1-1-2001

Sedentism among the Archaic fisher-folk of northern Chile: A malacological perspective

Sally D Llull-Billings
University of Nevada, Las Vegas

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http://dx.doi.org/10.25669/89fg-t4l0

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SEDENTISM AMONG THE ARCHAIC FISHER-FOLK OF NORTHERN CHILE: A MALACOLOGICAL PERSPECTIVE

by

Sally Llull Billings

Bachelor of Arts
University of Nevada, Las Vegas
1994

A thesis submitted in partial fulfillment
of the requirements for the

Master of Arts Degree
Department of Anthropology
College of Liberal Arts

Graduate College
University of Nevada, Las Vegas
December 2001

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The Graduate College
University of Nevada, Las Vegas

October 4 , 20 01

The Thesis prepared by

Sally Llull-Billings

Entitled

"Sedentism Among the Archaic Fisher-Folk of Northern Chile: A Malacological Perspective"

is approved in partial fulfillment of the requirements for the degree of

Master of Arts, Anthropology

Examination Committee Chair

Dean of the Graduate College

Examination Committee Member

Claude N Warren
Examination Committee Member

Margaret M Lyneis
Examination Committee Member

Graduate College Faculty Representative

ABSTRACT

Sedentism Among the Archaic Fisher-Folk of Northern Chile: A Malacological Perspective

by

Sally Llull Billings

Dr. Bernardo Arriaza, Examination Committee Chair
Professor of Physical Anthropology
University of Nevada, Las Vegas

Oxygen isotope analysis of shell material from the Camarones West Shell Midden and from the site of Quiani has revealed that year-round collection of shellfish for food by the people of the Chinchorro Culture was not practiced. Additional shell demographics from the site of Quiani further support the oxygen isotope results. Radiocarbon dating revealed that the midden sample spanned the Classic Chinchorro and Transitional Chinchorro epochs, from 5590 to 3830 B. P. Shell classification and quantification of these sites also revealed that shellfish collection and the types of shellfish harvested has been consistent from Chinchorro times to the present.

This report is the first attempt to utilize oxygen isotope analysis in conjunction with shell middens in the Camarones River Delta to determine seasonality of resources and its relationship to sedentism. This finding may be important to future arguments for fully sedentary Chinchorro communities.

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ACKNOWLEDGMENTS

Many people have contributed in some form or fashion to this work to whom I would like to express my deepest gratitude. First and foremost I would like to thank my advisor, Bernardo Arriaza, for his support for my work, for the first spark of inspiration that he gave me that led me to do this research, and for inviting me to visit Chile. I would also like to thank the faculty and staff of the Museo Arqueológico de San Miguel Azapa, in particular Luis "Lucho" Briones, Calogero Santoro, Eliana Belmonte, and my good friend, Raul Rocha. Their help and support has been immeasurable. Also, two faculty members of the Universidad de Tarapaca, Jorge Corrales, and Arnaldo Vilaxa, who provided technical assistance for underwater diving. Many thanks and love to Maria Morales Nuñez and her mother, Doña Julia, and Heraldo Gonzalez for taking me into their home and treating me like one of the family. Thanks to Rick Sutter, Sloan Hart, and Matt Dubrava for their generous help at the site of Camarones.

I would also like to thank Dr. Daniel Sandweiss of the University of Maine and Dr. Harold B. Rollins of the University of Pittsburgh for the repeated personal communications we interchanged, and for their input and assistance in getting the information I needed about oxygen isotope analysis and the regression formulae I needed to convert the data to temperature. Thanks to Craig Shadel of DRI for the oxygen isotope analysis of the shells.

Thanks to Dr. James McClean of the Natural History Museum of Los Angeles County, for allowing me to browse through his shellfish collections. To Dr. David Reese of the Field Museum of Natural History of Chicago, thanks for all of the references and abstracts he sent me that enabled me to expand my search for background information. Pat Lafollette, an amateur shell collector, helped me to identify different species of shells and provided stimulating and thought provoking conversation via e-mail.

Thanks to the National Geographic Institute for the grant that enabled us to process the radiocarbon data for the Camarones West shell midden.

Special thanks to the members of my committee, Dr. Alan Simmons, Dr. Margaret Lyneis, and Dr. Claude Warren, for their support and patience.

