlacing, depending on the organization and spacing of the warp, the amount of force used to beat in wefts, the use of discontinuous warps and wefts and the arrangement of the picking pattern. Variants and elaborations of the technique are too numerous to list.

3.4.3 Tapestry Weaving

Tapestry weaving is a weft-facing variation of interlacing using discontinuous wefts passed back and forth in only part of the warp to create solid color blocks. Variations in the technique include turning weft yarns back without interlocking with the warp or other wefts in the next color block resulting in slit-tapestry or turning around the weft yarns comprising resulting in fabric without slits including such techniques as interlocking and dovetailing (see Emery 1980:78-83 for a full discussion of the variants of tapestry weaving.

3.4.4 Coiling

Coiling is a type of basketry involving two elements “the foundation [which] produces the coiled item’s rigidity, [and] the stitches [which] maintain the object’s structural integrity” (Jolie 2006:22). In the Atacama, coiled hats called chucus are made using a slight variation
of this technique where a thick cord is used for the foundation which is coiled around itself and held in place by stitches in a finer yarn often covering the foundation entirely. Stitches can also be used to create designs on the finished product. A video of the technique can be found on the Museo Chileno De Arte Precolombino website at:

Chapter 4. Stable Isotope Research: A Brief Introduction

This chapter briefly outlines the background underpinning stable carbon and nitrogen isotopic studies in archaeology and the Caleta Vitor camelids. To avoid repetition, the methodology and the development of our referential dataset (isoscape) are presented in overview only, and described in detail in Chapter 8.

Stable carbon and nitrogen isotope studies provide a quantitative assessment of the diet and living conditions of people and animals. These signatures can then be contextualized within the natural isotopic distribution of an environment where specific ecological niches can be ascribed; identifying the geographic origin of the sampled consumer. Vogel and Merwe (1977) were the first to successfully apply stable light isotope analysis in archaeology to identify a shift in dietary dependence from wild plants (C3 plants) to mostly corn (C4 plants) in New York state using δ13C analysis on human bone collagen samples. The study tested the hypothesis that consumers of plants using the C4 (Calvin) photosynthetic pathway, which have a higher 13C/12C ratio than those using the C3 (Hatch-Slack) pathway, will have a different δ13C in bone collagen than consumers of a primarily C3 plant diet. With this principal established, researchers set about refining the method to gain an understanding of C4 and C3 expression in the tissues of consumers versus that in the diet consumed, with some offset for fractionation during metabolic processing, using controlled diet experiments (Lee-Thorp 2008; Finucane et al. 2006; DeNiro and Epstein 1981).

DeNiro and Epstein (1981) found that bone collagen δ15N is a proxy for dietary δ15N. Unlike δ13C, δ15N is reflective of the trophic level of a consumer, elevation, aridity and, in the case
of plants, the way in which a species obtains nitrogen (Tykot 2004). Similarly, Nitrogen isotope analysis is based on the principle that the 15N/14N ratio in animal tissue is reflected by the diet consumed. δ13C and δ15N analyses are an unmatched tool for paleodietary and paleoenvironmental reconstructions and a method of identifying where animals grazed within an environment where an adequate understanding of natural isotopic distribution is established.

Since the initial discoveries, δ13C analysis has expanded to other types of bodily tissues including bone apatite (Krueger and Sullivan, Charles 1984; Lee-Thorp et al. 1989; Ambrose et al. 2003), tooth enamel (Lee-Thorp et al. 1994; Sponheimer and Lee-Thorp 1999) and dental calculus (Poulson et al. 2013; Salazar-García et al. 2014) and δ13C and δ15N analyses have also been successfully applied to hair (Wilson et al. 2007), nail (O’Connell et al. 2001) and South American camelid fiber and bone collagen, successfully identifying the origin of camelid fiber artifacts from Peru, Bolivia and in the Argentine puna (Aufderheide et al. 1988; Kellner and Schoeninger 2008; Thornton et al. 2011; Knudson et al. 2012; Dantas et al. 2014; Samec et al. 2014; Szpak et al. 2014; Szpak et al. 2014 Szpak et al. 2015; Gil et al. 2016; Grant 2017).

Using these methods, researchers have detected camelid management (husbandry/pastoralism) and camelid product exchange networks on the western Andean slope (outside the highlands) and demonstrated variability in camelid management practices including maize foddering and the continuation of camelid hunting alongside camelid husbandry (Thornton et al. 2011; Szpak et al. 2014a and b; Dufour et al. 2014; Szpak et al. 2016; Grant 2017).
4.1 Referential Archaeological Camelid Groups of the Western Andean Slope

Szpak et al. (2016) developed four referential groups of camelids with geographically discernable grazing preferences and habitats across the western Andean slope, between 7º and 18ºS (Figure 2):

1. Mixed irrigated cultigens (MXC), exhibiting roughly equivalent intake of $C_3$ and $C_4$ irrigated plants in a lowland setting.

2. Wild coastal vegetation (WCV), roughly equivalent intake of $C_3$ and $C_4$ vegetation from fog oases exhibiting extreme hyperarid growing conditions and some marine influence.

3. Cultivated $C_4$ crops ($C_4C$), diets comprising mostly irrigated, $C_4$ plants (maize) from mid-altitudes (~2,700m asl).

4. High-elevation $C_3$ pastures ($C_3P$), predominantly $C_3$ wild plants from high altitude pastures.
Figure 2. Referential camelid groups of the western Andean slope.
4.2 Expectations

Previously proposed models estimate that coastal inhabitants procured this scarce camelid product during the Archaic Period by local marginal hunting or exchange with inland groups (Núñez and Santoro 2011; Rivera 1991). However, there is “no evidence to suggest that the inhabitants of the site hunted camelids to any extent during the Archaic Period nor is there any evidence for the presence of domesticated species, either llama or alpaca, prior to the Formative Period” (Carter 2016). It has been suggested that from the Formative Period, onward, coastal inhabitants obtained camelid fiber through exchange with inland groups and in the Late Period, it is assumed that trade with the empire took over as the main source of camelid fiber (Capriles 2014; Carter 2016; Rothhammer and Dillehay 2009; Santoro et al. 2014). In any case, camelid fiber is typically associated with highland sources, strongly indicating the Caleta Vitor camelids will correspond to Szpak et al. (2016)’s C3P regimen (Figure 2).
Statement of Contribution: Early Coastal Fiber Technology from the Caleta Vitor Archaeological Complex in Northern Chile

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Tracy Martens:
Conducted the artifact recording in Arica, Chile (2017). Organized the data for analysis and completed background research. Developed research question and drafted the all sections of the research paper in conjunction with co-author.

Signed
Ms. Tracy Martens

Judith Cameron:
Participated in research question development, drafting and editing of the research paper. Contributed to technical analysis.

Signed
Dr. Judith Cameron
Chapter 5. Early Coastal Fiber Technology from the Caleta Vitor Archaeological Complex in Northern Chile

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Abstract

The marine subsistence economy of the prehistoric people of northern Chile was heavily reliant on fiber technology for the components of nets, lines, and tethers. Despite the significance and the remarkable preservation of fiber artifacts along the arid Atacama coastline, these components have received little direct attention. This case study of fiber artifacts from the Caleta Vitor archaeological complex is the first broad overview of techniques, material usage/preference, and fiber-processing conventions at a northern Chilean Archaic period site. The data presented in this paper indicate gradual change in material preferences over time, shifting from locally available vegetal fiber, which dominates the Archaic period, with small amounts of camelid fiber, to the predominance of camelid fiber in the Late Formative period. This change coincides with the appearance of more complex weaving techniques indicating participation in the previously established textile tradition proposed by Ulloa (2008) as stretching from the Azapa Valley to the Loa River.
5.1 The Significance of Fiber Technology

For millennia in northern Chile, fiber technology played a central role in economic life, providing not only the basic components of clothing and the matting that sheltered the living and shrouded the dead but also the basic tools on which the marine exploitation strategies of the Chinchorro and their successors depended. For these subsistence activities, people relied heavily on reeds that grew abundantly along the quebradas that drain to the Pacific coast. In the early years of their settlement of the coast the Chinchorro learned how to weave fine, shredded reed fiber to make a wide range of artifacts, including mats for roof thatching; clothing such as breechcloths and fringe skirts or faldellines; funerary bundles; and hunting, fishing, and gathering implements such as chinguillo, reed nets. Twisted camelid wool, cotton fibers, and leather were also integrated into this industry (Santoro et al. 2005). Despite its broad application, fiber technology has not received a great deal of attention in this pivotal area, where the dry conditions of the Atacama have made possible the excellent preservation of perishable artifacts. In other parts of the Andes—Paloma, Monte Verde, Quebrada Jaguay, Guitarrero Cave, and La Yerba—pioneering investigations (Adovasio 1997; Adovasio and Lynch 1973; Adovasio and Maslowski 1980; Beresford-Jones et al. 2018; Bird 1963; Jolie et al. 2011; Sandweiss et al. 1998; Ulloa 1981a, 1981b, 2001) of fiber based materials from archaeological contexts have highlighted the significance and antiquity of fiber technology in the Americas and the role of these artifacts in the rise of complex societies. These investigations have also produced important evidence of maritime adaptations and bolstered claims of Pleistocene occupation of the high Andes. The techniques of twisting, spinning, plying,
and knotting are fundamental to fishing: they are required to make lines that attach to fishhooks and net weights, as well as basketry containers for fish and other marine resources. Archaeologists have established that fishing technology was in use along the Peruvian coast from the late Pleistocene/early Holocene; it was probably introduced by the earliest migrants to northern Chile more than 10,000 years BP (Carter 2016; Sandweiss et al. 1998; Santoro et al. 2017a) and quite possibly when the Andean coast was first settled in the late Pleistocene (Keefer et al. 1998). The distribution of diagnostic items of material culture across some 500 km of coastline at Archaic period sites between the Ilo and Loa Rivers shows the extent of Chinchorro mobility (Arriaza 2008; Carter 2016; Marquet et al. 2012; Santoro et al. 2012; Standen et al. 2017). The most enduring item produced by the Chinchorro is the burial mat that remained unchanged over thousands of years: it served as shrouds from at least 9,000 BP through to the final stages of decline of the Chinchorro culture in the Early Formative period (ca. 3600 BP), despite many other changes in mortuary practices (Arriaza 1995; Arriaza et al. 2005; Aufderheide et al. 1993; Cassman et al. 2008). These iconic items were made using a technique called twining, considered to be a precursor to loom weaving (Cassman et al. 2008; Doyon-Bernard 1990)—a later technological development attributed to contact with highland groups arriving in the area during the Formative period by 3,500 BP (Carter 2016:243; Ulloa 1981a). Knowledge of Archaic fiber technologies on Chile’s northern coast has been obtained primarily from burial contexts. Despite studies of fishing technology demonstrating the prevalence and antiquity of cordage (Bird 1943; Carter 2016; Sandweiss 2008; Sandweiss et al. 1998; Schiappacasse and Niemeyer 1984), there is practically no information about the use of fibers for other domestic purposes. Cassman and
colleagues (2008) point out that, although the production of reed mats is commonly noted at burial sites, their expert construction suggests that they had a much broader application. Even so, these items have received limited attention and, in some instances, were not even collected during excavation. As a result, fiber technology before the introduction of weaving by highland groups remains undocumented. Except for Cassman and colleagues’ (2008) investigation of burial mats, there are no detailed analyses of fiber technology at Chinchorro sites.

### 5.2 Background

The coastal region of northern Chile (Figure 3) was occupied during the Early Holocene by marine hunter-gatherers who became known as the Chinchorro, famous for their distinctive mummification techniques evidenced as early as 7,500 BP and continuing into the Formative period (ca. 4,000–1,500 BP), when the culture went into decline (Arriaza 1995, 2008; Bittmann and Munizaga 1976; Marquet et al. 2012; Roberts et al. 2013). The rich biota of the Pacific coast of northern Chile enabled the Archaic marine hunter-gatherers and their successors to develop a semi-sedentary mobility pattern, which provided food security even after circa 10,000 BP when a prolonged drought made the intermediate depression, the core of the Atacama Desert, inhospitable (Gayo et al. 2012; Latorre et al. 2013; Santoro et al. 2017b). The inhabitants of Caleta Vitor remained heavily dependent into the Late period (600–476 BP) on marine proteins, which they complemented by exploiting or trading a limited range of terrestrial resources for both food and craft production (Aufderheide et al. 1988; Castro 2014; King et al. 2018; Poulson et al. 2013; Rivera 2008; Roberts et al. 2013; Santoro et al. 2012, 2017a; Tieszen and Chapman 1992). These subsistence and craft economies have been described as “stable and local” (Bland et al. 2017:282), with
inhabitants exploiting the same locally available, raw resources for both food and pottery production over an extended time period (Carter 2016; Roberts et al. 2013). The final phase of the Chinchorro culture (4,000–3,600 BP), during the beginning of the Formative period, is marked by changes in burial practices and agricultural products, textiles, and exotic trade goods (Carter 2016; King et al. 2018; Rivera 1991, 2008; Roberts et al. 2013; Santoro et al. 2017a). Long-distance trading networks were made possible by highland camelid caravans that facilitated the movement of goods to the coast and back (Carter 2016). Despite the influx of trade goods and people from the highlands, the Loa region, and possibly other, more distant areas, as well as the continuation of many aspects of their material culture, this is considered the final phase of Chinchorro culture (Table 1). The Formative Period (4,000–1,500 BP) is one of change and considered to be the “first stage of Andean tradition in northern Chile” (Rivera 1991:21), with the arrival of trade goods and people from the highlands including pottery (ca. 3,000 BP) and hallucinogenic drug paraphernalia like snuff trays (McRostie 2014; McRostie et al. 2017; Muñoz et al. 2016; Núñez and Santoro 2011; Rothhammer and Dillehay 2009; Ulloa 2008). The impact of these external pressures appears to have varied across the region (Santana Sagredo et al. 2015; Valenzuela et al. 2015). Some sites adopted pastoral and agricultural subsistence strategies (particularly in the Lluta Valley) whereas others remained focused marine hunter-gatherers (Santoro et al. 2017a).
Figure 3. Map showing the archaeological sites, modern cities, waterways, and quebradas mentioned in the article (ANU Cartography).
5.2.1 The Archaeological Context

The Caleta Vitor complex lies at the Pacific coastal terminus of Quebrada de Chaca/Vitor in the Atacama Desert of northern Chile, approximately 50 km south of the Chilean–Peruvian border. The site consists of rock art, middens, occupation areas, and burials. Before recognizable, scientific archaeological work commenced in this region, interest focused largely on mummified human remains, which museum representatives from around the world took to form their collections (Carter 2016). Max Uhle’s 1919 investigations and subsequent establishment of a chronological sequence for Arica (Uhle 1974) marked the beginning of earnest archaeological work in northern Chile (Carter 2016). This work was followed by Junius Bird’s (1943) extensive excavations at coastal sites from Arica to Taltal, from which he concluded that the prehistoric people of this region had a marine-focused economy. These early chronologies were impressively constructed without the benefit of radiocarbon dates. At that time, occupation of the region was thought to span just 2,000 years. The greater antiquity of the region only began to be recognized in the early 1990s, when occupation of the general area was dated to the Pleistocene (Arriaza 1995; Auferheide et al. 1993; Núñez et al. 2002; Rivera 1991; Sandweiss et al. 1998; Santoro et al. 2005). At Acha, which lies 5.4 km inland from Arica, occupation is now dated to the Early Holocene (Standen and Santoro 2004). Based on extensive bioarchaeological work, isotopic research, and studies of genetically controlled dental traits, scholars have now established the origin of the people known as the Chinchorro, shown the persistence of the marine economy that supported them, and demonstrated the evolution of what is now recognized as the world’s oldest human mummification procedures (Arriaza 1995; Arriaza et al. 2005; Poulson et al. 2013; Roberts et al. 2013; Rothhammer and Dillehay 2009; Sutter 2000). In this article, we focus on fiber data from excavations undertaken between 2008 and 2010 at Caleta Vitor.
(Carter 2016), the first documented archaeological excavations of the site. Although Carter’s excavations were conducted primarily to collect in situ material culture and attempted to avoid graves that contained prestige and curated goods, he did encounter some graves that were intermingled with occupation areas. This report is therefore a record of fiber artifacts in regular domestic use, as well as burial items, in open coastal camps in northern Chile. Carter (2016) divided the Caleta Vitor complex into seven zones: CV1–CV7 (Figure 4).

Only CV1, CV2, and CV7 produced Archaic and Formative period fiber artifacts. CV1 was the largest of the three preceramic midden and occupation areas: it produced several burials, including one reed-wrapped extension featuring the remains of bird skin and feather embellishments (the burial was left in situ and reburied later). This burial led Carter to conclude that the material culture in this area was Chinchorro in origin. Radiocarbon dates (Table 1) confirm Carter’s assessment that CV1–CV3 span the Archaic and Early Formative periods. CV2, with its well-defined stratigraphy in which both ceramic and preceramic layers contain burials, was identified by Carter as a midden and occupation area dated between the Early and Late Formative periods (Table 1). The area was heavily disturbed by military activities and looting and is separated from CV4 by a road on its northern boundary. CV7 is the northernmost zone, described as a low-density midden with several burials that were reburied at the time of excavation (Carter 2016). Materials from CV7 are dated to the Late Archaic period (see also Latorre et al. 2017; Santoro et al. 2017a for chronology on these seven archaeological zones). Fiber artifacts were first found in Middle Archaic period deposits, whereas indirect evidence for cordage technology was recovered from layers dating to the Early Archaic. A fine shell bead was found in the layer above CV3/1/30, dated 8662–9487 BP (ANU31014-9186). The bead, which measured 4.7 mm in diameter and was
1.4 mm thick with a 2.3 mm hole, was almost certainly suspended on a cord. Bones from very small fish species identified as net caught were found in large numbers in the earliest Archaic period unit (CV3/1/31), dated 9271–9487 BP. As Carter explains, nets would have been necessary to catch the large numbers of very small sardines and anchovies (Engraulidae) represented in the unit. Other excavated species and small animals are also presumed to have been net caught.

Table 1. Radiocarbon Assays from Caleta Vitor Archaeological Complex Roberts et al. (2013: 2362).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Context</th>
<th>Material</th>
<th>Age (cal 2 sigma)</th>
<th>Period</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGAMS10509</td>
<td>CV1/3/25</td>
<td>calyx</td>
<td>6411-6631</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UGAMS10508</td>
<td>CV1/3/14</td>
<td>calyx</td>
<td>6496-6717</td>
<td>Middle Archaic</td>
<td>Chinchorro</td>
</tr>
<tr>
<td>ANU31018-918</td>
<td>CV1/3/9</td>
<td>cane</td>
<td>5664-5910</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANU31017-918</td>
<td>CV7/1/10</td>
<td>cane</td>
<td>4839-5039</td>
<td>Late Archaic</td>
<td>Late Chinchorro</td>
</tr>
<tr>
<td>UGAMS10506</td>
<td>CV1/2/13</td>
<td>calyx</td>
<td>4437-4525</td>
<td>Late Chinchorro</td>
<td></td>
</tr>
<tr>
<td>UGAMS10524</td>
<td>CV7/1/6</td>
<td>calyx</td>
<td>4094-4408</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UGAMS10513</td>
<td>CV2/1/39</td>
<td>cotton seed</td>
<td>3346-3458</td>
<td>Early Formative</td>
<td>Final phase of Chinchorro culture</td>
</tr>
<tr>
<td>UGAMS10505</td>
<td>CV1/2/6</td>
<td>algarrobo pod</td>
<td>3263-3360</td>
<td>Early Formative</td>
<td>4,000-3,600 (Aapa)</td>
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<tr>
<td>UGAMS10507</td>
<td>CV1/3/1</td>
<td>algarrobo pod</td>
<td>2484-2697</td>
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<tr>
<td>ANU31013-918</td>
<td>CV2/1/20</td>
<td>charcoal</td>
<td>2363-2713</td>
<td>Late Formative</td>
<td>Alto Ramirez (2,500-1,500)</td>
</tr>
<tr>
<td>UGAMS10510</td>
<td>CV2/1/1</td>
<td>algarrobo pod</td>
<td>1931-2129</td>
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</tbody>
</table>
5.3 Methodology

The fiber remains excavated from Caleta Vitor were analyzed in Arica, Chile, at the Laboratorio de Arqueología y Paleoambiente, Instituto de Alta Investigación (IAI), at the Universidad de Tarapacá (UTA), between March and May 2016. The techniques were identified and described in accordance with classifications devised by Adovasio (1977), Emery (1980), Wendrich (1991), Cassman (1997), Kuttruff and Strickland-Olson (2000), and Jolie and colleagues (2011). All items were initially inspected with the unaided eye, followed by examination under an Aven 26700-302 zipScope at 50X magnification. They were then photographed with a Canon 30X handheld digital camera. We measured the dimensions using digital and conventional calipers. After dividing the items into three broad categories based on their material composition—animal, vegetal, and cotton—we used a dissecting microscope at 400X magnification to verify identifications of the camelid and cotton fibers. Because the focus of the research was technical analysis of the fragments, we did not engage in archaeobotanical research, although this is planned for a future project. After determining the items’ material composition, we analyzed their structural composition: we measured and recorded the number of elements and the twist, spin, ply, and reply (after Emery 1980:8–14). Once these basic characteristics were identified, we analyzed the fabric structures, documenting attributes such as condition, color, tightness, and the angle of twist. We calculated fabric density (Supplemental Table 1) scores where appropriate based on Cassman’s (1997:87) formula: warp diameter/warps/unit + weft diameter/wefts/unit.
5.4 Results and Discussion

Altogether, we identified and recorded 546 fiber artifacts (Supplemental Table 2) from 38 excavation units assigned to the Middle Archaic, Late Archaic, Early Formative, and Late Formative periods, based on recently obtained radiocarbon dates (Table 1; after Carter 2016). The Middle Archaic unit (CV 1/3/10) produced the highest number of fiber artifacts (n = 226). Unfortunately, that unit was heavily disturbed by a rodent burrow that extended horizontally into the profile. Although the disturbance is described as discrete and not affecting the neighboring units (Christopher Carter, personal communication 2018), it raised questions about the provenance of the textile fragments found there. The disturbed context included not only hundreds of camelid fiber threads but also four small fragments of camelid wool textile (8285–1, 8285–2, 8285–3, 8285–4) ranging in size from 35 mm x 24 mm to 10 mm x 7 mm. These “seemingly precocious fragments” (David Beresford-Jones,
personal communication 2018) were similar to those encountered in the interlaced textiles from Guitarrero Cave (see the later discussion). We therefore obtained radiocarbon assays on three of the camelid fragments (8285–3, 8285–4, 8285–5), as well as on a thread (8285–6). The radiocarbon determinations confirmed that the artifacts were indeed out of sequence, belonging to the Late period (Table 2), and the artifacts from unit CV1/3/10 were subsequently reassigned and will be discussed in another article on the Late Horizon fiber artifacts from the site.


<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Context</th>
<th>Material</th>
<th>Radiocarbon age (yr BP)</th>
<th>Age (cal BP) ±1σ</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>WK47776</td>
<td>CV1/3/10</td>
<td>Interlaced camelid fibre textile 8285-2</td>
<td>671 +/-20</td>
<td>560-650</td>
<td></td>
</tr>
<tr>
<td>WK-47777</td>
<td>CV1/3/10</td>
<td>Interlaced camelid fibre textile 8285-3</td>
<td>654 +/-17</td>
<td>550-630</td>
<td>Late Horizon</td>
</tr>
<tr>
<td>WK-47778</td>
<td>CV1/3/10</td>
<td>Interlaced camelid fibre textile 8285-4</td>
<td>656 +/-19</td>
<td>550-640</td>
<td></td>
</tr>
<tr>
<td>WK-47779</td>
<td>CV1/3/10</td>
<td>Cameld fibre thread 8285-6</td>
<td>573 +/-18</td>
<td>520-550</td>
<td></td>
</tr>
</tbody>
</table>

In total, 36.42% of the fragments from securely dated strata were camelid, confirming the high value placed on this species during the prehistoric period. The proportion of camelid fiber fragments steadily increases over the four periods, supplanting vegetal fiber in the Late Formative period as the most common material (Figure 5). Although small quantities of camelid fecal pellets were left at the Caleta Vitor site circa 3346–3458 BP, the absence of camelid bones in the collection, along with strong marine isotopic signatures in the human remains, indicates a dietary reliance on marine proteins that lasted through to the Late Holocene (Roberts et al. 2013). According to Carter (2016), the Chinchorro traveled up the
quebradas (<2,500 m above sea level) to wetter, more ecologically abundant ecosystems to hunt wild guanaco during the Middle and Late Archaic periods and engaged in exchange with highland groups circa 3500 BP. This interpretation is supported in northern Chile by evidence near Antofogasta that indicates that wild camelids were hunted for fibers and meat from the Early Holocene onward (Llagostera 1979). A small proportion (2.1%) of the fibers were identified as *Gossypium barbadense* (cotton) (Figure 5).

Northern Peru is one of the origin centers for *G. barbadense*, and scholars previously noted in the appearance of cotton at preceramic northern Peruvian sites and identified cultivated cotton by 5490 BP (Dillehay et al. 2007). Significantly, the appearance of worked cotton at Caleta Vitor (CV1/3/2), below unit CV1/3/1 dated 2484–2697 cal BP, is pre-dated by cotton seed from CV2/1/39, dated 3358–3446 cal BP, which itself is approximately 500 years later than the earliest appearance of the material on the Peruvian south coast, as identified at Otuma and dated 4150 cal BP after the preceramic period (Beresford-Jones et al. 2018). Cotton’s exceptionally long staple makes it well suited for the production of fine, strong threads for fishing lines and nets. At Caleta Vitor, Carter identified large numbers of netcaught fish species from the Early Archaic period unit (CV3/1/31), dated 9271–9487 BP. As Carter deduced, nets would have been necessary to catch fish in such large numbers. Previous investigations on the coast of northern Chile did not provide any archaeological evidence of cotton use in domestic and ceremonial contexts during the Archaic period. Instead, it was posited that people only used camelid and vegetal fibers (Standen 1997, 2003; Standen and Santoro 2004). After its initial appearance in the beginning of the Early Formative period, cotton was rarely found in subsequent sequences, with just six threads and one fragment of interlaced textile identified (see the later discussion). The absence or
low occurrence of cotton could be explained by post depositional factors, given that a conglomeration of unworked cotton from the same unit was in good condition. It was also apparent that the earliest cotton threads from the beginning of the Early Formative period were in a more degraded condition than the unworked cotton and the worked and unworked animal and vegetal materials from the same unit, requiring extreme care in handling. The lack of cotton could also be a result of a digenetic process affecting preservation in situ or to chemical or physical treatments of the material before deposition.

Vegetal artifacts are prominent throughout the sequence, eventually dropping off in the Late Formative period when camelid fiber becomes the most common material (Figure 5). Cassman and colleagues’ (2008) comparative analysis of extant plants from the Lluta Valley and vegetal material from a Chinchorro burial shroud from the Azapa Valley indicates that the material was derived from a reed (sedge) belonging to the family Cyperaceae, most likely *Schoenoplectus* sp.

![Material Proportions Over Time](image)

*Figure 5. Material proportions over time.*
5.4.1 Structural composition

Twining is the simplest textile production technique identified in the collection (Figure 7). In total, 12 twined fragments were excavated from Middle and Late Archaic sequences and from Late Formative units. This technique requires no tools and is generally considered to be one of the earliest methods for constructing fabrics in the world and, as mentioned, the precursor to loom weaving (Bird 1963; Doyon-Bernard 1990; Emery 1980; Ulloa 2008).

Twining requires two sets of elements: one passive, one active. Semi-rigid strips of vegetal materials that constitute the warp (passive, structural element) are laid on the ground, while flexible cordage constitutes the weft (active element) that passes over and under each of the warp strips (Adovasio 1977). Caleta Vitor’s fragments were all examples of spaced twining and z-twinning. This structural element appears to have received little or no processing. Twining differs from loom weaving in the absence of a wooden frame and the orientation of the maker’s body. The warps are oriented parallel to the long axis of the maker’s body, rather than at right angles as in loom weaving. No change to the technique over time was observed, although one of the Late Archaic fragments (8219–3) was coarser than earlier examples. This particular fragment was made from a broader reed than found in other examples and may simply represent a specific application requiring a stiffer textile.

Unfortunately, the inadequate remnants of the active elements of these artifacts did not allow the determination of fabric density. The earliest South American examples of twining come from Guitarrero Cave, which were recently redated to at least 11,000 BP (Jolie et al. 2011), and from Quebrada Mani in the Pampa del Tamarugal basin (Santoro et al. in press).

The simplicity of twining is deceptive as the technique can be used to create highly elaborate designs. This is exemplified by examples found at Huaca Prieta in Peru, where geometric designs and animal figures were achieved using transposed warp floats, a
technique in which elements are added or diverted to create patterns. This technique dates to 4,000 BP (Anton 1987; Bird et al. 1985; Emery 1980). In northern Chile, similar twined reed fragments were found at Acha, and similarly worked plant fiber mats were common from at least 8,000 years BP (Arriaza 2008; Standen and Santoro 2004). The Chinchorro are characterized by their distinctive, complex processes for the treatment of the dead (Standen et al. 2017), so unsurprisingly, the vast majority of the twined fragments from Archaic period sites in the archaeological record come from burial contexts. Nevertheless, the interpretation of the function of the open-twined fragments at Caleta Vitor is complicated by research showing other domestic applications for twining, including baskets, cloaks, floor matting, and house construction. Significantly, many of the fibers that were used to fasten the wefts in the twined fragments were spun in a clockwise direction, resulting in a Z-spin, and then they were plied in a counterclockwise direction, giving an S-ply. Just 6 of the 91 camelid threads from the site display S-spin and Z-ply. As with the camelid threads, the cotton threads were mostly Z-spun and S-plied and replied in the Z-direction, with only two threads constructed in the S-spin, Z-ply orientation. This technique appears to be a cultural preference: spinners at other sites in the south-central Andes also favored Z-spun, S-plied threads (Oakland 1986). Using criteria for thread thickness identified by Emery (1980), we found that most of the camelid threads displayed medium to tight twist angles in plying (40°–20°) and tight to very tight angles in the initial spin (20°–10°). Although thread thicknesses varied between artifacts (0.3 mm–1.8 mm), this attribute appears to be contingent on function. Individual threads were relatively evenly spun and plied, reflective of a well-practiced craft rather than the work of novices. Nevertheless, further refinement is notable in the appearance of the finest threads (0.3 mm thick) in the latest periods. Vegetal thread construction did not achieve the same consistency as camelid thread production,
though the Z/S orientation was still preferred, with only 17.24% of threads displaying the S/Z orientation in Formative period units (Supplemental Table 2). As expected, interlaced camelid fiber textiles were found in the Late Formative period sequences in balanced and warp-facing structures, with a 1:1 tabby weave, along with a fragment of cotton textile, dyes, and warp stripes (Figure 8). Interlaced textiles in Caleta Vitor’s Formative period were probably produced on looms with heddles rather than by handpicking, as in earlier looms. This interpretation is based on evidence for interlaced textiles of comparable age from the Azapa Valley (Azapa 70 site), where a similar suite of techniques has been identified, with the addition of some weft-facing structures (Ulloa 2008). According to Ulloa (2008), the tunics and other warp-faced artifacts from Azapa 70 belong to a broad regional textile tradition that stretches from the Azapa Valley to the Loa region (Agüero and Cases 2004). Even though the samples from Caleta Vitor were much smaller and fragmented than those found at Azapa 70, the co-occurrence of 1:1 balanced tabby weaves, warp-striped, and plain warp-faced structures suggest that they belong to the same textile tradition. Despite the lack of extant remains of looms in Chile, scholars have established that the heddle loom (an advanced version of the backstrap loom) was in use in the region during this time. Technical evidence comes from the fineness and regularity of tunics, bags, and other items excavated from the Azapa Valley combined with evidence of contact with highland groups known to have this technology (Agüero 1995; Agüero and Cases 2004; Ulloa 2008). Significantly, the heddle loom type was common in Peru from 4,000 to 3,800 BP (Doyon-Bernard 1990).
Figure 6. Earliest cotton thread recovered from the Caleta Vitor archaeological complex; (b) The early cotton thread (a) at 400X magnification, showing diagnostic convolutions.

Figure 7. Small fragment of vegetal twining from CV2/1/3.
5.5 Conclusions

Significantly, the heddle loom type was common in Peru from 4,000 to 3,800 BP (Doyon-Bernard 1990). Additional evidence for increased contact between Caleta Vitor and the highlands comes not only from the aforementioned camelid fecal pellets but also the presence of snuff trays. Combined with the archaeological textile evidence, these diagnostic artifacts and camelid pellets confirm greater mobility than previously evidenced throughout the established Chinchorro sphere of interaction, from down the coast to the Loa River area and up to the highlands. Yet the evidence suggests that the weavers of Caleta Vitor were not strongly influenced by highland styles or techniques until the late Intermediate period as shown by the appearance of interlacing and weft-faced structures. These research findings are in accordance with those of Cassman (1997) that showed minimal influence before 1300 BP. Neutron activation studies on pottery clays (Bland et al. 2017) demonstrated that the production of utilitarian pottery at the site remained “stable and local” throughout the Formative and later periods despite external influences. Based on iconography and technical analysis, Ulloa (2008) also detected a similar decline in highland influence among Azapa 70 weavers. Whether these variations in influence reflect differences in migration or trade is difficult to determine, but it is clear that the weavers at Caleta Vitor remained focused on local traditions through to the end of the Formative period.
Figure 8. Interlaced fragments: (a) 8231–1 camelid fiber in balanced, 1:1 plain weave; (b) 8347 camelid fiber in warp-striped plain weave; (c) 8233–8 cotton warp-faced plain weave.
5.6 Acknowledgements

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Supplemental Materials. Supplementary material accompanying this paper is presented in Appendix A.
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Statement of Contribution: Inka Interaction with Remote Groups in Northern Chile: A Case Study using Camelid Fiber as a Proxy for Inka Involvement at the Pacific Caleta Vitor Bay

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Signed
Ms. Tracy Martens

Judith Cameron:
Participated in research question development, drafting and editing of the research paper. Contributed to technical analysis.

Signed
Dr. Judith Cameron
Chapter 6. Inka Interaction with Remote Groups in Northern Chile: A Case Study using Camelid Fiber as a Proxy for Inka Involvement at the Pacific Caleta Vitor Bay

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Abstract

Classical Cusco architecture and Inka material culture have long been interpreted as proxies for Inka influence in South American archaeology. As a corollary, the absence or the scarcity of Inka style artefacts at many coastal sites in northern Chile has been interpreted as evidence that this region was not directly under the hegemony of the Inka Empire. On this basis, the archaeological complex at Caleta Vitor was initially deemed to have experienced minimal external influence but recently the conventional defining characteristics of Inka influence have been challenged by archaeologists who now extend them to include provincial Inka architecture and road construction as well as mining operations - one of the hallmarks of state organized labour across the region. In this paper we suggest Inka influence may also be discernible through changes in the material composition of archaeological textiles at the Caleta Vitor site, specifically the preponderance of camelid fibers in shell midden deposits from the Late Period, a period that is concurrent with the intensification of the exploitation of marine resource.
6.1 Introduction

The Late Period in the South Central Andes is characterized by broad-scale Inka influence (Santoro and Uribe 2018). In Northern Chile, Inka influence is described as heterogeneous; contingent on geography, local populations and resources from which mit’a (taxation) could be extracted (D’Altroy 2003; Murra 1956; Santoro et al. 2010; Zori and Urbina 2014). Notwithstanding the imposition of state economic controls and organized labor in each respective region, everyday objects continued to be “made, used and discarded in village economies” with little or no political interference from the Inka (D’Altroy 2003:202). As a consequence, archaeological evidence for Inka influence in terms of classical Inca traits has been both difficult to detect and highly variable from site to site (D’Altroy 2003; Santoro and Uribe 2018; Zori et al. 2017). Correspondingly, the initial archaeological investigations of the Late Period materials from the Caleta Vitor site (Carter 2016) found little evidence of Inka political interest or imperial impact on the local economy.

Archaeological textiles are a little studied artifact class yet they are uniquely suited to this line of inquiry particularly as fiber and fiber implements played an important role in the rise of Andean social complexity, as trade goods in Inka exchange and as powerful cultural symbol (Beresford-Jones et al. 2018; D’Altroy 2003; Murra 1962). At Caleta Vitor, locally available vegetal fiber artifacts were the most common materials in the Middle and Late Archaic sequences, even after camelid fiber was incorporated into the fiber processing industry (Martens and Cameron 2019). During the Archaic and Early Formative Periods, camelid fiber was obtained by hunting Guanacos, which would not have been uncommon along the coast at Taltal and Cerro Moreno Antofagasta.
It is commonly suggested that significant changes in camelid fiber procurement occurred during the Late Formative Period when trade routes using camelids were established with the highlands (Carter 2016). At Caleta Vitor this argument is supported by concurrent increases in camelid droppings, highland products and camelid fiber (Martens and Cameron 2019). It is possible that during the Late Period, trade relations between the Inka and local polities in northern Chile, including Vitor Bay, were formalized following the expansionary campaign of Topa Inca Yupanqui (ca. 1471-1493) into northern Chile, introducing state control of commodities and organized state labor (Santoro and Uribe 2018, citing Jimenez de la Espada 1965).

Inka administration in the north of Chile was conducted through tambos in the Arica highlands (Santoro and Uribe 2018) and the commodification of textiles and fiber under the Empire’s strict economic controls is strongly attested (Murra 1962). In the Late Period, fiber implements such as fishing lines, nets and tethers continued to be central to the marine economy of Caleta Vitor. Given these factors, it is enticing to conclude that camelid products were increasingly imported from the highlands, and this is commonly asserted in the literature. However, our isotopic investigation (presented in Chapter 8 of this thesis) clearly indicates that camelid fiber was a product of the lomas plant formations and not the highlands. Therefore, we interpret changes in the proportion of camelid fiber in the Caleta Vitor assemblage, indirectly, to Inka influence but note that the fiber was not a highland product. The data suggest that the increase in camelid fiber is more likely owed to population increase, related to Inka expansion and trade, and the corresponding need for more fiber implements.
6.2 Methodology

All of the fiber remains excavated previously by Carter (2016) at Caleta Vitor were analysed in Arica, Chile at Laboratorio de Arqueología y Paleoambiente, Instituto de Alta Investigación (IAI), Universidad de Tarapacá (UTA) between March and May 2016. The construction techniques were identified and described in accordance with classifications devised by Adovasio (1977), Emery (1980), Wendrich (1991) and Jolie (2011). All items were initially inspected with the unaided eye, followed by examination and photography under an Aven 26700-302 zipScope at 50X magnification and photographed with a Cannon 30x handheld, digital camera. Dimensions were measured using digital and conventional callipers.

The items under analysis were then divided into three broad categories based on material composition: animal, vegetal and cotton. Despite the fact that cotton is a vegetal fiber, it is categorised and described separate from vegetal fiber owing to its exogenic origin and the clear differentiation in the treatment of this material. Following initial determinations, a dissecting microscope was used at 400X to verify identifications of the camelid and cotton fibers. Because the technical analysis of the fragments was the focus of the research, time did not permit any archaeobotanical research although this is planned for a future project.

Once material composition was established, structural composition was determined. The number of elements (twist, spin, ply and reply) were measured and recorded using criteria developed by Emery (1980, 8–14). Once these basic characteristics were identified, fabric structures were identified. Attributes such as condition, color, tightness and angle of twist were also documented.
6.3 Caleta Vitor Archaeological Complex

The Caleta Vitor archaeological complex is located between the Azapa and Camarones valleys on Chile’s far north coast, at the Pacific terminus of Quebrada Chaca/de Vitor, a deep, steep-sided ravine that carries fresh water across the hyper-arid Atacama Desert from the Andean highlands to the Pacific coast. Quebradas make human occupation in this terrestrially barren region possible, cutting across the steep and untraversable coastal cliffs of northern Chile thereby providing access to the rich marine biomass of the coastal waters and provisioning the only fresh water in the area (Rivera 2008; Rivera 1991). Archaeologists have produced firm evidence of occupation in the region from the Late Pleistocene when the first inhabitants established a marine economy that supported life for thousands of years into the Late Holocene (Núñez et al. 2002; Sandweiss et al. 1998; Santoro et al. 2005).

The first extensive and systematic excavations of the complex were led by Chris Carter from 2008-2010. Carter divided the Caleta Vitor complex into eight sectors that include middens, burials and cave rock art, (ranging in age from the Early Archaic through to the Late Period) (Table 3) (Carter 2016). The Late Period data relevant to this paper came from Trenches CV4/1 and CV6/1. Both trenches were excavated to a depth of approximately 80 cm into dense midden deposits characterized by well-defined stratigraphy containing 25 distinct units dated to the end of the Late Intermediate Period through to the Late Period (Table 3). The units contained abundant marine animal bone and shell, maize, ceramics and camelid droppings as well as algarrobo (Prosopis spp.), molle (Schinus molle), cotton (Gossypium barbadense) and squash (Curcubita spp.). Cultural deposits continued well below the basal layers in both trenches (Santoro et al. In press; Carter 2016; Roberts et al. 2013).
Table 3. Radio Carbon Dates from Caleta Vitor Archaeological Complex, after Carter (2016:222).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Context</th>
<th>Material</th>
<th>Cal Age BP</th>
<th>Cultural Period</th>
</tr>
</thead>
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<tr>
<td>UGAMS10522</td>
<td>CV6/1/8</td>
<td>Maize</td>
<td>500-543</td>
<td></td>
</tr>
<tr>
<td>UGAMS10517</td>
<td>CV4/1/1</td>
<td>Seeds</td>
<td>529-631</td>
<td>Late/Inka Period (500-560 BP)</td>
</tr>
<tr>
<td>UGAMS10518</td>
<td>CV4/1/19</td>
<td>Maize</td>
<td>535-646</td>
<td>Late Intermediate Period (900-600 BP)</td>
</tr>
<tr>
<td>UGAMS10523</td>
<td>CV6/1/16</td>
<td>Maize</td>
<td>551-650</td>
<td></td>
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</tbody>
</table>

6.4 Fiber Technology and the Economy at Caleta Vitor

Throughout the Archaic and much of the Formative Period, the people of Caleta Vitor belonged to a widespread cultural group known as the Chinchorro, famous for their well-developed socio-economic and technological systems adapted for coastal habitation as well as early, complex mortuary procedures that included a variety of mummification techniques (Arriaza 1995; Arriaza et al. 2005; Santoro et al. 2012; Standen et al. 2017). The Chinchorro occupied coastal settlements extending from the Ilo River in southern Peru to the Rio Loa in northern Chile, maintaining similar subsistence strategies, material cultural and burial practices (Ulloa 2008; Marquet et al. 2012; Rivera 2008; Arriaza et al. 2005). Their subsistence economy was heavily reliant on fibers for nets, lines and tethers, produced from locally available species, particularly fibers from the Cyperaceae family of sedges (Cassman et al. 2008).