And lastly, my greatest thanks to my husband, Paul Billings, and my children, Tabitha and Michael Stewart, and my parents, Juan and Sally Llull, for their years of love, support, and patience.

CHAPTER 1

INTRODUCTION

The study of mobility and settlement patterns among prehistoric peoples has been influenced by the changing trends in archaeological method and theory. The cultural phenomenon called sedentism has not been extensively examined exclusively on its own terms, but as it relates to specific subsistence practices. Sedentism has often been associated with food production, in the sense that without the stabilizing effect of plant cultivation and to a lesser extent, animal domestication, settlement in one place was not feasible on a permanent basis. As humankind's dependency on plant cultivation increased through time, the level of residential mobility decreased, which in turn often led to social complexity. The resulting surplus of food allowed more time for craft specialization, which in turn led to the redistribution of goods and services, and hence to the rise of social classes. The development of social complexity has been regarded as the normal progression of events that occur when a society shifts from a mobile hunting and gathering economy to an agricultural economy. These criteria often have been applied to many prehistoric peoples of the world, without taking into account other factors that may have contributed to changing settlement patterns and social development.

Even today scholars tend to utilize the more traditional classification of societies put forward by Service (1971), and this has greatly influenced how settlement patterns and subsistence strategies are studied. Service's broad classifications of societies into band, tribe, chiefdom, and state level societies continues to be the model that is most often used to categorize prehistoric societies and is based on settlement patterns and site formation (Renfrew and Bahn 1996:166). According to this model, band-level societies are characterized as mobile hunters and gatherers who did not engage in any type of food production, and thus, in an evolutionary sense, were the most primitive type of society. Once food production was adopted as the primary subsistence practice, human settlements became more economically stable and shifted to a year-round occupancy of an area.

New methods in environmental and biological archaeology have shifted the focus of investigation from the culture history of sites to a regional perspective of settlement patterns, subsistence, and site formation. It is no longer feasible to limit past human experience to a few broad classifications that are outdated and increasingly difficult to support. Many different types of adaptation strategies for band-level prehistoric peoples are now recognized (Barbosa et al 1994; Gaspar 1994; Koike 1975; Perlman 1980; Ranere and Hansell 1978; Renouf 1978) thanks to changes in methodologies and the use of new technologies (Koike 1975; Stein et al 1992; Thomas and Thompson 1992) brought about by multidisciplinary scientific inquiry. This has allowed us to broaden the scope of our theoretical paradigms concerning many areas of research, including sedentism.

A case in point pertains to those pre-agricultural societies that are known to have occupied areas of diverse resources, such as coastal environments. There is ample evidence from a variety of sources that make a strong case for the permanent occupation of these types of sites without any indication of farming whatsoever.

Many researchers have used an environmental approach in the study of settlement patterns and site permanence. For coastal sites, the preservation of pre-ceramic shell middens that have been found in association with many prehistoric sites worldwide has produced valuable and ample data . The type of data that can be obtained from these middens range from identifying the type and quantity of food consumed through time, to site demographics, to the determination of the season of occupation of a site at any given time during its history (Rollins et al 1987; Rollins et al 1990; Stein 1992; Stein et al 1992; Waselkow 1987). The analytical techniques that have been used to study shell middens include oxygen isotope ratios and mollusk shell ring growth to determine climate and environmental change, and mollusk shell-meat ratios to determine caloric intake (Claassen 1998).

One ancient coastal group in particular has been the focus of some scientific debate in recent years. The Chinchorro culture of northern Chile spans some 5,000 years, from around 7,000 years to about 1,100 before the beginning of the Christian era (Arriaza 1995). This culture presents an interesting paradox for archaeologists because the Chinchorro people deviated from traditional band-level behavior; the complex mortuary tradition of artificially mummifying the dead that they practiced does not coincide with the mobile lifestyle of hunting and gathering groups.

The purpose of this study is to examine the preexisting data obtained from shell middens and other coastal sites, and to generate new data for the prehistoric Chinchorro culture of coastal northern Chile, in order to a) determine whether this group was mobile or sedentary, and b) to establish whether coastal resources played a key role in their settlement patterns. By utilizing oxygen isotopic ratios on marine shells obtained from shell middens in the Camarones delta and from the site of Quiani to determine water temperatures and thus the season the shellfish were harvested, new perspectives on the continuing debate of the nature of Chinchorro settlement patterns and how they fit within the scheme of pre-agricultural hunting and gathering societies can be presented.