During the Late Formative Period, pan Andean changes in subsistence strategies, socio-cultural and technological patterns permeated pre-Columbian societies (Solis et al. 2001). Evidence of highland material culture as well as materials from the tropical forest on the eastern side of the Andes appear along with the introduction of exotic crops, incipient agriculture, camelid fecal matter and snuff paraphernalia for the consumption of
hallucinogenic drugs, and new burial customs appear at sites across the region. In the fiber assemblage from Caleta Vitor, a steady decline in vegetal fibers culminating in the dominance of camelid fiber by the Late Formative Period was previously recorded (Martens and Cameron 2019). This shift accords with previously observed transformations through other archaeological Formative contexts at the site including maize, camelid droppings, cotton seeds, the appearance of burial mounds, and ceramics (Carter 2016).

These economic changes do not appear to be consistent across the region. By the Late Period, the subsistence economy of Caleta Vitor had diverged from that of the neighbouring groups living in the interior of the Azapa and Lluta Valleys where intensive maize agriculture was underway and isotopic analyses show a subsequent reduction in marine resource consumption (Santoro et al. 2016; Valenzuela et al. 2015).

During the Late Period at Caleta Vitor, maize and other domesticates appear in the archaeological record without any associated evidence of intensive agriculture. Instead, there is evidence of increased intensity in the maritime economy that coincides with increased population and pottery discard rates (Carter 2016). Camelid remains and evidence of camelid consumption appear throughout interior habitats in northern Chile during the Formative (Muñoz et al. 2016) whereas at Caleta Vitor only camelid faecal pellets appear during this period, increasing in abundance through to the Late Period (CV2/1, CV4/1, CV4/6, CV6/1, CV6/2 and CV6/3) without any macroscopic archaeological evidence of camelid breeding or consumption (Carter 2016:244). Moreover, Inka style artifacts are sparse at Caleta Vitor, with the recovery of just a single pucu dish (Carter 2016), and an Inka unku discovered following a looting incident (Martens et al. under review).
6.5 Fibre Analysis and Distribution

Altogether 711 fiber artifacts (Table 4) were recorded from 25 excavation units dated from the end of the Late Intermediate Period through the Late Period based on recently obtained radiocarbon dates (Table 3). The highest concentrations of fiber artifacts occurred in units CV6/1/9 (n=156) and CV4/1/11 (n=101) accounting for 36.1% of all recorded fiber artifacts. Artifact deposition rates appear consistently in both trenches with all but the bottom two units of CV6/1 (15 and 16) producing at least one fiber-based artifact. Carter (2016:422) reports that midden deposits comprising CV4/1 and CV6/1 were deposited in a very short timeframe and temporal variations in ceramic discard are mirrored in the two trenches (Carter 2016:237). Additionally, both trenches produced similar assemblages of fish bone, shell, lithics and ceramics; no zone specific differences between could be inferred.

The methodology used for the analysis is shown below. In total, 90.2% of the artifacts were identified as camelid fiber and 7.2% were cotton with the remaining 2.6% comprised of vegetal fiber (Table 2). Almost 2% (n=13) of the yarns were bicolored camelid fiber and 3.3% (n=23) of artifacts were dyed (Table 4). Interlaced textiles (Figure 8), one of which contained a ball of compressed white powder (Figure 9), indicate knowledge of more complex weaving techniques. These units also produced a partly complete sling (Figure 10) and a fragment of coiled basketry (Figure 10), as well as a maize cob (Figure 10) and a stone wrapped in cotton yarn (Carter 2016, fig. 7.11).
Table 4. Late Period Fiber Artifact Attributes from Caleta Vitor Archaeological Complex: numbers indicate the occurrence of particular attributes in the collection.

<table>
<thead>
<tr>
<th>C14 date</th>
<th>Context (CV unit/Trench/excavation unit)</th>
<th>Camelid</th>
<th>Vegetal</th>
<th>Cotton</th>
<th>Interlaced&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Twined&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Coiled&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Dyed&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Knotted</th>
<th>Detail</th>
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<td>6/1/8</td>
<td>18(Z/S)</td>
<td>1(?)</td>
<td>5(Z/S)</td>
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<td>124(Z/S)</td>
<td>9(Z)</td>
<td>1(Z)</td>
<td>1(Z/S) 1(I)</td>
<td>6(Z/S) 3(S/Z)</td>
<td>5</td>
<td>1</td>
<td>2(A)</td>
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</table>

NOTE. Context refers to the assigned zone at Caleta Vitor/the trench number and the excavation unit (see Figure 1) A= camelid fiber, (c)=cotton, <sup>a</sup>all interlaced fabrics are camelid unless specified, <sup>b</sup>twining is vegetal, <sup>c</sup>coiling is vegetal, <sup>d</sup>dyed fibers are all camelid, (BY) bicolor yarn.
6.6 Structural Composition

The majority (90.8%) of the yarns in the assemblage were Z/S constructions, conforming to the South Central Andean convention reported by Oakland (1986:45). Spin direction is a geographically consistent trait in textiles from the region, motor habits developed while each spinner learns spinning and plying (Edward Jolie personal communication 2018).

6.6.1 Camelid

In terms of material composition, camelid yarns (n=635) were the most common in the assemblage. Spin and ply direction were very consistent with 96% conforming to Z/S spin direction. Camelid yarns varied in thickness (1-4.1 mm; averaging 1.2 mm) suggesting a range of applications for the finished products. The angle of twist in the yarns ranged from loose to very tight (0.4 - 15 twists per 5 mm, averaging 2.91 twists/5mm). Yarn colors ranged from light brown to black and included red, brown, and orange colored fibers. A few examples were white. The dyed yarns were red, green and yellow in color.

6.6.2 Vegetal

Vegetal cordage received limited preparation, made by simply twisting single elements of limited length (Figure 10). Twist directions were evenly split between Z/S (43%) and S/Z (43%) with the remaining 14% consisting of untwisted single elements. Most vegetal cordage measured between 3 and 8 mm in thickness with only one finer example measuring 1.2 mm.
6.6.3 Cotton

Cotton yarns were slightly more consistently processed, with over half produced in the Z/S direction (59%) with the remainder processed in S/Z (41%) (Table 4). The cotton yarns were generally fine, and comparable to camelid fiber yarns (0.4- 2.7 mm; averaging 1 mm in thickness). The angle of twist of cotton yarns was moderate (2 to 6 twists per 5 mm; averaging 2.4 twists). The cotton yarns were not dyed; most were natural brown in color with hues of yellow and orange.

6.6.4 Colors and Colorants

A greater diversity in the color of camelid yarn color was observed in the Late Period segments compared to the previously analysed from the Archaic and Formative Periods that consisted almost entirely of red/brown yarns (Martens and Cameron 2019). According to Dransart (1991:316), diversification in wool color reflects change from the usage of wild guanaco or vicuña which have cinnamon/brown coats with some white to the usage of domesticated llama or alpaca which have a greater range of colors, including shades of red, brown, black and white.

Dyed yarns rarely appear in the assemblage and it is not immediately clear if they were produced locally or were trade goods. Pre-Columbian dyestuffs include a dizzying array of plant roots, stems and leaves as well as the cochineal beetle (Dactylopius spp.) which is native to central and south America, and mineral mordanting agents such as alum, lime and urea that are necessary to achieve desired hues (Cardon 2007; Lambaré et al. 2011; Niemeyer and Piwonka 2015; Wouters and Rosario-Chirinos 1992).
6.6.5 Twining, Coiling and Interlacing

Basketry and vegetal cordage were scarce with a single example of the twining technique consisting of the active element constructed in the Z-direction (Figure 10). Only one fragment of coiled basketry was identified (Figure 10. The fragment is comprised of a stiff, lightly processed, grass bundle base making up the core passive element and untwisted lengths of vegetal cordage comprising the active element. The active element is passed around the bundled grass that makes up the passive element. The active element does not interact with itself (it is non-interlocking) and the item was worked in a clock-wise direction.

Fabric construction was identified in ten examples of interlacing - nine in camelid and one in cotton (Figure 9). All fragments are 1:1 warp faced plain weaves in natural brown and reddish-brown camelid fiber with one in brown cotton segment and one camelid example featuring dyed green and red stripes (Figure 9).
Figure 9. (a) 1:1, Warp striped camelid fiber interlacing, CV4/1/14. (b)
Warp facing textile fragment with lime/calcite ball, CV6/1/9 Caleta Vitor.

6.6.6 Other Textile Artifacts

As mentioned, the assemblage also contained a sling (Figure 10). Slings are synonymous with terrestrial hunting and herding activities depicted on ceramic figurines (Bjerregaard 2010). Slings were also used as weapons and as headgear or worn around the waist in Late Period burials in the Arica region (Cassman 1997). Slings usually consist of two main components - a central, rectangular cradle with a cord extending from each end, often with
a loop or tassel at the ends. The Caleta Vitor sling is made of light and dark brown camelid fiber although one side is entirely missing while the remaining cord was broken roughly in half and mended using less decorative, finer cord. No attempts appear to have been made to match the repair with the original, although the replacement is produced using a similar technique. The original cord was fist braided, a technique described in detail by Bjerregaard (2010) that is still used in the region to produce slings for costumes worn by the Tinkus dance groups of Arica (Figure 11). As the name implies, fist braiding is done manually without tools (2010: fig.5). Cords are commonly embellished with diamond patterns created using 2-span floats as evidenced in the example. Cradles are usually interlaced with a slit in the middle.

Figure 10. (a) Sling, CV6/1/9 (b) Sling dove-tailed join detail, CV6/1/9 (c) Fragment of coiled basketry, CV4/1/7 (d) Maize cob wrapped in cotton yarn, CV6/1/2 (e) Length of vegetal yarn from twisted, single elements, CV6/1/11 (f) Active element of vegetal twining.
The Caleta Vitor sling cradle is interlaced with dove-tailed tapestry joins (see Emery 1980:80) that create a checker-board pattern (Figure 10). Two other associated artefacts from trench CV6/1 probably functioned as bobbins used to hold lengths of spun yarn between production and use (Figure 10). Function is indicated by cotton yarn wrapped around a maize cob and an unworked stone wrapped in a similar way (Arnold 2018, fig. 7). Highland weavers still use these unusual devices where they are known as a khiwina qala (Arnold 2018).

A ball of compressed white powder was also wrapped in a fragment of 1:1 warp faced, plain weave brown cotton cloth (Carter 2016, fig. 7.6). Carter (2016:238) identified the ball as lime or calcite remains belonging to the 8,000-year-old Andean tradition of coca leaf chewing, a practice also evidenced by these components and cocoa leaves in northern Peru at Las Pircas and Tierra Blanca (Dillehay et al. 2010). The concoction releases alkaloids from the leaves, precipitating the desired stimulant that is used to suppress hunger, provide...
energy and relieve the effects of altitude sickness. The leaves were clearly important to the Inka economy and ceremonies were carried out by Inka using highly elaborate textile bags as emblems of imperial authority (Hughes 2010). One such bag was recovered from Caleta Vitor still containing coca leaves, though it lacks archaeological provenance owing to looting (Figure 12).

6.7 Discussion

Fiber and processed fiber items like textiles were central to both the Inka and Caleta Vitor economies (Martens and Cameron 2019; Murra 1962). Fiber items were also essential components of the marine technologies on which the coastal inhabitants of Caleta Vitor depended. Carter (2016:387) estimated that net-caught fish species accounted for 33.1% of total fish weight while larger, line caught or speared species, made up 60% of fish body weight represented. Moreover, isotopic research indicates a near total reliance on marine resources at the site (Roberts et al. 2013).

The textile industry at Caleta Vitor was initially plant based, with 65% of the items from the Middle Archaic made from local sedges and grasses with that proportion dropping through to the Formative Period with just 36% of the artifacts being plant based whereas 57% were camelid (Martens and Cameron 2019). This initial change in fiber type coincides with the appearance of camelid droppings at the site, presumably resultant from the arrival of camelid caravans from the highlands (Carter 2016) or other yet unknown forms of interaction.
Figure 12. Bag containing coca leaves, CV2/3.
The Late Period assemblage described here, appears to mirror the changes previously described for Archaic and Formative Periods that were concurrent with the increased usage of camelid fiber and decreased usage of vegetal fiber (Martens and Cameron 2019). Over 90% of the fibers under analysis were camelid, while vegetal fibers were much rarer (2.6%) with cotton slightly more common (7.2%) than in the Formative Period (3.9%). As with the Formative Period, this shift in raw material was accompanied by a significant increase in camelid droppings at the site. Carter (2016:354-355) reports that 23 of the 25 units analysed contained camelid droppings and the surfaces of both CV4 and CV6 assigned to the later Formative Period had substantial deposits of them.

Construction techniques used to make the analysed fragments did not vary from those recorded for the Formative Period where there was a predilection for warp-faced plain weaves and warp stripes. All of these items were probably made on back-strap looms with heddles, an interpretation attested by the fineness and regularity of the weaves, along with warp striped fabrics (Martens and Cameron 2019). The appearance of a sling was not unexpected as many have been reported in the Arica region, but it is not immediately clear if this item of material culture was imported or locally made, though it seems more likely to have been an import given its connection to herding activities which were not evidenced at Caleta Vitor. Coiled basketry is not common at the site, first appearing with ceramics and other highland technologies during the Formative Period.

The maize cob and rock wrapped in cotton thread provide the first direct indication of on site textile production at Caleta Vitor. While it is possible that textiles were produced locally from the Archaic Period onwards, these unusual winding devices provide direct evidence of yarn curation prior to use.
Ulloa (2008) has already identified and described a broad scale textile tradition stretching from the Azapa Valley through the Rio Loa that featured warp-faced textiles, stripes and specific tunic styles which began in the Formative Period. The same textile tradition was clearly apparent at Caleta Vitor over the same period where it seems to have continued into the Inka Period, although the intervening Middle Horizon and Late Intermediate Periods remain unstudied. Nevertheless, such continuity suggests that the autonomy identified in local ceramics production, where local clays were favoured throughout the Late Periods (Bland et al. 2017), also characterised fiber processing.

In terms of Inka hegemony, it is clear that the Inka approach to new territories was highly variable and although the Empire is better-known for large-scale projects such as the Inka Road System, mining operations and state organized craft production, many necessities of life village continued to be produced in villages for daily consumption, largely unhindered by the state (D’Altroy 2003; 202-203, 289). Moreover, the Inka integration of northern Chilean coastal populations did not include the construction of large scale architecture. Rather, it was accomplished through a variety of socio-economic arrangements including the extraction of natural resources, intensification of previously established activities such as maize agriculture and the imposition of tax.

It has only recently been established that at least one trade network was administered through Tambo Belen and/or Zapahuira in the Arica highlands to supply coastal products such as marine bird guano fertilizer, maize and fish to the highlanders (Carter 2016; Santoro 1995; Santoro and Uribe 2018). Our research has demonstrated that the period of Inka influence at Caleta Vitor was marked by the in extraction of marine resources and increased
instances of camelid fiber. With the presence of the Inka established in the region, it seems plausible that the noted changes in these materials at Caleta Vitor may be related to Inka expansion into the region. It is possible that the intensification of the traditional maritime economy of the people at Caleta Vitor was a consequence of population increase related to Inka expansion or, possibly, a political arrangement between Inka State officers and local leaders that resulted the intensification of local maritime productivity as part of the corvee labor system known as mit’a imposed by the Inka on local populations where Inka officers provided local leaders with certain luxury goods (i.e. pottery, textiles) in order to foster prestige at a local level.

The Late Period sequences show a significant change in the choice of raw materials - vegetal fibers were almost abandoned during this period and camelid fibers were preferred in Caleta Vitor. Previously, this increase has been attributed to the increased availability of these fibers via the camelid caravans traveling the east-west Inka Road System to exchange for marine resources, including marine bird guano fertilizer that were highly valued by the Inka. However, isotopic signatures (presented in chapter 8) of this thesis indicate that local camelids foddering on lomas vegetation supplied the fiber needs of the people of Caleta Vitor. This finding suggests that the increases in camelid fiber at the site reflect local changes including population increases and perhaps an increase in the availability of camelid fiber through increased local exchange, probably facilitated by llama caravans as evidenced by the concurrent increase in droppings at Caleta Vitor.
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Signed
Ms. Jacqueline Correa

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Christopher Carter: Data acquisition (excavation), writing and editing drafts.

Signed
Dr. Christopher Carter

Judith Cameron: Participated in research question development, drafting and editing of the research paper. Contributed to technical analysis.

Signed
Dr. Judith Cameron
Chapter 7. An Inku Unku from the Caleta Vitor Archaeological Complex, Northern Chile

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Abstract

As insignia of power and prestige, Inka unku (tapestry tunics) communicated the strength and extent of Inka socio-political hegemony in the Andes. Of the 38 extant examples we have located, 21 are from archaeological sites between Pativilca and the Acari Valley in Peru while the remainder are from unspecified regions of Peru or have no provenance. Given the rarity and socio-political significance of these garments, the discovery of an Inka unku at Caleta Vitor, a remote coastal site on Chile’s far north coast that has long been seen as peripheral to Inka interest is significant. This paper describes this previously unknown unku type using established technical and stylistic criteria and explores the socio-political ramifications of the discovery and the relationship it implies between the site and the State.
7.1 Unkus: Insignia of Inka Power

Inka tapestry tunics (unkus) (Figure 13), especially those with toqapus (Figure 13a), were highly symbolic Andean garments, symbols of Inka power and wealth that were directly linked to the top levels in the socio-political organization of the Inka Empire (c.1400 and 1533) (Cummins 2007; Pillsbury 2002; Rowe 1979). The Sapa Inka, for instance, not only wore unku, woven by specialists from the finest fibers of the Andean camelids (vicuña wool), but also bestowed unkus as imperial gifts on male official representatives, leaders of recently conquered territories and military commanders (Murra 1975; Rowe 1992, 1978; Rowe 1979). According to Pedro Pizarro, the Inka also stored worn unkus for redistribution to people of lower socio-economic status to perpetuate a strategy of asymmetric reciprocity which created a requirement for recipients to compensate the State for its generosity (Murra 1975). These gifts were also integral in negotiations between State officials and regional leaders where the Inka transferred a certain quota of political power materialized in prestigious goods like unkus (Bauer and Covey 2002; Murra 1975; Rostworowski 1988; Santoro 2016; Santoro et al. 2010, Santoro and Uribe 2018; Uribe 2004; Zori and Urbina 2014).
Just as toqapus were associated with royalty, unkus of lesser quality featuring the checkerboard pattern (Figure 13b) were usually associated with the Inka military, though checkerboards can also be found on royal attire. The symbolism of Inka corporate art is deeply rooted in the cultural history of the central Andes (Berenguer, 2013: 336). As Bray (2000) points out, without a system of writing, Inka iconography and spatial organization in other items of material culture were highly meaningful. It is not coincidental that different forms of art including Aríbalos and unkus shared the same iconography and spatial organization:

“Imagery expressed in the imperial art of the Inca aided in the construction of state authority and can inform about the nature of rulership. Given that the Inca never developed a writing system, it might be assumed that state art potentially played a larger role in conveying information, communicating identity, and legitimizing elite rule” (Bray 2000:169).

Given the symbolic role of unkus as insignia of Inka power, the discovery of an unku (Figure 14) from a pre Hispanic archaeological context at Caleta Vitor, (Figure 15) an isolated bay on the far north coast of Chile, advances of our current understanding of Inka interaction with the relatively small polities of this region. More broadly, this discovery serves to emphasize the concept that this rather marginal territory was part of the heterogenous, rich scope of ecosystems embraced by the Empire throughout the Andes. Here we compare the stylistic and diagnostic technical attributes of the Caleta Vitor unku, henceforth known as CV unku, with attributes of previously documented unkus and historically depicted unkus (Cummins 2007; Hughes 2010; Rodman and Cassman 1995; Rowe 1979; Rowe 1978; Pillsbury 2002).
7.2 The Inka/Late Period Northern Chile

The now famous Inka Road network or Qapaq Ñan (Figure 15) reached the coastal settlements of northern Chile during the southern expansion campaign initiated by Topa Inka Yupanqui (ca. 1471-1493). By then, the Empire sprawled some 5,000 km to the south of Ecuador (Jimenez de la Espada 1965). Murra (1962: 722) and Hughes (2010: 148) attribute the expansion and eventual administration of this vast territory to the production and regulation of textiles which were integral to the spread and maintenance of the economic

Figure 14. (a) The CV unku, folded in half, as worn. (b) The CV unku laid flat out with neck slot in the center. Photo courtesy Paola Salgado.
Figure 15. Map showing known and proposed Inka roads in Northern Chile, southern Peru and Bolivia, important archaeological sites, modern cities and known Inka unku sites.

and political and ideological systems central to the Inka State. The vast network of roads were strategically located to connect productive areas and urban centers, where yields were obtained through the labor tribute (mit’a) (Carter 2016; D’Altroy 2003; Murra 1962, 1980, 1989; Santoro 2016; Santor and Uribe 2018; Santoro et al. 2010; Zori and Urbina 2014). The Caleta Vitor complex lies at the mouth of the Chaca Valley, one of the nodes in the Inka Road network (Figure 15), connecting littoral regions rich in sea bird guano such as Morro de Sama, in southern Peru to Iquique in northern Chile (Julien 1985; Santoro et al. 2010).
This littoral branch of the network was connected through a transversal trail to the south via Hacienda Camarones to the major trade hub of Tarapacá Viejo, which was part of the southern royal major branch connecting el Cusco to Santiago of Chile. It was used by Diego de Almagro when returning to Cusco in 1537 and later by Pedro de Valdivia on his journey to colonize the Capitania of Chile (Santoro 2016; Santoro and Uribe 2018; Zori and Urbina 2014).

Unlike previously identified Inka sites, Caleta Vitor bay is not directly connected to farming nor grazing land and evidence of agriculture and camelid pastoralism is notably absent in the pre-Inka sequences at the site. Highland migrants arrived in the region thousands of years before the Inka (Formative Period 4000-2500 BP) along with domesticates (llama, alpaca, maize), distinctive cultural practices (burial rights) and technologies (backstrap loom, ceramics). These new technologies were gradually adopted across the region, with Azapa Valley becoming an important agricultural center (Rivera 1991, McRostie et al. 2017; Ugalde et al. 2012). People at Caleta Vitor, however, remained staunch marine hunter-gatherers (Carter 2006; Roberts et al. 2013; Santoro et al. 2017) as has been observed in other locations along the Pacific coast of northernmost Chile, until late in prehistory (García and Uribe 2012; Pestle et al. 2015).

The ensuing period, contemporaneous with the Tiwanaku polities that developed and expanded from the circum Titicaca lake region in the highland of Bolivia (1500-1000 BP), strengthened interactions between highland and lowland people. Major social disaggregation amongst Tiwanaku polities coned with stressful environmental conditions (drought) provoked significant socio-political and geopolitical change in the region, followed
by inter-group tensions associated with the Late Intermediate Period (1000-660 BP) when camelid caravanning, increased contact and intensified long distance trade occurred across the South Central Andes.

The people of Caleta Vitor clearly participated in this trade network whilst maintaining their marine focused subsistence activities without adopting large scale agriculture. This is evidenced by maize and rodent droppings (cuy; guinea pig, Cavia porcellus) becoming common and camelid droppings increasing significantly from 650 BP onwards in zones CV4 and CV6 (Carter 2016: 354). The increase in camelid droppings is indicative of caravanning to the site, facilitated by the network of Inka Roads maintained through labor tax that connected the archaeological site to neighboring valleys and the highlands. Despite these trade links, Inka material culture at the Caleta Vitor site was limited to a single pucu dish featuring a bird-head found on the surface of CV2 and the unku that is the subject of this paper (Carter 2016:235). At the same time, there is evidence of increased population related to Inka activity, reflected by the intensification in marine food extraction and the rate of pottery discards in the Late Period deposits of CV4 and CV6 (Carter 2016).

7.3 The Archaeological Context

Caleta Vitor is at the coastal end of Quebrada Chaca/ de Vitor (Figure 15), one of the five narrow, steep-sided canyons that reach the Pacific coast of the Atacama Desert of northern Chile (Standen and Santoro 2004, Núñez and Santoro 2011, Roberts et al. 2013). Intermittent streams flow in the bases of these formations, providing fresh water from the high Andes which supports a limited range of vegetation on fluvial terraces and areas with
subterranean water along the stream’s outlet. The quebradas are deeply incised (>1 km) at the Coastal Cordillera, upon reaching the sea (Hoke *et al.* 2004). The Caleta Vitor site is a circumscribed archaeological complex concentrated in the southern margin of the mouth of Quebrada Chaca (18°45’09.94’S, 70°20’08.65’W). The northern portion of the quebrada mouth lacks a marine terrace, making it less suitable for habitation than the southern portion, with no space for residential or burial activities. The coastline outside the mouth is bounded by high cliffs (700-1,000 m asl) and the absence of marine terraces making access the shore difficult or impossible on foot. Consequently, the mouth of the quebrada represented the only access to the marine resources of the coast, accessible by walking a marked path on the slope of the valley which remains visible today (Figure 16).

*Figure 16.* Well-worn walking path along the southern slope of Quebrada de Vitor.
Seven archaeological sectors were delineated at the mouth of the quebrada with activity zones restricted to specific topographic features used to define the boundaries of the zones, numbered from CV1 (Caleta Vitor 1) to CV7 (Caleta Vitor 7) (Figure 1 and 4). Shell middens covered more than 525,000 m$^2$, reaching a depth of over 5 m, representing more than 9,000 years of continuous occupation by different social groups who left behind distinctive remains, including rock paintings, tumulus, burials and domestic areas. Occupation has been chronologically framed by more than 50 radiocarbon dates on a variety of different materials (plant material, shell, human bone, charcoal (Roberts et al. 2013, Swift et al. 2015, Carter 2016, Latorre et al. 2017, Santoro et al. 2017, Martens and Cameron 2019). The area has been studied by several teams who have constructed a chronology and documented various historic trajectories (Roberts et al. 2013, Swift et al. 2015, Carter 2016, Bland et al. 2017, Disspain et al. 2017, Latorre et al. 2017, Santoro et al. 2017, Martens and Cameron 2019).

7.3.1 The CV unku

The CV unku was discovered during the excavation of CV2/1 amongst a collection of artifacts discarded following the looting of a burial chamber, years before archaeological excavations began (Figure 17). Based on exposed, intact mummy bundles observed within CV2, it appears that a complete mummy was removed from the chamber in the past. Apart from the unku, other artifacts cached in the chamber included two coiled hats currently under analysis by two of the authors (Martens and Cameron in prep), a miniature bow and five arrows, five bags and numerous fragments of twined mats and textiles (Carter 2016: Figure 7.13).
Figure 17. Items recovered from a looted burial chamber exposed during the excavation of CV2/1, chucus hats, the CV unku, bags, miniature bow and arrows (photo by Chris Carter).

7.4 Methodology

The technical analysis of the CV unku was conducted at the Instituto de Alta Investigación, Universidad de Tarapacá in 2016. The garment and stylistic features were measured in accordance with protocols developed by Rowe (1979). The technical features such as thread count and weaving techniques were also recorded following Emery (1980), D’Harcourt (1962) and Rowe (1978, 1997). A schematic drawing was produced, and the artifact was photographed using a hand-held camera with detailed photos taken at 50x magnification using an Aven Zipscope. Warp and weft thread compositions were confirmed under a dissecting microscope at 400x magnification. Data generated by the technical analysis was
then compared to technical data on other unkus previously recorded by Rowe (1978, 1997), Rowe (1979) and Pillsbury (2002).

Stylistic analysis was based on a survey of published sources and online museum collections that allowed us to review 38 mostly complete unkus (Table 5) and many more fragments, augmented by illustrations in historical sources. This review in conjunction with stylistic attributes defined as diagnostic by Rowe (1978, 1997), Rowe (1979), Bray (2000) and Pillsbury (2002) focused on spatial organization, previously identified motifs (and elaborations), color and overall design.
<table>
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<th>Current location</th>
<th>Type</th>
<th>Length</th>
<th>Width</th>
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<td>Rowe 1979 (BW2), Sawyer 1968(95)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>71.1911.21.448</td>
<td>near Lima</td>
<td>Musée du Quai Branly</td>
<td>BW</td>
<td>90.5</td>
<td>78</td>
<td>Berthon, 1911, Rowe 1979 (BW3)</td>
<td>cotton</td>
<td>wool</td>
<td></td>
</tr>
<tr>
<td>1534</td>
<td>Lima, Ancon</td>
<td>Field Museum of Natural History</td>
<td>BW</td>
<td>-</td>
<td>-</td>
<td>Rowe 1979 (BW5)</td>
<td>butterflies on yoke- catalog says the piece is in two parts</td>
<td>cotton</td>
<td>wool</td>
</tr>
<tr>
<td>RT-2377</td>
<td>Peru</td>
<td>Museo Nacional de Arqueología, Antropología y Historia del Perú</td>
<td>BW</td>
<td>110</td>
<td>98</td>
<td>Dixon 2013 (Cat.181)</td>
<td>-</td>
<td>cotton</td>
<td>wool</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>National Museum La Paz</td>
<td>BW</td>
<td>-</td>
<td>-</td>
<td>Rowe 1979</td>
<td>no image provided</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>389-2357</td>
<td>-</td>
<td>California Academy of Sciences</td>
<td>BW</td>
<td>82.5</td>
<td>73.5</td>
<td>Rowe 1978, Rowe 1992 (Fig 1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Held in a private collection</td>
<td>BW</td>
<td>86.5</td>
<td>78</td>
<td>Rowe 1978</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Dallas Museum of Art</td>
<td>BW</td>
<td>88.3</td>
<td>80</td>
<td>Pillsbury 2002 (Fig 5)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V A 16621</td>
<td>Nazca</td>
<td>the Staatliche Museen zu Berlin</td>
<td>BW</td>
<td>88</td>
<td>76.2</td>
<td>online catalog</td>
<td>-</td>
<td>cotton</td>
<td>wool</td>
</tr>
<tr>
<td>TM.1966.59.28</td>
<td>-</td>
<td>The George Washington Textile Museum</td>
<td>IK</td>
<td>84</td>
<td>71</td>
<td>Rowe 1978, Rowe 1979 (IK5)</td>
<td>made in two webs</td>
<td>wool</td>
<td>wool</td>
</tr>
<tr>
<td>91.147</td>
<td>Ica Valley</td>
<td>The George Washington Textile Museum</td>
<td>IK</td>
<td>95</td>
<td>78.5</td>
<td>Rowe 1978, Rowe 1979 (IK1), Jones 1964, King 1965, Rowe 1992</td>
<td>made in two webs</td>
<td>wool</td>
<td>wool</td>
</tr>
<tr>
<td>1929.26.0149</td>
<td>Ica Valley</td>
<td>Etnografia Muset</td>
<td>IK</td>
<td>79</td>
<td>97</td>
<td>Rowe 1979 (I2)</td>
<td>-</td>
<td>wool</td>
<td>wool</td>
</tr>
<tr>
<td>x.447</td>
<td>Rio Grande de Nazca</td>
<td>The Museum Fünf Kontinente</td>
<td>IK</td>
<td>92</td>
<td>76</td>
<td>Rowe 1979 (IK3), Jones 1964</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>86.224.133</td>
<td>-</td>
<td>The Brooklyn Museum</td>
<td>IK</td>
<td>84</td>
<td>74</td>
<td>Rowe 1979 (IK4)</td>
<td>-</td>
<td>wool</td>
<td>wool</td>
</tr>
<tr>
<td>-</td>
<td>Armatambo, Lima Valley</td>
<td>Lima. Museo Nacional de Antropología y arqueología</td>
<td>IK</td>
<td>92</td>
<td>76</td>
<td>Uhle 1931, Taullard 1949, Means 1931, Rowe 1979 (IK6)</td>
<td>-</td>
<td>wool</td>
<td>wool</td>
</tr>
<tr>
<td>maybe VA31526</td>
<td>Ica Valley (or Chibote district)</td>
<td>Ethnologisches Museum</td>
<td>IK</td>
<td>88</td>
<td>70</td>
<td>Rowe 1979 (K8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Code</td>
<td>Origin</td>
<td>Museum/Institution</td>
<td>Code</td>
<td>Style 1</td>
<td>Style 2</td>
<td>Code</td>
<td>Style 2</td>
<td>Museum/Institution</td>
<td>Code</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------------------------------------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
<td>------</td>
<td>----------</td>
<td>----------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>41.2/964</td>
<td>Peru</td>
<td>The American Museum of Natural History</td>
<td>IK</td>
<td>86</td>
<td>72</td>
<td>Rowe 1978 (Fig 3)</td>
<td>Wool</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>1957.136</td>
<td>Ica Valley</td>
<td>The Cleveland Museum of Art</td>
<td>IK</td>
<td>86.5</td>
<td>76.8</td>
<td>Pillsbury 2002 (Fig 11)</td>
<td>Wool</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>27569</td>
<td>Pachacamac</td>
<td>University Museum of the University of Pennsylvania</td>
<td>TW</td>
<td>80</td>
<td>71</td>
<td>Rowe 1978, Uhle 1903, Rowe 1979 (TW1)</td>
<td>Wool</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Ica Valley</td>
<td>Museo Histórico Provincial de Rosario Dr. Julio Marc</td>
<td>TW</td>
<td>84</td>
<td>74</td>
<td>Rowe 1979 (TW2), Taullard 1949</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1960.13.7</td>
<td>-</td>
<td>The George Washington Textile Museum</td>
<td>TW</td>
<td>-</td>
<td>79</td>
<td>Rowe 1979 (TW3), Rowe 1978, Pillsbury 2002</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Quebrada de la Vaca</td>
<td>Museo Regional de Ica</td>
<td>TW</td>
<td>80</td>
<td>70</td>
<td>Katteuman 1997 (Fig 11), (2007)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1964.12.2</td>
<td>-</td>
<td>The George Washington Textile Museum</td>
<td>DW</td>
<td>91</td>
<td>74.5</td>
<td>Rowe 1979 (DW2)</td>
<td>Cotton</td>
<td>Cotton/camelid</td>
<td></td>
</tr>
<tr>
<td>4-8325</td>
<td>Chavina, Acari Valley</td>
<td>Heast Museum of Anthropology</td>
<td>DW</td>
<td>87.5</td>
<td>74.7</td>
<td>Rowe 1979 (DW3)</td>
<td>Cotton</td>
<td>Cotton/camelid</td>
<td></td>
</tr>
<tr>
<td>1977.35.9</td>
<td>-</td>
<td>The George Washington Textile Museum</td>
<td>DW</td>
<td>97</td>
<td>76</td>
<td>Rowe 1978 (Fig 4)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2001.1399</td>
<td>Pinilla, Ocucaje, Ica Valley</td>
<td>The Museum of Fine Arts, Houston in the Alfred C. Glassell Jr. Collection</td>
<td>DW</td>
<td>94.5</td>
<td>76</td>
<td>Rowe 1978 (Fig 5)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>41.2/885</td>
<td>coast of Peru</td>
<td>American Museum of Natural History</td>
<td>DW</td>
<td>93.5</td>
<td>79</td>
<td>Rowe 1978 (Fig 17)</td>
<td>Cotton</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>National Museum La Paz</td>
<td>DW</td>
<td>-</td>
<td>-</td>
<td>Rowe 1978 (cover)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1977.35.10</td>
<td>-</td>
<td>The George Washington Textile Museum</td>
<td>DW</td>
<td>97</td>
<td>77</td>
<td>Rowe 1992 (Fig 3, 22)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1964.12.2</td>
<td>Peru</td>
<td>The George Washington Textile Museum</td>
<td>DW</td>
<td>91</td>
<td>74.5</td>
<td>Pillsbury 2002 (Fig 4)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>PC.B518.PT</td>
<td>Peru</td>
<td>Dumbarton Oaks Washington</td>
<td>AOT</td>
<td>91</td>
<td>76</td>
<td>Pillsbury 2002 (Fig 7), Conklin 1997, Rodman and Cassman 1995</td>
<td>Cotton</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>2001.1399</td>
<td>Pinilla, Ocucaje, Ica Valley</td>
<td>The Museum of Fine Arts</td>
<td>DW</td>
<td>95</td>
<td>77.5</td>
<td>Rowe 1979 (Fig 31)</td>
<td>Cotton</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>41.2/762</td>
<td>Pinilla, Ocucaje, Ica Valley</td>
<td>American Museum of Natural History</td>
<td>ZZW</td>
<td>80.5</td>
<td>73</td>
<td>Rowe 1979 (Fig 33)</td>
<td>Cotton</td>
<td>Wool</td>
<td></td>
</tr>
<tr>
<td>41.1275.106</td>
<td>-</td>
<td>The Brooklyn Museum</td>
<td>ZZW</td>
<td>89</td>
<td>79</td>
<td>Rowe 1978 (Fig 32)</td>
<td>Crossed fringe – later addition</td>
<td>Wool</td>
<td>Wool</td>
</tr>
</tbody>
</table>

Notes: BW- black and white checkerboard unku, IK- Inka key unku, TW- toqapu unku, DW- diamond waistband unku, AOT- all over toqapu unku, ZZW- zigzag waistband unku.
7.5 Technical and stylistic Features

Unkus are noted for their high degree of technical and stylistic standardization, features common to Inka state crafts that have been attributed to “mass production, in some cases, and as exemplary of corporate art, in others” (Bray 2000 citing Jones 1964, Stone-Miller 1992). Rowe (1978, 1997) has argued that the technical features of unku construction and dimensions of the garments are the most reliable methods of identification, because style is more easily duplicated than technique. However, because a great deal of standardization in style has also been noted (Rowe 1979, 1997, Pillsbury 2002, Bray 2008), we incorporated both technical features and style in our analysis of the CV unku.

Size was a very important functional attribute. With the benefit of detailed online museum catalogs, we obtained robust statistics on the size of these garments, with more than twice as many measured examples to draw from than recorded in Rowe’s (1979) landmark study. The dimensions of all but three of the 38 mostly complete, precolonial Inka unkus investigated in the study had been recorded, and one had only a width measurement. Unsurprisingly, this larger sample has resulted in greater variability than previously reported.

Previous investigators reported width to be more standardized than length (Rowe 1979; Rowe 1978, 1992; Pillsbury 2002). Rowe (1979:245, 247) reported widths as 72 – 79 cm across all styles with BW unkus reportedly more standardized at 74 – 79 cm in width. Our larger sample contained widths from 70 – 98 cm, outside Rowe’s original range, but averaged 76.2 cm (σ=4.60); within the expected range. Length measurements ranged from
79 – 110 cm with the average length at 89.0 (σ=5.04) cm, which is slightly below the range in Rowe’s (1978:7) data-base. Like previous analyses (Rowe 1978, Rowe 1979; Pillsbury 2002), we found marginally greater standardization in unku width overall than length across the sample (Table 6). We also located one particularly large outlier which measured 98 cm in width and 110 cm in length (Ministerio de Cultura del Perú: Museo Nacional de Arqueología, Antropología e Historia del Perú: RT2377). The dimensions of this very large unku did not significantly alter the standard deviations of width or length of the whole group but did significantly affect the standard deviation for BW unkus, owing to the comparatively smaller number of these garments. For this reason, it was eliminated from our calculations. It is interesting that without the very large BW unku the width range for these artifacts was 73.5 – 80 cm, a maximum of just one centimeter outside Rowe’s (1979:247) original range.

These findings confirm previous studies that found BW unkus to be the highly consistent in size amongst the known types. However, we noted a similar degree of standardization in DW unku dimensions, which have a comparative sample size (Table 6). The dimensions of unku TW1 in Rowe’s (1979) assemblages were also anomalous, originally reported to measure 91 x 56 cm, however, Rowe (1979: 251) recognized these measurements were incongruous with photographs of the garments and revised the actual measurements to 71 x 56 cm. During our survey of the online museum catalogues, we found that the measurement of TW1 had been re-recorded at 80 x 71 cm; now the typical measurement for an unku.
Table 6. Calculated average dimensions and standard deviation of published unkus.

<table>
<thead>
<tr>
<th>Types</th>
<th>n=</th>
<th>Average Length</th>
<th>Average Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>38(^a)</td>
<td>84.41 (σ=5.04)</td>
<td>76.20 (σ=4.60)</td>
</tr>
<tr>
<td>BW unkus</td>
<td>10(^b)</td>
<td>87.93 (σ=3.43)</td>
<td>78.80 (σ=2.22)</td>
</tr>
<tr>
<td>IK unkus</td>
<td>9</td>
<td>87.40 (σ=5.0)</td>
<td>76.81 (σ=8.10)</td>
</tr>
<tr>
<td>DW unkus</td>
<td>8</td>
<td>93.07 (σ=3.5)</td>
<td>76.00 (σ=1.6)</td>
</tr>
<tr>
<td>TW unkus</td>
<td>4(^c)</td>
<td>81.33 (σ=3.50)</td>
<td>76.00 (σ=1.64)</td>
</tr>
<tr>
<td>Others(^d)</td>
<td>3</td>
<td>89.00 (σ=6.11)</td>
<td>76.40 (σ=2.6)</td>
</tr>
</tbody>
</table>

Note: (a) Three of the 38 unkus presented do not have both dimensions recorded. (b) The very large BW unku (RT-2377) was removed from these calculations. (c) One of the TW unkus has only a width measurement recorded (1960.13.7). (d) All over Toqapu unku, and Zizag waistband unkus.