The Chinchorro exhibited certain cultural characteristics that fall outside the traditional spectrum of traits that usually define band-level pre-agricultural societies. One of their more salient features was their practice of artificially mummifying their dead, which preceded the Egyptian tradition by several millennia (Arriaza 1995; Aufderheide 1993; Muñoz and Chacama 1982; Nuñez 1969; Schiappacasse and Niemeyer 1984). This, combined with the lack of evidence of agriculture in that area before 3450 B. P., and the wealth of evidence of a strong maritime economy has led some to speculate that the Chinchorro may have led a relatively sedentary existence (Arriaza 1995; Aufderheide and Allison 1992). Other authors disagree with this view, and have postulated that the Chinchorro were mobile hunters and gatherers (Muñoz and Chacama 1993: 46; Nuñez 1989-91-92; Rivera 1991). The abundance of maritime resources in a harsh desert environment may have been the key variable by which the Chinchorro could have achieved the stability necessary for sedentary living. The fact that a seemingly simple pre-agricultural society could live a sedentary lifestyle strongly implies that other non-agricultural prehistoric societies could have, as well.

Understanding and identifying the forces that play key roles in the decision-making processes regarding the choice of one type of subsistence strategy and settlement over others can avoid stereotypical classifications of human societies. In this way, a broader range of cultural behavior can be attributed to hunter-gatherer societies.

The main focus of this study seeks to understand the role of coastal adaptation and the development of residential sedentism for the Chinchorro culture. This residential sedentism may have been the prime factor that permitted the development of a complex funerary tradition for which the Chinchorro are known. The methodology used to investigate whether the Chinchorro were sedentary, based on a coastal subsistence strategy, included the sampling of the shell midden Camarones West that dates to 5590 B.P. (Ramsey 2000) and the analysis of the shell material removed from the midden. The site is chronologically associated with the Chinchorro culture in the coastal area of the Camarones Gorge, at the mouth of the Camarones River. Several samples of shell material were submitted for oxygen isotope analysis to the isotopic laboratory of the Desert Research Institute, University of Nevada, Las Vegas in order to determine sea surface temperatures and thus the season the shells were gathered for food. By doing this, it may be possible to determine the degree of site usage, and thus the degree of residential permanence that is attributable to this area.

Location and Environment

The modern coastal environment of northern Chile is that of a desert with little or no precipitation. The coastline forms the westernmost margin of the Atacama Desert. The lack of precipitation along the coast is due to the cold Humboldt current, which inhibits evaporation of the coastal waters. Transverse winds push masses of cool, moist air up and over the Andes, where the rain is deposited (Arriaza 1995: 31; Crom 1993:17). The topography of this area is dominated by east-west trending mountain chains, canyons and valleys that were formed during the Late Pleistocene. Rivers that originate in the high Andes flow westward through these valleys and canyons to drain into the Pacific Ocean (Crom 1993:17-18). Presently, these rivers are seasonal, flowing during the spring and early summer months, November through December. These rivers and small littoral springs constitute the only water sources in this region and have created coastal oases that provide a rich ecosystem of plants, birds and animals. The actual shoreline is comprised of rocky beaches and cliffs, interrupted by narrow sandy beaches. This fertile coastal strip is not only archaeologically rich, but is vital for the maintenance of modern populations who utilize these oases for crop cultivation. An important fishing industry presently thrives off the coastal waters, and provides food for both the local population and for export.

The project area is located at the mouth of the Camarones River, in the gorge that bears the same name, at 19° 12' latitude south, and 70° 17' longitude west (Muñoz 1989:85; Schiappacasse and Niemeyer 1984:3) (Figure 1). This area lies approximately 100 kilometers south of the city of Arica. The area is characterized by the river delta, and is bounded on the northern and southern margins by fluvial terraces that give way to the sharply rising mountains that form the gorge walls. The delta terminates in a sandy beach that measures approximately 1,400 meters in length, and stretches between the northern and southern margins of the gorge (Figure 2).