In terms of overall dimensions (Rowe 1978; Rowe 1979, 1992), the CV unku is 91 cm in length and 80.5 in width which is slightly wider than the average (76.20 cm) but within Rowe’s standard (73.5 - 98 cm). The CV unku was woven in two webs (warps) from both ends and joined by 3/3 dovetailing along the shoulders (Figure 18a) as illustrated in Emery (1980:80). The warp consists of 2 and 3-ply cotton yarns spun in an Z/S direction and woven using the interlocking tapestry technique in 2-ply Z/S camelid fiber yarns, making use of eccentric wefts (Emery 1980:83) along the edge of the yoke to give it a smooth edge (Figure 18b). Lazy lines can be seen in the large, medium brown (red) area (Figure 18c) and the fabric is entirely double faced with no discernable, loose weft ends. It has a moderately high thread count of 40 wefts by 7 warps per cm and edges are finished in overcasting (Emery 1980: 233, 236). Although insufficient remained of the edge seam to determine technique, presumably the garment was sewn up to the arm holes. The neck-slot is woven in with discontinuous warps (Figure 18d), as described in Emery (1980:236).
Although unkus are typically woven in interlocking tapestry weave in a single web, Rowe (1979) reported three exceptions constructed in the same way as the CV unku, with two webs and joined by dove-tailing along the shoulder. Two of these garments are housed at the George Washington Textile Museum (TM.1966.7.172, TM1966.59.28 and 91.147) and another example (TW1) is housed at the University of Pennsylvania Museum of Archaeology and Anthropology (27569) (Figure 13e).

Based on these characteristics, we have identified a further unku constructed in this way. The Chicago Field Museum’s online catalog describes a BW5 unku, (catalog 1534) (Figure 13b), as being “in two pieces” leading us to conclude that it may have been joined in the same way as the above-mentioned Textile Museum, Pennsylvania Museum and CV unkus.
Figure 18. Diagnostic features of the CV unku (a) 3/3 dovetail shoulder join, (b) eccentric wefts creating a smooth edge along the yoke (c) lazy line in the solid red area between the yoke and bottom panel (d) the neck slot created using discontinuous warps.
7.6 Discussion

The CV unku’s stylistic attributes comprise three elaborated elements: (1) a vertically striped yoke with straight sides, (2) surrounded by a large, plain red area (dark brown), and (3) a plain black and a white checkerboard pattern across the bottom panel (Figure 14). This arrangement does not strictly conform to a specific imperial unku style documented by Rowe (1979). Nevertheless, the construction techniques, dimensions and spatial arrangement of motifs resemble the classic unku design defined by Rowe (1997) and Pillsbury (2002). In their landmark studies, Rowe (1978) and Rowe (1979) identified four Inka unku styles and several provincial styles whereas Pillsbury focused on spatial organization (2002:71), describing these garments as boldly geometric, favoring plain color blocks as well as “certain areas of elaboration” with the waist, neck and lower boarder interpreted as possibly representing important information about the wearer (Pillsbury 2002:73). Rowe (1997) also identified these three diagnostic unku features with consistent spatial organization: (1) a stepped yoke as seen on black and white checkerboard (BW) unkus, (2) a change in pattern part way down as seen on Inka key (IK) unkus, and (3) a decorative band about the waist as on diamond waistband (DW) unkus. The garment clearly conforms to previously identified technical attributes shown in Table 7 and follows Rowe (1979) and Pillsbury’s (2002) spatial organization convention and recognizable elaborations found on other unkus.
Table 7. Diagnostic Features of Inka *unkus*.

<table>
<thead>
<tr>
<th>Technical Attributes</th>
<th>CV Unku Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Attributes</strong></td>
<td>-</td>
</tr>
<tr>
<td>Greater length than width</td>
<td>✓</td>
</tr>
<tr>
<td>Careful finishing so that the cloth is double-faced</td>
<td>✓</td>
</tr>
<tr>
<td>The neck slot created by discontinuous warps and then overcast, often with cross-knit-loop stitch for reinforcement at the ends (see unfinished neck slot example in Rowe 1978: Figure 9)</td>
<td>✓</td>
</tr>
<tr>
<td>High thread count</td>
<td>✓</td>
</tr>
<tr>
<td>(Pillsbury (2002) reports up to 15 warps x 100 wefts/cm)</td>
<td></td>
</tr>
<tr>
<td>Edges and openings have intricate seaming often in chained warp loops with cross-knit-loop stitch</td>
<td>✓</td>
</tr>
<tr>
<td>The entire garment is woven in a single web or less commonly, two webs, joined along the shoulder with dovetailing</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Warp Attributes</strong></td>
<td>-</td>
</tr>
<tr>
<td>Cotton warp, in 2 and/or 3-ply yarns in Z-spin/S-ply **</td>
<td>✓</td>
</tr>
<tr>
<td>The warp is horizontal during wear</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Weft Attributes</strong></td>
<td>-</td>
</tr>
<tr>
<td>Weaving in tapestry with interlocking joins</td>
<td>✓</td>
</tr>
<tr>
<td>Wefts in camelid fiber, 2 ply Z-spin, S-ply with a few examples using cotton wefts</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Other Common Characteristics</strong></td>
<td>-</td>
</tr>
<tr>
<td>Eccentric wefts</td>
<td>✓</td>
</tr>
<tr>
<td>Lazy lines</td>
<td>✓</td>
</tr>
</tbody>
</table>
The commonest, most researched unku style is the BW (Figure 13) of which only 12 mostly complete examples are recorded. These feature a red, stepped yoke with the remainder of the garment covered in black and white checks. Importantly, the BW style is associated with the military (Pillsbury 2002, p. 75, Berenguer 2013). The same checkerboard pattern is depicted on uniforms worn by military officers in Guaman Poma’s manuscript (1615 [2009] Figures 38, 54, 98) and further confirmed by Francisco de Xerez’s 16th century account of Atahualpa’s army (Pogo 1936; Xerez 1891). The CV unku also features a plain black and white checked area across the bottom panel that is placed in the same position as the horizontal stripes on IK unkus (see Rowe 1979:Figures 4-6; Rowe 1978:Figure 3, Rowe 1992:Figure 2; Pillsbury 2002:Figure 1;), as well as on a ZW unku (Rowe 1978:Figure 32, Rowe 1979:Figure 13) and a DW unku (Rowe 1978:Figure 31) where it is described as the “lower panel” (Rowe 1979:250).

Pattern changes were also observed in this part of the garment. The checkerboard on the CV unku is executed in four rows of checks, with eleven featured on one side and ten on the other (including half squares on the outside) (Figure 14). The checks are between 8 - 9.5 cm high and 7.3 - 9.5 cm wide, which compares favorably with the average check size of 7.4-7.9 cm reported by Rowe (1979:247), not including the partial checks at the edge of the garment which measured 4 - 4.2 cm in width.

When the CV unku was compared with previously identified Inka unku using criteria developed by Rowe (1978; 1992) and Rowe (1979) clear correlations were apparent. The technical features of the CV unku compare favorably with the 12 diagnostic technical features identified in Table 7. However, to our knowledge, the CV unku is the only extant
example in this exact style although correlates are illustrated in historical documents.

Significantly a similar unku is rendered on a 16th century coat-of-arms depicting Topa Inca Yupanqui who was responsible for the southern expansion of the Inca Empire into northern Chile in the 1400’s (Figure 19) (Cummins 2007: Figure 24). Albeit colonial in style and age, this depiction on the Topa Inca Yupanqui coat-of-arms features an unku with a straight sided yoke, elaborated with small diamonds, over a solid color separated from the bottom boarder of plain black and white checks bordered by a zigzag line and a row of what appears to be smaller checks across the very bottom. The spatial arrangement of the design elements on this coat-of-arms is unusual in that the area between the yoke and the checkerboard is much larger than on other IK or DW unkus.

A more convincing correlate is depicted in Guaman Poma’s drawing (Figure 19) of a soldier taking part in the Coya Raymi Quilla celebration (Guaman Poma 1615[2009]:98). The only observable difference between Poma’s depiction and the CV unku is the presence of a striped yoke. Yokes occur on 12 known BW unkus (Rowe 1978 Figure 1, 1979 Figures 1-3, 1992 Figure 1, Stone-Miller 1992 Catalog 205, Dixon 2013 Catalog 181). In these extant examples, yokes are invariably solid red in color, with a few featuring zoomorphic designs, placed in the area around the neck and always accompanied by plain black and white checks. However, BW unku yokes differs from the CV unku yoke in that they are “stepped”, an effect created by “setting back the top of each vertical row [of squares,] one more square” (Rowe 1979:247). Conversely, the CV unku’s checkerboard pattern is restricted to the bottom panel whereas the yoke is covered by thin stripes and does not create the typical stepped pattern of the BW unkus.
The CV unku appears to be the only reported example with this type of elaborated yoke. The stripes on the CV unku yoke are also idiosyncratic in that they are narrow (0.7 - 0.9 mm in width) and arranged in a repeated pattern of black (dark brown), gold (beige), black (dark brown), white (Figure 18). Comparable examples of fully striped unkus are featured in Felipe Guaman Poma’s manuscript (1615[2009]) that illustrates the tunic of a provincial administrator (Hughes 2010 Figure 12). It is worth noting that stripes occur in abundance on Formative Period textiles from Arica (Ulloa 2008) and Caleta Vitor (Martens and Cameron 2019) and continue through to the Late Intermediate Period (1100 – 600 BP) (Cassman 1997, Horta 2004, Aguero 2000), prior to the appearance of the Inca. This is not to imply that the CV unku was made locally as evidence from the Arica region indicates household textile production without the formalization associated with unku weaving, at least up to 600 BP (Cassman 1997:160). Furthermore, coastal tunics are typically shorter and wider, worn with a fully visible loin cloth whereas Inka tunics are longer, nearly reaching the knee (Rodman and Cassman 1995).

Scholars have previously established that the Inca practiced various strategies for controlling local populations, which resulted in dynamic processes of interaction between the State and local communities (Santoro and Uribe 2018:12). The regionally specific approach characteristic of Inka expansion campaigns depended on existing crafts or valuable subsistence behaviors (weaving, herding), the presence of natural resources (minerals, farmland) and the existence of a taxable population (Bauer and Covey 2002; Murra 1975; Rostworowski 1988; Santoro 2016; Santoro et al. 2010, Santoro and Uribe 2018; Uribe 2004; Zori and Urbina 2014).
At other sites, archaeological evidence for Inka interaction is evidenced by the presence of large-scale urban and farming projects and conspicuous symbols of power embedded in Inka material culture (textiles, ceramics, metal and wooden objects) (Santoro and Uribe 2018). A number of smaller sites in the Lluta (Molle Pampa, Cruces de Molino), Azapa (Azapa 15, Pubrisa) and Camarones valleys have also produced sufficient material culture to indicate intensive interaction with the Inka State (Schiappacasse 1999; Valenzuela et al. 2015; Muñoz et al. 1997).

Figure 19. (a) Portrait of Topa Inka Yupanqui, 18th Century, copy of a portrait associated with a coat-of-arms first issued in 1545 (Dumbarton Oaks Collection). (b) Guaman Poma’s drawing of a soldier taking part in the Coya Raymi Quilla celebration (Guaman Poma 1615[2009]:98).
7.7 Conclusions

The technical and stylistic characteristics identified in this analysis of the CV unku compare so favorably with other extant unku in museums collections, archeological finds and pictorial evidence in historical documents that we have come to the inevitable conclusion that it is a pre-Hispanic Inka unku. Although the Caleta Vitor site does not have the pre-requisite architectural, agricultural structures or materiality usually associated with Inka socio political interaction seen at other sites, the CV unku represents an indisputable, powerful symbol of Inka political authority. Finally, the checker board feature indicates the CV unku is likely associated with the military, however the ramifications of this association in the site’s relationship with the State will require further research.

7.8 Acknowledgments

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Zori, Colleen, and Simón A. Urbina

Statement of Contribution: Procurement of camelid fiber in the hyperarid Atacama Desert coast: insights from stable isotopes

Title: Procurement of camelid fiber in the hyperarid Atacama Desert coast: insights from stable isotopes

Authors: Eugenia M. Gayo, Tracy Martens, Hillary Stuart-Williams, Jack Fenner, Calogero M. Santoro, Christopher Carter, Judith Cameron

Publication outlet: Quaternary International Special Issue

Current status of paper: Under Review

Contribution to paper: Organization and analysis of data, preparation of referential dataset,

Euginia M. Gayo: Analyses and interpretation of data. Drafted the article.

Signed

Dr. Euginia M. Gayo

Tracy Martens: Conducted the artifact recording. Organized the data for analysis and completed background research. Developed research question and drafted research paper in conjunction with co-authors.

Signed

Ms. Tracy Martens

Hilary Stuart-Williams: Contributed to conception and design. Conducted stable isotope analysis and editing the article.

Signed

Dr. Hilary Stuart-Williams
Jack Fenner: Contributed to conception and design. Interpretation of data. Revision and editing of the article.

Signed ***see email on following page***
Dr. Jack Fenner

Calogero M. Santoro: Acquisition and interpretation of data. Revision and editing of the article.

Signed
Dr. Calogero M. Santoro

Christopher Carter: Data acquisition, drafting and editing article.

Signed
Dr. Christopher Carter

Judith Cameron: Participated in research question development, drafting and editing of the research paper. Contributed to technical analysis.

Signed
Dr. Judith Cameron
Author contribution statement

JF
Jack Fenner

Reply all
Fri 12/07, 5:20 AM
Tracy Martens

Hi Tracy,

I just got back into Ulaanbaatar. Yes the statement is fine.

Regards,
Jack
Chapter 8. Procurement of camelid fiber in the hyperarid Atacama Desert coast: insights from stable isotopes

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Abstract

Pastoralism and camelid management are traditionally attributed to the sociopolitical, economic and cosmovision of Andean populations, rather than to lowland hunter-gatherer societies, living on the Pacific coast where camelid hunting is considered a marginal activity, and husbandry is a difficult enterprise given the hyper-arid conditions of lowland terrestrial ecosystems. Contrary to this interpretative historical view, our stable isotope analyses applied to 48 camelid fiber samples, show this highly valued camelid byproduct was obtained from camelids sustained on local lomas vegetation formations during the Archaic (ca. 6,500-4,000 cal BP), Formative (ca. 4,000-1,500 cal BP) and Late periods (ca. 660-476 cal BP).
8.1 Introduction

Artifacts made out of South American Camelid elements (unprocessed fiber, bones, skins, yarns and textiles) are common at archaeological sites in the Atacama Desert and elsewhere in the Andes, since the earliest human colonization, by the end of the Pleistocene (Santoro et al. 2019). Wild guanacos still occupy relict areas along the coast of Taltal (25°S) and until few years ago were found at Cerro Moreno Antofagasta. This formed part of a larger territory, from the Pacific coast to the high Andes where there were wild populations of these animals which were hunted and captured throughout the entire pre-Hispanic epoch until few decades ago. In contrast, camelid pastoralism, is associated with more productive ecological zones located over 3,000 masl, like the high Andean peat-bogs (bofedales), and altiplano grasslands (Murra 1965; Topic et al. 1987). Accordingly, traditional procurement models for the South-Central Andes attribute such items in the archaeological record as products of local hunting, pastoralism or interregional interaction between different social groups from the high altitude Andes toward lower altitude regions of the Pacific coast (Capriles and Tripcevich, 2016; Murra 1965; Núñez and Dillehay, 1995; Rivera, 1991; Santoro et al. 2005). Recent isotopic research in coastal Peru is shifting our understanding camelid pastoralism and trade in camelid products on the western slopes of the Andes, outside the highlands (Dufour et al. 2014; Finucane et al. 2006; Goepfert et al. 2013; Grant 2017; Szpak et al. 2016; 2015; 2014; Thornton et al. 2011). These studies have revealed that low altitude husbandry of small flocks of camelids was part of the economy of lowland polities, under quite different conditions compared to the more suitable pastoralist prairies of the Andes where large scale pastoralism took place. Accordingly, the supply of camelid fiber for lowland groups was not exclusively dependent on political and economic arrangements with
highland pastoralists. This implies that interregional exchange networks were more complex than previously thought (Grant 2017; Szpak et al. 2015; 2014).

Recent archaeological research, including this study, is broadening our understanding of prehistoric animal consumption, demonstrating that far from being synonymous with diet, camelids were used for transportation, sacrifice in ritual as well as visual consumption in rock art (see Valenzuela et al. 2015). Non-dietary products of camelids referred to as secondary or by-products, are gaining recognition as “fundamental in the economy of local [northern Chilean] societies” not only for clothing and ceremonial items but as essential components of fishing technologies (Valenzuela et al. 2015). This is key when considering the social groups of the hyperarid coast of the Atacama Desert (e.g. Caleta Vitor), where such secondary camelid products are abundant. Nevertheless, these items have received little archaeological attention, as they have been described in terms of form, manufacturing technique (yarn characteristics, weave, dyes, repair), style and iconography (surface embellishments), for socio-cultural, chronological definitions, social interaction, ethnicity (Agüero 2000; Cassman 2000; Paulinyi-Horta, 2018; Ulloa 1981a; b) and for the discussion and characterization of the subsistence economy which heavily relied on marine resources. Essentially, the potential relevance of camelid products has been overshadowed in the archaeological record because the meat of these animals was not an important dietary resource in the littoral Atacama (Carter 2016; King et al. 2018; Roberts et al. 2013).

Previously proposed models estimate that procurement of the very scarce camelid product by coastal inhabitants during the Archaic Period was achieved by local marginal hunting (Núñez and Santoro, 2011; Rivera 1991), or through exchange from inland groups. Whatever
the case, these alternative scenarios do not appear to apply to the Caleta Vitor archeological complex (Carter 2016), a coastal site in northern Chile and focus of this research, where there is “no evidence to suggest that the inhabitants of Caleta Vitor hunted camelids to any extent during the Archaic Period nor is there any evidence for the presence of domesticated species, either llama or alpaca, prior to the Formative Period” (Carter 2016). Beginning in the Formative Period, it has been suggested that coastal inhabitants obtained camelid fiber through exchange networks established with high altitude pastoralists, when highland technologies and migrants appear in the region (Capriles 2014; Carter 2016; Rothhammer and Dillehay 2009; Santoro et al. 2014).

In this paper, we employ stable isotope analysis to test whether the fiber artifact collection from Caleta Vitor conforms to the theoretical estimations of camelid fiber procurement by groups living along the Atacama Desert coastline. By identifying temporal variations in the origin of camelid fiber artifacts from Caleta Vitor archaeological complex, we contribute data to better understand the dynamics of broader socio-economic strategies that dictated access and consumption of camelid fiber by the marine hunter-gatherers living at this bay on the Pacific coast of northern Chile. By taking a deep-time perspective, we draw attention to the contribution of socio-political factors commonly thought to drive the procurement and exchange of valuable resources, including external pressures such as imperial control, the intensification of existing economic strategies and the role of nearby pastoralists.
8.2 Environmental and archaeological contexts from Caleta Vitor Complex

Situated along the western slope of the South-Central Andes, northern Chile is characterized by an abrupt relief that rises from sea level to over 5,000 masl at the Chilean-Bolivian Altiplano just 150 km east of Caleta Vitor (Figure 20c). The Atacama coastal region is among the driest places on the Earth, intense hyperarid conditions result from the almost total lack
of local rainfall (<5 mm/yr) and high evaporation rates (>2,500 mm/yr) (Houston 2006).

Freshwater resources are scarce, but surface runoff occurs at the base of East-West
trending, deeply incised ravines or quebradas (~900 m deep) that drain the Andes across the
hyperarid desert and discharge into the Pacific Ocean (Figure 20). These quebradas connect
the inland Atacama Desert with the Pacific Ocean, opening up the only access along what is
otherwise an impenetrable and steep landscape delineated by the Coastal Range (Figure
20).

The unproductive terrestrial landscape across the littoral Atacama sharply contrasts with
the extraordinarily diverse and abundant marine biota brought by the upwelling of cold and
nutrient-rich waters in the Humboldt Current System. As part of the absolute desert
landscape (Arroyo 1988), the Atacama coast is practically unvegetated except for distinct
riparian and wetland communities found within quebradas or localized lomas vegetation
formations along the Coastal Range at elevations between 400 and 900 masl (Figure 20B).
This latter community is sustained by the moisture provided by marine fog (locally known as
Camanchaca) or rare extreme rainstorms (<50 mm/day) (Muñoz-Schick et al. 2001; Pliscoff
et al. 2017), and includes several endemic taxa of shrubs, cacti and other seasonal plants.
Vegetational formations in the adjacent inland are confined to elevations above 2,200 masl
(Villagrán et al. 1983) (Figure 20), where precipitation is frequent during the austral summer
(20-300 mm/year, Houston, 2006). These appear as vegetational belts differentiated in
composition and structure by an abrupt ascendant rainfall-elevation gradient that
characterizes the western Andean slope (Houston 2006). Between 3500 and 4500 masl, the
permanent groundwater discharge sustains High-Andean Bofedales on wide-flat terrain
from the Altiplano (Villagrán et al. 1983). Because the availability of palatable hydrophyts,
these peat-bog wetlands represent preferred habitat and pastureland for both wild (vicuña) and domestic (alpaca, llama) camelids. Above 3,900 masl, camelid foddering areas are complemented with grasses present at the so-called “Puna” and “High Andean Steppe” vegetation belts (Castellaro et al. 2004).

The earliest pioneers to arrive in the coastal region seems to have been part of human groups that moved along this mega patch (Osorio et al. 2017) and for that reason came equipped with a marine toolkit for exploiting this highly productive marine ecosystem. Marine biota was a key resource in sustaining continuous although demographically irregular, occupation over the last 13,000 years (Gayo et al. 2015; Santoro et al. 2017). Increasing social, political and economic complexity was then achieved either by innovating specialized toolkits or by cultural-technological exchange using small vessels along coastal waters (Santoro et al. 2017; Standen et al. 2018). During the Archaic, a mobility extended up the quebradas to access a variety of plants (i.e. reeds, rhizomes, wood) and fauna including camelids which were more common in higher less arid regions (Santoro et al. 2014; Standen et al. 2018).

Later in the Holocene, coastal hunter-gatherers went through structural changes linked to the impoverishment of ecosystem services brought about by negative hydroclimate anomalies, increased population growth, overexploitation and/or the impact of El Niño Southern Oscillation (ENSO) on the availability of marine resources (Gayo et al. 2015; Marquet et al. 2012; Santoro et al. 2017). During the Formative (4000-1500 BP) socio-economic changes take place in some areas of the Atacama Desert. Many inland groups began transitioning to agricultural subsistence while coastal groups retained their marine
hunter-gatherer economies and adopted some introduced technologies; including pottery production, weaving, and some cultural practices, including changes to burial conventions and the use of hallucinogenic snuff (Carter 2016; McRostie 2014; McRostie et al. 2017; Muñoz et al. 2016; Núñez and Santoro, 2011; Roberts et al. 2013; Rothhammer and Dillehay 2009; Santana-Sagredo et al. 2015; Ulloa, 2008; Valenzuela et al. 2015). At Caleta Vitor there is concurrent increases in camelid faecal pellet volume and camelid fiber artifacts during this time (Martens and Cameron 2019). This increase has been interpreted as the beginning of highland camelid caravaning to the site which facilitated the movement of highland goods to the coast and vice versa (Carter 2016; Pimentel et al. 2017).

Following the Formative period, interaction with highland groups may have been more formalized; as it is estimated that Tiwanaku polities (1700-1000 BP) tried to get access to lowland resources through different forms of direct or indirect colonization (Knudson 2008; Korpisaari et al. 2014; Muñoz et al. 2016; Torres-Rouff et al. 2013). These socio-political and economic interactions are archaeologically visible on Tiwanaku stylistic pottery (or Tiwanaku-like), textiles and metal objects that circulated as prestige goods within emergent local elites. The rest of the population seems to have had less access to these imported good as seen in domestic pottery production at Caleta Vitor made with local raw materials and techniques applied to undecorated vessels (Bland et al. 2017).

After 1,000 BP the Tiwanaku polities lost their power and new societal groups emerged in the South-Central Andes within a rather tumultuous epoch linked to generalized impoverishment of environmental conditions because of droughts and the Little Ice Age. This time is known as Late Intermediate period. Along the Pacific coast and lower valleys
and oases small scale chiefdoms emerged, giving rise to the florescence of local ceramic, textile and other craft made with highly complex local iconographic styles. At Caleta Vitor, an increase in camelid faecal pellets and rock art portraying camelids are dated to this period, indicating that no disruption in the flow of trade goods followed the collapse of the Tiwanaku polities (Carter 2016). Additionally, two corral features extending from rock shelters at the site are interpreted as short-term accommodation for domesticated camelids involved in caravan exchange which is not interpreted as onsite pastoralism (local conditions are unsuitable) (Carter 2016).

Late Intermediate period Chiefdoms faced the rise of the Central Andean Inca Empire (660-476 BP). The Inka’s socio-political, economic and ideological expansion transformed the social structures of local chiefdoms (Covey 2000; Rivera 2008; Santoro and Uribe 2018; Santoro et al. 2010; Zori and Urbina, 2014). The subsistence economy of Caleta Vitor during this Late Period, however, diverged from the neighboring Azapa and Lluta valleys where intensive maize agriculture was underway and isotopic research indicates a subsequent reduction in marine resource consumption (King et al. 2018). Significantly, maize and other domesticates appear in the archaeological record of Caleta Vitor without evidence of intensive agriculture. Instead, there is evidence of increased intensity in the maritime economy during the Late Period, coinciding with increased population and pottery discard rates (Bland et al. 2017; Carter, 2016). Whereas camelid remains, and evidence of camelid consumption appear at Lluta valley sites such as Molle Pampa, only camelid droppings appear during the Formative Period at Caleta Vitor, increasing in abundance through the Late Period, without any evidence of camelid pastoralism or consumption (Carter 2016). Coastal products such as sea bird guano and maize may have been traded for highland
products; specifically, camelid wool. At Caleta Vitor there is an increase in camelid fiber usage and the near abandonment of vegetal fiber during this time.

8.3 Regional stable isotope ecology

Stable isotope analysis has successfully identified the origin of camelid fiber artifacts across the South-Central Andes (e.g. Grant 2017; Szpak et al. 2015; 2014). Such analyses are based on the principle that $^{13}$C/$^{12}$C and $^{15}$N/$^{14}$N isotope ratios in keratin reflect the diet of animals during tissue formation (Lee-Thorp, 2008). Because both δ$^{15}$N and δ$^{13}$C in basal resources vary predictably with elevation across the aridity gradient of the western Andean slope, keratin isotopic composition can be geographically contextualized to infer foraging location, and in turn discriminate between highland versus lowland provenance.

For instance, δ$^{15}$N in plants is negatively correlated with altitude and mean annual precipitation (Szpak et al. 2013; Tieszen and Chapman 1992), and in turn the most enriched values (> +4‰) are found along the coast (e.g. lomas formations) as well as inland areas of the Atacama Desert (<2,000 masl). This trend is apparently linked to biogeochemical processes affecting the nitrogen cycle such as preferential volatilization of $^{14}$N under extreme hyperarid conditions, and/or increasing cycle “openness” in marine N inputs brought about by the Camanchaca (Díaz et al. 2016; Szpak et al. 2013). The use of natural $^{15}$N-enriched fertilizers (i.e., sea guano or terrestrial animal manure) might exacerbate higher δ$^{15}$N signals in plants growing at lower elevations of the western Andean slope (Szpak et al. 2012).
Unlike the globally expected negative relationship between δ¹³C values in C₃ plants and humidity levels, a systematic positive variation with mean annual precipitation (MAP) has been verified on the western Andean slope (Szpak et al. 2013; Tieszen and Chapman 1992). In this area both variables are related as δ¹³Cfoliar= -30.1 + 0.5 log MAP (r² = 0.81; p 0.001, Szpak et al. 2013). This contra-intuitive isotope enrichment along the altitudinal-humidity gradient results from a photosynthetic adjustment to elevational stress that overtakes the effect of decreased water-use efficiency under a humid but thin atmosphere at higher elevations (Szpak et al. 2013). C₄ and CAM plants remain immune to this environmental-driven isotope signature variation, both exhibiting an overlapping mean of -12‰ across the entire elevational gradient (Cadwallader et al. 2012; Szpak et al. 2013; Tieszen and Chapman 1992). Nevertheless, natural and domestic C₄ resources are uncommon above 3,000 masl, mostly constrained in distribution to hotter and drier elevations (Szpak et al. 2013).

According to this regional stable isotope ecology, Szpak et al. (2016) recognize four archaeological camelid populations representing discernible and specific foddering types and herd habitats across the western Andean slope between 7º and 18ºS (Figure 21). The first group consists of low-elevation camelids (n= 214) foraging relatively equal proportions of irrigated C₃ and C₄ cultigens which are referred to as a “Mixed Irrigated Cultigens” (MXC) regime according to Szpak et al. (2016). These camelids are relatively recurrent along the Peruvian coast from the Early-Horizon or Formative period (850 BC), and are characterized by high carbon (δ¹³C= -15.4‰ ± 2.5‰) and nitrogen (δ¹⁵N= +7‰ ±1.3‰) isotope compositions in bone collagen (Dufour et al. 2014; Finucane et al. 2006; Szpak et al. 2015; Verano and DeNiro 1993). A second low-elevation population includes individuals (n= 9) relying on wild C₃ and C₄ vegetation (δ¹³C= -13.2‰ ± 2.3‰) from fog oases or lomas
formations (DeNiro 1988; Thornton et al. 2011; Verano and DeNiro 1993). This “Wild Mixed Vegetation” assemblage (WCV, Szpak et al. 2016) are even more enriched $^{15}$N ($\delta^{15}$N= +13‰ ± 2.1‰) values due to the effects of hyperaridity at the coast. At mid-elevations (2,700 masl) of the Peruvian sierra, camelids (n= 10) fed mainly with cultivated and irrigated maize (“Cultivated $C_4$ Crops” or $C_4$, Szpak et al. 2016), are characterized by $\delta^{13}$C and $\delta^{15}$N values of -9.8‰ ± 1.3‰ and +6.7‰ ± 1.3‰, respectively (Finucane et al. 2006). Whereas, 132 archaeological samples with low carbon ($\delta^{13}$C= -18.3‰ ± 1.6‰) and nitrogen ($\delta^{15}$N= +7.5‰ ± 1.4‰) isotope compositions in bone collagen define the $C_3$ pasture regime ($C_3P$, Szpak et al. 2016). These camelids grazed a predominantly $C_3$-diet (>70%) either bofedales or high-elevation grasses from the puna or high Andean steppe (DeNiro 1988; Finucane et al. 2006; Szpak et al. 2015; Thornton et al. 2011).

8.4 Research expectations

Traditional analyses of the material composition and structure of the camelid product assemblage from Caleta Vitor archaeological complex revealed new insight into the early development of fiber processing technology, but only indirect evidence of the geographic origin of the material itself. This paper examines the origin of the camelid fiber assemblage by establishing their $\delta^{15}$N and $\delta^{13}$C compositions, and contextualizing results within the well-established regional stable isotope ecology. Our expectations are based on previously suggested exchange networks for the South-Central Andes that associate camelid artifacts with highland trade or hunting (Núñez and Dillehay 1995; Núñez et al. 1975; Valenzuela et al. In press; Valenzuela et al. 2011). Changes in procurement strategies owing to changes in socio-political control and influence have been suggested to include the arrival of camelid
caravans during the Formative period and impacts of the subsequent highland polities however, the geographic origin of camelid fiber has yet to be shown as being outside the highlands. Accordingly, we expect that camelid samples from all periods will consistently reflect diets rich in C\textsubscript{3} plants, typical of animals foraging in bofedales, puna or the high Andean steppe.

8.5 Methods

8.5.1 Stable isotope determinations

Archaeological materials from Caleta Vitor were made available for recording and sampling by the Instituto de Alta Investigación (IAI) de Arqueología y Paleoambiente, Universidad de Tarapacá (Arica, Chile) between March and June 2016. Of the 198 units excavated, 88 contained worked and/or unworked camelid fiber. Of the seven areas excavated, five (CV1, CV2, CV4, CV6 and CV7) contained fiber artifacts appropriate for this study. These areas have been dated from 330-500 (UGAMS10519) to 6411-6631 (UGAMS10509) cal BP (Table 8). A total of 48 samples were analyzed (Table 8) for $\delta^{13}$C and $\delta^{15}$N on keratin; 40 from securely dated strata and eight from undated burials containing late period artifacts.

It was not possible to determine what section of the hair was represented in the artifacts, as they were a part of processed fiber items. Therefore, samples should be considered bulk. Preparation followed the procedure proposed by O’Connell et al. (2001). Weighed samples ranging from 0.116-3.308 g were treated twice, washed in methanol and chloroform solution (2:1 v:v), followed by rinsing in deionized water and drying under a fume cabinet. $^{13}$C/$^{12}$C and $^{15}$N/$^{14}$N ratios were analyzed at the Stable Isotope Laboratory of the Research
School of Biology at the Australian National University (Canberra, Australia) on a Micromass Isochrom Continuous Flow Isotope Ratio Monitoring Mass Spectrometer coupled to an Elemental Analyzer. Working standards cystine and glycine indicate a 1 - σ measurement error of 0.11‰ and 0.07‰, respectively. Multiple archaeological sample replicants (n=10) indicate measurement errors at 0.19‰ for δ¹³C and 0.6‰ for δ¹⁵N. Results were returned corrected to VPDB (δ¹³C) and Air (δ¹⁵N).

Table 8: Chronology and chrono-cultural periods for archaeological contexts from Caleta Vitor that contain camelid fibers (Carter 2016; Santoro et al. 2017).

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Context</th>
<th>Dated material</th>
<th>Age (¹⁴C BP)</th>
<th>Calibrated age (cal BP, 2 sigma)</th>
<th>Cultural period</th>
<th>Regional socio-cultural phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGAMS10508</td>
<td>CV1/3/14</td>
<td>Calyx</td>
<td>5860 ± 30</td>
<td>6490-6720</td>
<td>Middle Archaic</td>
<td>Chinchorro (8,000-6,000 BP)</td>
</tr>
<tr>
<td>ANU31018-9189</td>
<td>CV1/3/9</td>
<td>Cane</td>
<td>5110 ± 35</td>
<td>5660–5910</td>
<td>Late Archaic</td>
<td>Late Chinchorro (6,000-4,000 BP)</td>
</tr>
<tr>
<td>ANU31017-9188</td>
<td>CV7/1/10</td>
<td>Cane</td>
<td>4400 ± 35</td>
<td>4840–5040</td>
<td>Late Archaic</td>
<td>Late Chinchorro (6,000-4,000 BP)</td>
</tr>
<tr>
<td>UGAMS10506</td>
<td>CV1/2/13</td>
<td>Calyx</td>
<td>4030 ± 30</td>
<td>4440–4525</td>
<td>Late Archaic</td>
<td>Late Chinchorro (6,000-4,000 BP)</td>
</tr>
<tr>
<td>UGAMS10524</td>
<td>CV7/1/6</td>
<td>Calyx</td>
<td>3880 ± 25</td>
<td>4090–4410</td>
<td>Late Archaic</td>
<td>Final Chinchorro (4,000–3,600 BP)</td>
</tr>
<tr>
<td>UGAMS10513</td>
<td>CV2/1/39</td>
<td>Cotton seed</td>
<td>3230 ± 25</td>
<td>3350–3450</td>
<td>Early Formative</td>
<td>Azapa (4,000–2,500 BP)</td>
</tr>
<tr>
<td>UGAMS10505</td>
<td>CV1/2/6</td>
<td>Algarrobo pod</td>
<td>3100 ± 25</td>
<td>3260–3360</td>
<td>Early Formative</td>
<td>Azapa (4,000–2,500 BP)</td>
</tr>
<tr>
<td>UGAMS10507</td>
<td>CV1/3/1</td>
<td>Algarrobo pod</td>
<td>2470 ± 25</td>
<td>2480–2700</td>
<td>Late Formative</td>
<td>Alto Ramirez (2,500–1,500 BP)</td>
</tr>
<tr>
<td>ANU31013-9185</td>
<td>CV2/1/20</td>
<td>Charcoal</td>
<td>2525 ± 35</td>
<td>2360–2710</td>
<td>Late Formative</td>
<td>Alto Ramirez (2,500–1,500 BP)</td>
</tr>
<tr>
<td>UGAMS10510</td>
<td>CV2/1/1</td>
<td>Algarrobo pod</td>
<td>1930 ± 30</td>
<td>1930–2130</td>
<td>Late Formative</td>
<td>Alto Ramirez (2,500–1,500 BP)</td>
</tr>
<tr>
<td>UGAMS10523</td>
<td>CV6/1/16</td>
<td>maize</td>
<td>660 ± 25</td>
<td>550–650</td>
<td>Late Period</td>
<td>Inka Empire (660-476 BP)</td>
</tr>
<tr>
<td>UGAMS10518</td>
<td>CV4/1/19</td>
<td>maize</td>
<td>630 ± 30</td>
<td>535–650</td>
<td>Late Period</td>
<td>Inka Empire (660-476 BP)</td>
</tr>
<tr>
<td>UGAMS10517</td>
<td>CV4/1/1</td>
<td>seeds</td>
<td>610 ± 25</td>
<td>530–630</td>
<td>Late Period</td>
<td>Inka Empire (660-476 BP)</td>
</tr>
<tr>
<td>UGAMS10522</td>
<td>CV6/1/8</td>
<td>maize</td>
<td>530 ± 25</td>
<td>500–540</td>
<td>Late Period</td>
<td>Inka Empire (660-476 BP)</td>
</tr>
<tr>
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<td>CV4/6/1</td>
<td>seed</td>
<td>420 ± 20</td>
<td>330–500</td>
<td>Late Period</td>
<td>Inka Empire (660-476 BP)</td>
</tr>
</tbody>
</table>
For practical reasons, we report the chronology for camelid fiber assemblages in terms of cultural periods for the South-Central Andes: Late Archaic (n= 12 samples), Formative (n= 11) and Late period (n= 25). Assemblage groupings are based on diagnostic chrono-cultural artifacts or absolute dates available for strata of each excavated area as well as seven artifacts recovered from an undated burial assigned to the Late period (see Tables 8 and 9).

8.5.2 Statistical analyses

We explored the relative contribution of C\textsubscript{3} and C\textsubscript{4} plants in the assimilated diet of each individual represented in the Caleta Vitor archaeological complex by implementing a Bayesian mixing model (siarsolomcmcv4) with the SIAR 4.2 package (Parnell \textit{et al.} 2010) for R 3.3.1. We followed the best practices for stable isotope mixing models proposed by Phillips \textit{et al.}(2014). δ\textsuperscript{13}C values for both dietary resources were defined by averaging the signature for modern C\textsubscript{3} and C\textsubscript{4} plants available in published baselines for the western Andean slope between 7\degree and 18\degree S (Cadwallader \textit{et al.} 2012; Szpak \textit{et al.} 2013; Thornton \textit{et al.} 2011; Tieszen and Chapman 1992). All modern isotope compositions were increased by +1.5\%o to account for the Suess effect (Yakir 2011). Thus, in our model δ\textsuperscript{13}C for C\textsubscript{3} and C\textsubscript{4} plants acquired mean (±1SD) values of -24.81\%o±2.00\%o and -12.34\%o ±1.41\%o, respectively. A keratin-diet fractionation factor of +2.4\%o±1.2\%o (Szpak \textit{et al.} 2015) was assumed. Since keratin has fast turnover rates (Hobson 2008), carbon and nitrogen isotope composition of fiber assemblages from Caleta Vitor only provide data for short-term dietary features, restricted to a discrete interval before fiber were recovered and processed.
To complement our inferences on the temporal evolution of camelid fiber procurement practices, we described isotope niches for Caleta Vitor camelid groups. These niches represent the area in a δ^{13}C-δ^{15}N bivariate space that describes properties for the population trophic niche (see Jackson et al. 2011). Hence, we examined dietary similarities among our three groups and archeological analog camelid populations defined by Szpak et al. (2016) as representative for specific foddering types and elevations of the western Andean slope (see Figure 21). Over 55.6% of samples (n= 203) integrating referential populations have had their bone collagen isotope compositions described. For comparative purposes, raw stable isotope on keratin either from Caleta Vitor or referential samples (n= 162) were adjusted to reflect carbon and nitrogen compositions of bone-collagen (Table 9) by increasing δ^{13}C_{keratin} and δ^{15}N_{keratin} by +1.3‰ and +0.86‰, respectively (O’Connell et al. 2001; Szpak et al. 2014). Because the number of entries on keratin (44.4%) and bone-collagen (55.4%) stable isotopic characterizations within the overall camelid-analog dataset (n=365 samples) is essentially equivalent, our inferences on niche interactions are not strongly influenced by biases introduced by the direct comparison of short (keratin-inferred) and long-term (collagen-inferred) diet history.
Figure 21: A- Estimated isotope niche (SEA_c) from the distribution of carbon and nitrogen values of referential archaeological camelid groups described by Szpak et al. (2016) for the western Andean slope. Dashed ellipses describe basic standard ellipses (SEA). B- SEAb for archeological analog populations showing corresponding 50, 95 and 99% credible intervals of posterior distributions of 10,000 simulations. Abbreviation for foddering regimes according to Szpak et al. (2016), where MXC: Mixed Irrigated Cultigens, WCV: Wild Mixed Vegetation, C_4C: Cultivated C_4 Crops, and C_3P: C_3 Pasture.

We computed sample-size corrected (SEA_c) and Bayesian (SEA_b) Standard Ellipse Areas as estimators of isotope niches (expressed as ‰²) using the SIBER 2.1.3 package (Jackson et al. 2011). The SEA_c describes the core isotope niche for a given population, permitting the quantification of niche overlaps between groups that differ in sample size. Whereas, the SEA_b provides robust estimates for comparing niche amplitudes. Our approach for inferring potential origin areas for fiber assemblages assumes that equivalent diet compositions and isotope niche overlaps between Caleta Vitor populations and archeological analogs described for the western Andean slope reflect similarities in trophic regimes. In this sense, we follow the perspective of Szpak et al. (2015) for interpreting an overall origin for a given camelid-fiber assemblages instead of individual inferences except for discussing those samples that are characterized by extreme stable isotope values.
8.6 Results and Discussion

8.6.1 On the camelid origin

Stable isotope compositions of camelid fibers range between -21.5‰ and -12.0‰ for δ13C, and between +5.8‰ and +17‰ for δ15N (Figure 22, Table 9). Fiber assemblages from the Archaic to the Late Formative exhibit similar ranges in δ13C (-21.5‰ – -16.1‰) and δ15N (+7.1‰ - +14.1‰). Except for one Archaic sample (id 7266), estimates of the diet composition reveal that C3-plants were an important basal resource (61% - 83%, Table 2), approximating to contributions inferred for reference groups foddering under MXC and WCV regimes (Szpak et al. 2016). This notion is supported by high 15N isotopic compositions either of keratin or adjusted bone-collagen values (Table 9), suggesting that camelids represented in Caleta Vitor most likely grazed on the lowlands (<2,000 masl), where intense hyperarid conditions lead to a high δ15N signature (>+5‰) in the vegetation (Díaz et al. 2016; Szpak et al. 2013; Tieszen and Chapman 1992).

Figure 22. Carbon and nitrogen isotopic composition of camelid fiber assemblages from Caleta Vitor per chrono-cultural period.
Table 9. Stable isotope data for camelid fibers from Vitor. δ\(^{13}\)C and δ\(^{15}\)N bone-adjusted values are provided as well as individual results for mixing models accounting for the relative contribution of C\(_3\) and C\(_4\) pathways on the diet. Values in brackets indicate Bayesian credible intervals. *Artifact types - Yarns are all singles or two ply constructions, with spin and ply direction indicated as per Emery (1980). Not worked indicates fiber which shows no sign of preparation for processing. Tunic (stripe) indicates a tunic (shirt) with vertical stripes. 1/1 plain weave indicates of a tabby weave or interlaced construction (Emery, 1980). Chucus are coiled hats (for a description see Berenger, 2006). Slings are hunting and herding implements (Martens and Cameron, 2019).

<table>
<thead>
<tr>
<th>Archaeological context</th>
<th>Artifact type *</th>
<th>Cultural Period</th>
<th>Sample ID</th>
<th>(\delta^{13})C fiber (‰, VPDB)</th>
<th>(\delta^{15})N fiber (‰, AIR)</th>
<th>(\delta^{13})C bone adjusted (‰, VPDB)</th>
<th>(\delta^{15})N bone adjusted (‰, AIR)</th>
<th>C(_3) contribution</th>
<th>C(_4) contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3/11</td>
<td>Thread z/s</td>
<td>Archaic</td>
<td>8322-29</td>
<td>-19.11</td>
<td>10.79</td>
<td>-17.81</td>
<td>11.65</td>
<td>0.70 (0.5 - 0.9)</td>
<td>0.30 (0.05 - 0.5)</td>
</tr>
<tr>
<td>1/3/11</td>
<td>Yarn z/s</td>
<td>Archaic</td>
<td>8322-27</td>
<td>-19.33</td>
<td>7.11</td>
<td>-18.03</td>
<td>7.97</td>
<td>0.71 (0.5 - 0.9)</td>
<td>0.29 (0.03 - 0.5)</td>
</tr>
<tr>
<td>1/3/11</td>
<td>Not worked</td>
<td>Archaic</td>
<td>7244</td>
<td>-19.51</td>
<td>11.13</td>
<td>-18.21</td>
<td>11.99</td>
<td>0.73 (0.5 - 0.9)</td>
<td>0.27 (0.03 - 0.5)</td>
</tr>
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<td>1/3/11</td>
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<td>7244</td>
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<td>-17.75</td>
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<td>0.3 (0.05 - 0.5)</td>
</tr>
<tr>
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<td>8285-56</td>
<td>-19.29</td>
<td>8.94</td>
<td>-17.99</td>
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<td>0.29 (0.04 - 0.5)</td>
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<tr>
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<td>Yarn z/s</td>
<td>Archaic</td>
<td>7266</td>
<td>-16.14</td>
<td>13.08</td>
<td>-14.84</td>
<td>13.94</td>
<td>0.51 (0.3 - 0.7)</td>
<td>0.49 (0.3 - 0.7)</td>
</tr>
<tr>
<td>1/3/9</td>
<td>Yarn z/s</td>
<td>Archaic</td>
<td>7266-1</td>
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<td>9.41</td>
<td>-18.2</td>
<td>10.27</td>
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<td>0.28 (0.03 - 0.5)</td>
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<tr>
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<td>Archaic</td>
<td>8285-95</td>
<td>-20.44</td>
<td>9.55</td>
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<td>0.78 (0.6 - 1)</td>
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<tr>
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<td>Archaic</td>
<td>6823-12</td>
<td>-20.04</td>
<td>11.78</td>
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<td>6823</td>
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<td>8596-6</td>
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</tr>
<tr>
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<td>Yarn z/s</td>
<td>Formative</td>
<td>8282-8A</td>
<td>-18.33</td>
<td>12.81</td>
<td>-17.03</td>
<td>13.67</td>
<td>0.65 (0.4 - 0.9)</td>
<td>0.35 (0.09 - 0.6)</td>
</tr>
<tr>
<td>2/1/24</td>
<td>Yarn s/z</td>
<td>Formative</td>
<td>7471-32</td>
<td>-19.87</td>
<td>10.17</td>
<td>-18.57</td>
<td>11.03</td>
<td>0.75 (0.5 - 1)</td>
<td>0.25 (0.02 - 0.4)</td>
</tr>
<tr>
<td>2/1/24</td>
<td>Yarn z/s</td>
<td>Formative</td>
<td>7471-14</td>
<td>-19.79</td>
<td>13.29</td>
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<tr>
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<td>Formative</td>
<td>8271-A</td>
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<td>11.49</td>
<td>-18.58</td>
<td>12.35</td>
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<tr>
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Because the earliest evidence for irrigated C₄ crops in adjacent areas of Caleta Vitor are dated to 3,000 cal BP (García and Santoro 2014), any relationship between Archaic fiber assemblages and the MXC foddering regime does not seem straightforward. Thus, fiber samples isotopically attributable to lowlands prior to the Formative period might reflect camelids consuming wild C₃ and C₄ plants available at the lomas formations. Formative assemblages could be integrating camelids grazing either on any of low-elevation fodder pattern or both regimens. δ¹⁵N in bone-collagen samples of archeological camelids from the WCV regime (+10.1‰ - +16‰) are comparatively enriched relative to MXC individuals (+4.1‰ - +11.8‰) (Szpak et al. 2016), but in our case there are no statistically significant differences in δ¹⁵N between Archaic and Formative samples (Chi square = 0.186, p=0.66), and adjusted nitrogen compositions (+7.9‰ - +14.9‰) overlap both ranges. The moderate positive correlation between δ¹³C and δ¹⁵N values (R-Pearson= 0.67, p<0.05), however, might indicate that Formative fibers come from camelids that consumed different C₃ or C₄ resources from irrigated and/or fog-sustained regimes. A weak and not statistically significant correlation (R-Pearson= 0.34, p>0.05) for Archaic assemblages suggest the opposite situation. 13C/12C and 15N/14N ratios of fiber for the Late Period camelids are comparatively broader in range, from -21.4‰ to -12‰ for δ¹³C and from +5.8‰ to +16.9‰ for δ¹⁵N (Table 2). This pattern arises from a sample with low nitrogen isotopic composition (+5.8‰) as well as five samples with highest δ¹⁵N (+15.2‰ - +16.9‰) and δ¹³C signatures (-14.5‰ - -12‰). Mixing models indicate that most camelids had a C3-based diet (66% - 83%), except for three samples enriched in 13C showing a predominant dietary contribution of C4 resources (60% - 79%). Either inter-sample variations in δ¹³C, diet compositions or high δ¹⁵N of fiber and adjusted bone-collagen are collectively consistent with MXC and
WCV patterns. The strong positive correlation between δ13C and δ15N (R-Pearson= 0.88, p<0.05) indicates that this fiber assemblage is defined by a camelid population with diverse consumption of C3 and C4 sources from both low-elevation regimens. Indeed, this implies that fibers with the most enriched carbon isotope compositions were likely recovered from camelids grazing mostly on C4 resources in the driest areas, that ultimately led to 15N-enriched samples (e.g. samples 8038-1, 7272-uw, 7665-3 and 7397-uw, Table 2). While, concurrent low δ13C and δ15N represent camelids from relatively wet areas consuming predominantly C3 vegetation.

Observed spatial arrangements of isotope niches for archeological referential groups in δ13C and δ15N space (Figure 21) indicate different foddering patterns brought about by differential consumption of C3 and C4 plants, but also by altitudinal variations in the δ15N signature of basal resources according to the pronounced moisture gradient that characterizes the region (Szpak et al. 2016). Indeed, MXC, C3P and C4C regimes are isotopically defined by individuals that grazed on a given mixture of resources defined by their photosynthetic pathways and/or δ15N signatures of available plants, which collectively describe a well-constrained SEAa and SEAc for each of these groups (Figure 21a-b). One exception is the population relying on wild vegetation from coastal fog oases that exhibits greater standard ellipses due to high inter-individual differences in δ13C and δ15N values (Figure 21). Albeit this pattern could reflect a heterogeneous dietary composition, we suspect that it arises from methodological biases as niche properties are inferred from simulations based on a small sample size (n=9), under the recommended minimum of 10
individuals, that typically reproduces reliable estimations for niche widths (Jackson et al. 2011; Syväranta J. et al. 2013).

Figure 23. A- Posterior Bayesian estimates for Standard Ellipse areas for archeological referential groups and Caleta Vitor assemblages showing the SEA\textsubscript{b} mode and corresponding 50, 95 and 99\% credible intervals of posterior distributions of 10,000 simulations. Abbreviations for referential groups as in Figure 20.

Niche propriety analyses based on bone-collagen adjusted bi-isotopic values for generic Archaic (n= 12 samples) and Formative (n= 11) chronological groups are in partial agreement with our previous inferences. We corroborate that Archaic (SEA\textsubscript{c}= 6.3\%/o\textsuperscript{2}, SEA\textsubscript{b}= 5.4\%/o\textsuperscript{2}) and Formative (SEA\textsubscript{c}= 6.9\%/o\textsuperscript{2}, SEA\textsubscript{b}= 6.2\%/o\textsuperscript{2}) assemblages have similar niche widths (Figure 23, Table 9), and pair-wise comparisons of the posterior distribution for SEA\textsubscript{b} evince non-significant differences in niche sizes (Table 10). In comparison to referential groups, both assemblages are equivalent in size to MXC (SEA\textsubscript{c}= 9.3\%/o\textsuperscript{2}, SEA\textsubscript{b}= 9.2\%/o\textsuperscript{2}) and C\textsubscript{3}P (SEA\textsubscript{c}= 7.2\%/o\textsuperscript{2}, SEA\textsubscript{b}=7.0\%/o\textsuperscript{2}), but broader than C\textsubscript{4}C (SEA\textsubscript{c}= 5.3\%/o, SEA\textsubscript{b}=4.4\%/o\textsuperscript{2}) and narrower than WCV (SEA\textsubscript{c}= 17.5\%/o\textsuperscript{2}, SEA\textsubscript{b}=14.2\%/o\textsuperscript{2}) regimes (Figure 23, Table 9). Taken together, these results and outputs from mixing models indicate that both groups shared broadly equivalent diets and also the same foddering area along the western Andean slope. The Late Period
group exhibits a wider dietary niche (SEA\textsubscript{c} = 13.3‰, SEA\textsubscript{b} = 14.2‰) than remaining Caleta Vitor archeological populations and most referential groups except for the WCV (Figure 23, Table 9). Nevertheless, the fact that all three SEA\textsubscript{c} describe overlapping isotope niches that are arranged in relatively equivalent positions across the $\delta^{13}$C-$\delta^{15}$N space (Figure 24a) suggest that assemblages from the Archaic to the Late Period occupied a similar tropic niche, and in turn exploited similar resources. If this is true, then the large inter-individual dispersion in carbon and nitrogen isotope compositions observed for the Late Period could reflect gathering of fibers from camelids with diverse trophic preferences. Or alternatively, that such niche amplitude in early counterparts is hindered by smaller sample sizes of Archaic and Formative assemblages that are considerably smaller in comparison with Late Period.

Table 10. Inferred isotope niches (%\textsuperscript{2}) for archeological referential groups and Caleta Vitor (CV) camelid assemblages (based on bone-collagen adjusted values). These are expressed as simple (SEA) or modes for size-corrected (SEA\textsubscript{c}) and Bayesian (SEA\textsubscript{b}) Standard Ellipse Areas. MXC: Mixed Irrigated Cultigens, WCV: Wild Mixed Vegetation, C\textsubscript{4}: Cultivated C\textsubscript{4} Crops, and C\textsubscript{3}: C\textsubscript{3} Pasture.

<table>
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<th>MXC</th>
<th>WCV</th>
<th>C\textsubscript{3}P</th>
<th>C\textsubscript{4}C</th>
<th>CV Archaic</th>
<th>CV Formative</th>
<th>CV Late Period</th>
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<td>4.38</td>
<td>5.44</td>
<td>6.20</td>
<td>14.16</td>
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Table 11. Matrix for pair-wise comparisons for the probability that SEA\textsubscript{b} of horizontal populations are smaller than the SEAs inferred for vertical camelid groups. MXC: Mixed Irrigated Cultigens, WCV: Wild Mixed Vegetation, C\textsubscript{4}: Cultivated C\textsubscript{4} Crops, and C\textsubscript{3}: C\textsubscript{3} Pasture.

<table>
<thead>
<tr>
<th></th>
<th>MXC</th>
<th>WCV</th>
<th>C\textsubscript{3}P</th>
<th>C\textsubscript{4}C</th>
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<th>CV Formative</th>
<th>CV Late Period</th>
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None of the SEAc for Caleta Vitor populations overlap with the isotope niche for the C4C regimen, which is in agreement with our previous inferences from mixing models (Figure 24 b-d). Although such models predict that our archeological assemblages match WCV and MXC foddering patterns, we found no Bayesian ellipse intersection between these referential groups and Archaic and Formative populations. The Late Period assemblage, however, moderately overlaps core isotope niches for archeological camelids relying on WCV as well as with the C3P regimen. When isotope niches are further described in terms of basic Standard Ellipse Area (SEA, dashed lines in Figure 24 b-d) for WCV, C3P and MXC archeological analog camelids groups, SEAc for Archaic and Formative cultural periods now intersect the niche described for camelids foraging at lomas and high-elevation C3 pastures (Fig 5. B-C). Similarly, we verify that the overlapping of Late Period, WCV and C3P populations increase considerably (Figure 24d). We are aware that this approach for comparing isotope niche interactions between populations differing in sample sizes is less robust than based on SEAc (Jackson et al. 2011; Syväranta J. et al. 2013). Nevertheless, we believe that it permits the generation of exploratory hypotheses from limited datasets that could be tested as further stable isotope data for Caleta Vitor or WCV archeological camelid populations become available.

The lack of an isotope niche overlapping either with SEA or SEAc for the MXC referential group indicates trophic niche differentiation within Caleta Vitor assemblages. Hence, similarities in resource exploitation inferred from mixing models arise from comparable positions that these populations occupy on the δ13C axis, which corresponds to the lower
extreme for the carbon range defining the MXC regimen (Figure 24). This finding suggests that provenance extrapolations based merely on the relative contribution of $C_3$ and $C_4$ plants to the diet are not sufficient and need to be supported by additional analyses—i.e., the relationship of isotope niches considering concurrently the $^{15}\text{N}/^{14}\text{N}$ ratio to segregate potential foddering areas. This is particularly true for the western Andean slope, where the spatial distribution of $\delta^{15}\text{N}$ values in basal resources varies predictably across different regional eco-geographical zones (Díaz et al. 2016; Szpak et al. 2013; Tieszen and Chapman 1992).

The marked displacement of isotope niches for our populations towards the lowest $\delta^{13}\text{C}$ and highest $\delta^{15}\text{N}$ isotope space explains those overlaps observed with $C_3P$ and WCV groups (Figure 24). Actually, Late Archaic period niches are embedded within the $\delta^{13}\text{C}$-$\delta^{15}\text{N}$ space in that SEA for both archeological analogs intersect (Figure 24). Because Caleta Vitor assemblages show relatively large isotopic overlap with the WCV, we argue that samples come from individuals foddering at the coastal lomas formations. Modest overlapping with $C_3P$ analog might be indicating also that some fibers were imported directly from the highlands or retrieved from high-elevation camelids that then were translocated into the lowlands and maintained under a WCV feeding pattern. Our data do not allow us to explicitly explore these possibilities as our reconstruction is based on bulk isotopic characterizations, and these kinds of changes in life-history traits need to be tested throughout serial analyses of fibers. We suspect, however, that niche interactions with the high-elevation $C_3$ pasture regimen results from the intra-regimen variability, which in turn determine that some samples could fall outside the overall range defining a given regimen (Szpak et al. 2016). Indeed, few samples from Caleta Vitor fit within the core isotope niche
of C₃P camelids (Figure 24), and even these are far from approaching its mean characteristic nitrogen (δ¹⁵N < +7.5‰ ± 1.4‰) and carbon (δ¹³C= -18.3‰ ± 1.6‰) isotope values (Szpak et al. 2016).

**Figure 24.** Estimated isotope niche (SEAₙ) from the distribution of carbon and nitrogen values of referential camelid groups and Archaic (B), Formative (C) and Late Period (D) populations represented in Caleta Vitor. Dashed cyan and purple lines describe basic standard ellipses (SEA) for archaeological camelids populations raised in highlands and low-elevation C₃/C₄ crop-fields, respectively.
8.7 On fiber procurement

From the Late Pleistocene to the historic times, human coastal populations of northern Chile relied on marine technologies to exploit resources from the highly productive Humboldt Current System (Flores et al. 2015; Núñez et al. 2002; Sandweiss et al. 1998; Santoro et al. 2005). Essential, functional components of this marine technology include fiber implements, an understudied artifact class including lines, nets and tethers, credited with providing over 90% of fish body weight represented in midden deposits at Caleta Vitor (Carter 2016; Santoro et al. 2017). The earliest examples of this technology, from Archaic period deposits, are made of locally sourced, twisted vegetal fiber (Cyperaceae spp.), supplemented by small amounts of camelid fiber (Martens and Cameron 2019; Standen et al. 2004). There is a steady shift in the proportions of raw materials over subsequent periods, with camelid fiber becoming dominant by the Late Formative. This trend intensifies in the Inka period with camelid fiber items becoming the mainstay of the fiber industry and vegetal fiber items becoming scarce (Martens and Cameron 2019). Notwithstanding the significance of this material in the local subsistence economy, the drivers of the steady increase in camelid fiber usage and the geographic source of the material had remained the subject of speculation.

Our stable isotope characterization of camelid fiber artifacts from the Caleta Vitor complex strongly suggests that the fiber-producing animals represented were a local resource, foddering in nearby lomas vegetation formations from the coastal range (400-900 masl). Hence, our results refine earlier hypotheses whilst confirming consistency in the source of this material over time in coastal groups from the Atacama Desert. Indeed, we verify that camelid fibers were more locally accessible to marine hunter-gatherers from the Archaic
onwards. Data presented here supports the notion that coastal fog oases were capable of maintaining low-elevation populations of camelids in the Atacama (Thornton et al. 2011). Because the vegetational structure and composition are largely determined by the intensity of marine fog (Muñoz-Schick et al. 2001), with increased plant cover and diversity during the austral winter and early-spring (Cereceda et al. 2008), we suspect that lomas formations may have sustained seasonal populations of camelids. This implies that coastal hunter-gatherers likely had limited opportunities to acquire fibers. Today, ENSO activity represents the main mechanism accounting for the inter-annual variability in the formation of marine stratocumulus over the Atacama coast (Cereceda et al. 2008; del Río et al. 2018), and in turn influencing directly the plant diversity patterns in these communities (Muñoz-Schick et al. 2001; Pliscoff et al. 2017). ENSO-induced changes in the intensity of Camanchaca and the structure of fog oases have been documented in the area during pre-Hispanic times (Latorre et al. 2011). Such changes apparently did not affect the overall availability of local camelids or the fiber procurement strategy of local hunter-gatherers.

Coastal-range camelid fiber extraction in the Central Andes is not a novel idea. Small-scale local production has been documented by the Early Intermediate Period (ca. 2000 BP) in agro-maritime groups from low-elevation valleys of northern Perú (i.e. Virú; Szpak et al. 2015; 2014). Still, the case of Caleta Vitor represents the first evidence for fiber procurement from wild-camelid populations, by marine hunter-gatherers since the Archaic. Although some fibers (i.e. exhibiting affinities with the C3P pasture regime) could have been supplied by inland groups (i.e. from Azapa Valley) that maintained an agro-pastoralist economy related to highland peoples (García and Santoro 2014), such interaction/exchange network was marginal. The record of such fibers could be alternatively explained by the fact
that camelids may foraged on low-elevation vegetation at well-irrigated areas that exist within coastal ravines. Marine hunter-gathers could have obtained fiber from camelids that inhabited coastal riparian oases is supported by a dietary analysis from archeological fecal samples recovered in shell-middens found at the nearby Caleta Camarones (ca. 50 km far south of Caleta Vitor). Indeed, Belmonte et al. (1988) evince archeological camelids that grazed riparian-estuarine vegetation at Caleta Camarones, including several grasses, *Schoenoplectus americanus* (C\textsubscript{3} pathway) as well as *Distichlis spicata* (C4).

By the Late Period, camelid fiber had completely supplanted vegetal fiber (<3%) and formed more than 90% of the assemblage. Interestingly, our isotopic data indicate no concurrent change in the source of fibers which were collected from animals living in nearby lomas formations. The increase of consumption of camelid fiber of local origin from the Formative period at Caleta Vitor, is in contraposition to the expansion of interregional interaction archaeologically visible through the introduction of a series of objects, raw materials, and crops (Carter 2016; Martens and Cameron 2019). The socio-economics and political mechanisms for these interactions may have included verticality, opportunistic exchange operations, military protection and marriage alliances. These mechanisms seem to fit better the socio-political evolution of farming groups in lowland valleys and oases (Gallardo 2013; Santoro et al. 2010). Coastal social groups, however, seem to have maintained independence and economic autarchy, expressed in a proper iconographic style that differentiated them from people of the lower valley that developed the well-known Arica iconography. Furthermore, it seems that leaders of interdependent sociopolitical coastal groups displayed cephalic feather headdress as a possible identity emblem (Horta-Tricallotis 2000), and maintained and controlled exchange networks with different inland groups as
observed in the Taltal area (25°S) (Ballester and Gallardo 2011). During the Inka period, despite all the political, economic and ideological rearrangement carried out by the State, coastal groups managed to maintain their independence and identity (Covey 2000; Horta-Tricallotis 2000).

In sum, in this political scenario, the increasing acquisition of camelid fiber, required by increased population that needed more material for fishing equipment and clothing appears to have been solved through the continuation of hunting in these areas, or by exchange with groups who had domesticated herds foddering in these formations.

### 8.8 Conclusion

Stable isotope analyses are contributing new lines of evidence which deepen the discussion of long-term pre-Columbian socioeconomic processes. Contrary to the general view of Pacific coast hunter-gatherer polities, the technological, economic, socio political, and ideological structural transformation initiated in the Formative period (ca. 4,000 BP) was integrated differently into these communities. In contrast to polities settled in lowland and highland valleys and oases where farming, herding and the other concomitant elements triggered rather drastic changes in the socio-political systems, coastal people do not appear to have been heavily impacted by the broad scale changes introduced during the Formative period. Instead, they adopted only a selection of the new outside technologies and material goods for their everyday life which according the results of our stable isotope analyses, did not include imported camelid fiber. Although camelid fiber usage increased over time, the source for this byproduct remained outside the world of highland domesticated camelid herds. Instead, fiber was obtained from wild animals grazing in the lomas vegetation. Hence,
we suggest that these coastal groups from the Atacama Desert maintained the old Archaic tradition of procurement involving hunting, representing a resilient behavior; an attempt of these maritime hunter-gatherers in the Atacama Desert Pacific coast to maintain this millennial traditional activity outside the “modernity” provided by the Neolithic inputs, as discussed for other extreme environmental ecosystems of the world (Vanhanen et al. 2019).

8.9 Acknowledgments

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Chapter 9. General Discussion and Conclusions

9.1 Overview and Aims

The thesis documents material and technical changes in Caleta Vitor’s fiber industry across the Middle and Late Archaic, Formative and Late Periods. The post-depositional environment of coastal sites in northern Chile provides excellent preservation conditions for fiber artifacts, and archaeologists have noted these items at sites across the region, as early as the Archaic Period. Despite their ubiquity, just a few studies of fiber artifacts have been conducted, but without a well-established trajectory of the fiber processing industry or understanding of the origin of fibers, the artifacts were of limited interest to archaeologists. Without detailed, quantitative analysis, researchers either relied on anecdote, observation or data from distant archaeological records from northern Peru, where cotton is native and significantly impacted the industry. Similarly, camelid fiber procurement by early populations on Chile’s north coast has remained subject to speculation, with limited data available on pre-Hispanic, camelid ranges or foddering areas outside the highlands.

The research provides a detailed account of fiber processing and cloth production choices as well as the first quantitative evidence of camelid fiber procurement in northern Chile. These detailed technological and material trajectories provide a contextual framework for future analysis of fiber artifacts while also demonstrating the importance of fiber items in the local subsistence economy. Further, the isotopic analysis provides much-needed clarity in understanding the local camelid fiber economy and a valuable framework of isotopic data that can be used to contextualize isotopic signatures in the future.
Fiber technology was essential to the marine subsistence economy of northern Chile’s, coastal, pre-Hispanic population which relied on composite fishing tools such as nets, hooks, harpoons and tethers that required durable yarns (lines) to function. These tools provided an estimated 90% of foodstuffs represented in midden deposits at the Caleta Vitor archaeological complex. Despite the importance of these fiber components, thread production, knotting, and other technologies required to produce these items had received limited or no attention from archaeologists. The papers in this dissertation employ traditional textile and stable isotope analysis as well as consultation of historic written sources, in conjunction with previously established site chronology to addresses this gap by:

1. Establishing fiber processing and cloth production technologies and;

2. Material types in use at the site;

3. Contextualizing textile style;

4. Establishing the influence of external pressures (cultural, political and economic) on the fiber industry and textile type and style at the site;

5. Testing previously established theories regarding the procurement of camelid fiber using stable light isotope analysis.
9.2 Summary of Findings

Fiber artifacts were not recovered from Early Archaic layers at Caleta Vitor. However, the use of nets during this period is implied by large numbers of net-caught fish species in the earliest Archaic Period unit (CV3/1/31), dated 9271-9487 BP (ANU31016-9187). Carter (2016) concluded that nets or line caught would have been necessary to catch the very small sardines, and anchovies (Engraulidae) represented in the unit. Other excavated species and small animals are presumed to have also been net caught. Additionally, a fine shell bead, recovered from the layer above CV3/1/30, dated 8662-9487 BP (ANU31014-9186) was almost certainly suspended on a cord. These items attest to a knowledge of cordage production at the site during the earliest occupation, however, they do not offer sufficient information for detailed analysis of fiber processing techniques which might include simple shredded plant material, fine strips of leather and/or twisted animal fiber.

The earliest processed cordage from Middle Archaic units (CV 1/3/17, 1/3/22) comprises short lengths of two-ply vegetal fiber yarns (n=6), likely composed of locally available sedges of the Schoenoplectus spp. family. Unfortunatley, those artifacts are very short fragments and it is not possible to ascribe them a specific use; however, the presence of net-caught fish species, beads and matting indicate a plethora of applications including subsistence, shelter, mortuary goods, and personal adornment. Similarly fragmented examples of processed camelid fiber yarns first appear soon after, early in the Middle Archaic (CV1/3/12, 1/3/11 and 1/3/9), along with processed vegetal fiber. These yarns were in a similarly fragmentary state but likely fulfilled the same purpose as those earlier, vegetal artifacts. One example of vegetal, Z-direction twining recovered from Middle Archaic Period (CV
1/3/9) is almost certainly associated with one of the two burials identified in trech CV1/3 by Carter (2016). Reed burial shrouds were used throughout the Chinchorro sphere of interaction in the Archaic and beginning of the Formative Period. Twining constructed in the same Z-orientation appears again in the Late Formative Period (CV2/1/2 and CV2/1/3) and Late Period (CV6/1/9).

Cotton is rare throughout the sequence, achieving a modest increase in occurrence from 2.1% of the Archaic and Formative Period fiber artifact collection to 7.2% of the fiber collection from Late Period deposits. Cotton first appears in the Early Formative (CV1/3/2) as a severely degraded, short fragment of yarn alongside more abundant camelid fiber and vegetal fiber yarns. It is interesting also to note the seeming reluctance of the Caleta Vitor population to adopt cotton for fishing nets and lines. Cotton’s exceptionally long staple and drought tolerance make it especially suitable for growing in the Atacama coast and desirable for marine resource exploitation. After the initial appearance of this material in the Early Formative Period, it is rare throughout subsequent sequences. However, the apparent rarity of this fiber might be an artifact of preservation bias rather than an accurate reflection of the use of the material in pre-Hispanic times.

Vegetal fiber yarns outnumber camelid fiber yarns until the Late Formative Period when the vegetal fiber falls out of favor, a trend that continues to the Late Period when vegetal fiber artifacts make up less than 3% of the total, and there is a clear preference for camelid fiber (90.2%). Notably, vegetal fiber yarns never achieve the same uniformity as camelid fiber processing. This may be a result of the physical characteristics of vegetal fiber which cause bast fibers to twist one way or another preferentially, called the fibrillar orientation.
(Bergfjord and Holst 2010) rather than differential treatment of the two materials, confirming this supposition will require experimentation.

The style and technical attributes of small textile fragments recovered from the site’s Late Formative Period deposits compare favorably with attributes typical of the broader textile tradition that stretched between the Azapa to Loa river valleys. Following the Formative Period when pottery, an array of domesticates and the backstrap loom arrive on the coast, a new local textile tradition developed, eventually spanning the area previously dominated by Chinchorro cultural traits; Rio Loa to the Azapa Valley. The tradition is expressed in technological features and encompasses standard stylistic attributes that became central to cultural identity in the region. Confirming Caleta Vítor’s participation in this regional, textile tradition is significant as it is one of a handful of confirmed sites outside the Azapa Valley. The transference of this complex technology and style across such a large territory, without written language, requires further investigation.

The suite of techniques that defines this tradition also appear in textiles from Late Period deposits at the site, however, further work including investigations of Middle Horizon and Late Intermediate Period textiles not represented in the excavations available for this dissertation will be required to show continuity in style and technique at Caleta Vítor and across the region. Local proxies for Inka State interaction in northern Chile and particularly, the coastal Atacama are still being developed. The unexpected discovery of an Inka unku at the site not only supports previous work indicating an Inka presence at the site but suggests a more formal relationship with the Empire that included direct administrative interaction.
This interaction may have been a part of the complex negotiation process undertaken by the Inka in newly conquered territories. *Unku* played an important role as material representations of Inka power. The unprecedented discovery is significant to the developing understanding of Inka activity on the northern Chilean coast, a region previously believed peripheral to Inka interest. Typical prerequisites of Inka involvement are absent at the site, however, the CV *unku* with concurrent increases in pottery discards, marine resource extraction, population increase and camelid droppings at the site may represent State involvement as well as a new set of proxies for Inka interaction on the northern Chilean coast.

Identifying the CV *unku*, recovered from CV2, as an Inka *unku* required stylistic and technical analysis as well as consultation of written historical sources and artworks. The technical features of the CV *unku* compared favorably on all diagnostic features of *unkus* and is technically unlike any local textiles. Stylistically, the garment is somewhat unique when compared to the database of extant *unkus*, but it adheres to expected spatial organization conventions and displays conventional types of elaborations. Further, the garment is compellingly similar to those depicted on a 16th-century coat-of-arms depicting Sapa Inka Topa Inka Yupanki as well as the famous Felipe Guaman Poma de Ayala manuscript titled *The First Chronicle and Good Government* (2009).

The isotopic results from all three Caleta Vitor camelid groups (Archaic, Formative and Late Period) overlap considerably in the $\delta^{13}C-\delta^{15}N$ space, indicating the animals exploited similar resources. The most significant overlap occurs with the ‘wild coastal vegetation'
(WCV) regime; characterized by an even mixture of wild C$_3$ and C$_4$ vegetation, likely from the lomas formations or ravine riparian zones, growing in proximity to a marine environment and effected by aridity. This indicates that the camelid fiber processed at the site during the Archaic, Formative and Late Periods was a local product, obtained from the Coastal Range where animals grazed on lomas vegetation (400-900m asl). This procurement model remained unchanged even after the arrival of camelid caravans at the site in the Formative Period. This finding supports Carter's (2016) conclusion that the Chinchorro obtained the necessities of life from their local environment and that this vital resource was more readily available in the coastal Atacama than previously indicated.

Camelid fiber steadily increased in prominence from the Middle Archaic Period onward, experiencing significant surges in use during the Late Formative and Late Periods. Both of these periods are marked by increased contact with highland groups. Previously, increases in camelid fiber at coastal sites were interpreted as reflecting increased exchange with highland groups, supplying a highland product. On the contrary, isotopic signatures presented in this thesis indicate that local camelids foddering on lomas vegetation supplied the fiber needs of the people of Caleta Vitor. This finding suggests that the increases in camelid fiber at the site reflect local changes such as population increases and perhaps an increase in the availability of camelid fiber through increased local exchange, probably facilitated by llama caravans as evidenced by the concurrent increase in droppings at Caleta Vitor.

In summary, the study

1. Identifies the first direct evidence of yarn production at Caleta Vitor in the Middle Archaic Period, as twisted vegetal fiber;
2. Presents the earliest indirect evidence of simple cordage, in the Early Archaic Period (a fine shell bead in the layer above (CV3/1/30) dated 8662-9487 (ANU31014-9186). As well as abundant net-caught fish species Enrigulidae in unit (CV3/1/31);

3. Identifies twined vegetal matting as the earliest textile type at the site, in the Z-direction, from Middle Archaic layers;

4. Confirms Standen (1997, 2003) and Standen and Santoro (2004)’s theory that vegetal and camelid fiber artifacts were used during the Archaic Period in northern Chile rather than cotton which appears in the Early Formative Period;

5. Confirms that the initial appearance of advanced cloth production techniques, including loom weaving, occurs in the Late Formative Period;

6. Identifies the textile styles and techniques of Caleta Vitor Late Formative and Late (Inka) Period woven fragments as belonging to the broader textile tradition of the region established by Ulloa (2008);

7. Provides the first evidence of low altitude camelid grazing in the lomas formations of the Coastal Range (400-900 masl) of northern Chile;

8. Identifies the first Inka unku ever discovered outside Peru.
9.3 Conclusions

Given the Early Holocene evidence for nets and decorative cordage at Caleta Vitor, people likely arrived at the site with knowledge of fiber processing that was sufficient to support a marine focused subsistence economy. Evidence of Late Pleistocene/ Early Holocene era fiber industries in western Utah, Peru and southern Chile (Jennings 1975; Adovasio 1997; Keefer et al. 1998; Sandweiss et al. 1998; deFrance et al. 2001; deFrance 2005; Jolie et al. 2011) indicate that fiber processing has deep roots in the Americas or was brought to the New World by the earliest pioneers as previously suggested by Adovasio and Maslowski (1980).

The fiber economy of Caleta Vitor transitioned from vegetal fiber, obtained from locally growing reeds to camelid fiber; from animals living in the Coastal Range, while cotton, introduced in the Formative Period, remained a marginal fiber source. This arrangement is contrary to previous models that indicate the Inka and other highland groups had a considerable impact on the exchange of camelid fiber in the region, and that camelid fiber was a highland product traded for coastal goods. A similar pattern can be seen in the continued exploitation of local clay sources despite contact with highland empires and the reticence of the population to adopt agriculture like their inland neighbors. This stability in subsistence behavior and craft material sourcing has been noted at Caleta Vitor by others (Carter 2016; Roberts et al. 2013; Bland et al. 2017) and across the broader region by Uribe and Vidal (2015). Determining whether this staunchness constitutes active resistance to new technologies and materials, risk aversion, or other environmental or socio-political factors
that limited the populations’ reliance on external or exchange goods will require further work.

The population was introduced to the backstrap loom by highland migrants and learned to weave during the Formative Period. While some highland textile styles appear at the site, the people of Caleta Vitor took part in the local textile tradition, spanning the Azapa to Loa valleys. Initial investigation suggests this tradition may have continued at Caleta Vitor through to the Late Period. This is the same region dominated by Chinchorro material culture in the Archaic Period, if further research confirms the tradition does carry on through to the Late Period at other sites, this represents a considerable geographic and temporal, cultural continuity spanning at least 7,000 years and over 500 km of coastline.

Isotopic evidence suggests that the population was not reliant on trade with highland groups for camelid fiber but rather, hunters obtained this vital resource from local camelid populations living in the coastal range. When considered in conjunction with other evidence for Inka activity at the site and changes in resource exploitation during the Late Period it appears there was a complex relationship between the site and the Inka State that has not been previously appreciated. The data suggest a complex pattern of exchange that did not include camelid fiber or affect clay sourcing for pottery production but likely did include some form of administration, increased resource extraction, and population growth. Whether this constitutes a new diagnostic suite for Inka activity in the region will require further work as will the adequate definition and characterization between the State and coastal sites in Chile’s northern Atacama.
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Appendix A. Supplementary Information for Martens T. and J. Cameron (published) Early Coastal Fiber Technology from the Caleta Vitor Archaeological Complex, Northern Chile. *Latin American Antiquity*.

**Supplemental Table 12 Fabric Density Scores Calculated as per Cassman (1997:87).**

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<tr>
<th>Context</th>
<th>Artifact Number</th>
<th>Warp diameter (mm)</th>
<th>Weft diameter (mm)</th>
<th>Warps x Wefts/ cm</th>
<th>Fabric density score (Cassman 1997:87)</th>
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Supplemental Table 13 Simplified summary of Artifact Material Types and Techniques by Archaeological Context.

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<td></td>
<td>1/3/22</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Z/S (n = 6)</td>
<td>-</td>
<td>-</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6411-6631</td>
<td>1/3/25</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a After Emery (19809)*

b All interlaced textiles are either cotton (CV2/1/2) or camelid fiber

c All twined fragments are vegetal

d All coiled fragments are vegetal and likely from the same artifact

*e All Dyed material is camelid fiber

*f V = vegetal, C = camelid
## Appendix B. Trench Summary from Carter (2016)

<table>
<thead>
<tr>
<th>Trench No</th>
<th>Number of units</th>
<th>Size (M)</th>
<th>Depth at Base</th>
<th>Basal Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV1/2</td>
<td>17</td>
<td>1.0x0.5</td>
<td>1.2</td>
<td>Bedrock</td>
</tr>
<tr>
<td>CV1/3</td>
<td>26</td>
<td>1.0x0.5</td>
<td>1.8</td>
<td>Bedrock</td>
</tr>
<tr>
<td>CV2/1</td>
<td>58</td>
<td>1.0x0.5</td>
<td>3.2</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV3/1</td>
<td>31</td>
<td>1.0x0.5</td>
<td>1.8</td>
<td>Bedrock</td>
</tr>
<tr>
<td>CV4/1</td>
<td>19</td>
<td>1.0x0.5</td>
<td>0.8</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV4/2*</td>
<td>5 (arbitrary)</td>
<td>1.0x0.5</td>
<td>0.8</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV4/3</td>
<td>2 (arbitrary)</td>
<td>0.75x0.75</td>
<td>0.15</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV4/5</td>
<td>10 (arbitrary)</td>
<td>1.0x0.5</td>
<td>1.0</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV6/1</td>
<td>16</td>
<td>1.0x0.5</td>
<td>1.2</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV6/2</td>
<td>5 (arbitrary)</td>
<td>1.0x0.5</td>
<td>0.5</td>
<td>Bedrock</td>
</tr>
<tr>
<td>CV6/3</td>
<td>6</td>
<td>1.0x0.5</td>
<td>0.6</td>
<td>Deposit continues</td>
</tr>
<tr>
<td>CV7/1</td>
<td>11</td>
<td>0.5x0.5</td>
<td>0.8</td>
<td>Sterile sand and loose rock</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trench No</th>
<th>Fish Bone</th>
<th>Other Bone</th>
<th>Shells</th>
<th>Lithics</th>
<th>Ceramic Shards</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV1/2</td>
<td>626.6</td>
<td>1291.0</td>
<td>3106.3</td>
<td>1211.7</td>
<td>-</td>
</tr>
<tr>
<td>CV1/3</td>
<td>2380.1</td>
<td>1256.6</td>
<td>6994.8</td>
<td>986.9</td>
<td>-</td>
</tr>
<tr>
<td>CV2/1</td>
<td>4506.4</td>
<td>1351.6</td>
<td>21410.2</td>
<td>2306.6</td>
<td>413.6</td>
</tr>
<tr>
<td>CV3/1</td>
<td>1207.4</td>
<td>835.8</td>
<td>12262.4</td>
<td>809.5</td>
<td>-</td>
</tr>
<tr>
<td>CV4/1</td>
<td>3657.6</td>
<td>320.4</td>
<td>16966.4</td>
<td>330.9</td>
<td>3133.3</td>
</tr>
<tr>
<td>CV4/6</td>
<td>764.5</td>
<td>507.1</td>
<td>1257.8</td>
<td>514.3</td>
<td>2853.4</td>
</tr>
<tr>
<td>CV6/1</td>
<td>2631.1</td>
<td>321.0</td>
<td>19535.4</td>
<td>2188.9</td>
<td>5839.9</td>
</tr>
<tr>
<td>CV6/2</td>
<td>198.3</td>
<td>5.5</td>
<td>1054.0</td>
<td>228.6</td>
<td>456.2</td>
</tr>
<tr>
<td>CV6/3</td>
<td>1555.8</td>
<td>2688.3</td>
<td>13434.1</td>
<td>861.6</td>
<td>1500.8</td>
</tr>
<tr>
<td>CV7/1</td>
<td>141.4</td>
<td>10.5</td>
<td>639.0</td>
<td>36.8</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>17099.6</td>
<td>11477.9</td>
<td>90600.4</td>
<td>9458.8</td>
<td>12197.2</td>
</tr>
</tbody>
</table>

*Net weight in grams per trench*