The delta itself is comprised of marshes of brackish water. The beach terminates in the north by an abrupt rocky point called Punta Norte (Schiappacasse and Niemeyer 1984:3). Along the south, the beach terminates in a series of high cliffs that form narrow terraces, where a two-track dirt road bends around the southern point to hug the westward facing cliff face. The shell midden Camarones West (marked with an asterisk) is located along the edge of the cliff that forms the southern boundary of the gorge, and which runs parallel to the coastline.

The terrace terminates in a small cove on the south and houses a small fishing fleet (Figure 3).

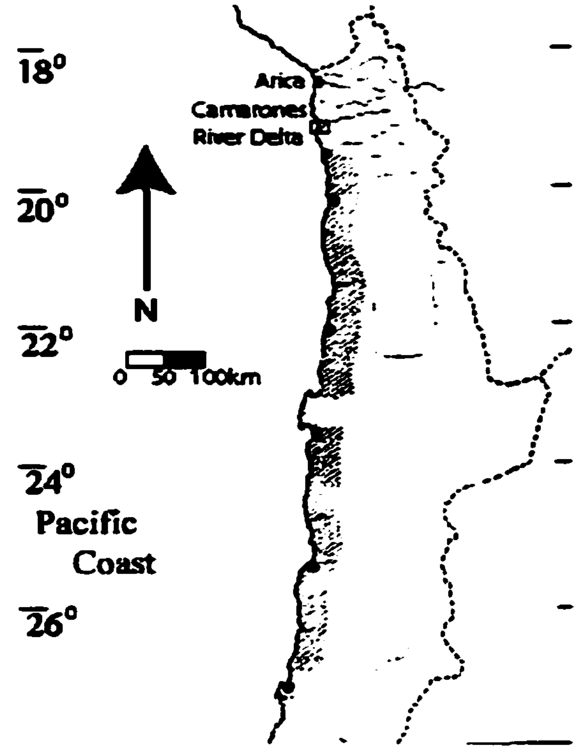


Figure 1. Project location (map illustration taken from Llagostera 1979).

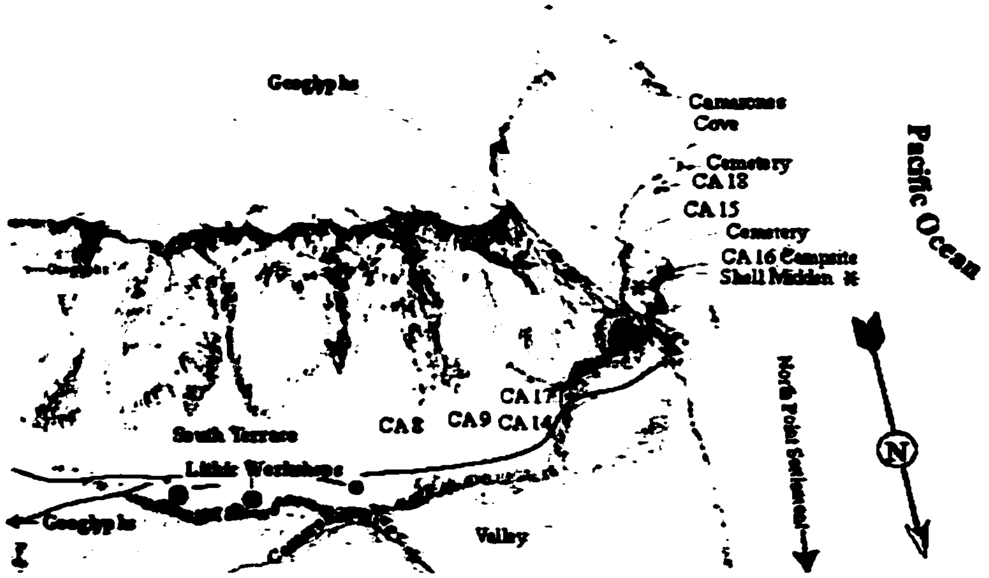


Figure 2. The Camarones delta and project area: three-dimensional perspective (illustration modified from Rivera 1984).

Figure 3. Camarones delta overview.

The climate along the coast of northern Chile is mild. Modern temperatures range from 15.5°C in the winter to 22°C in the summer (60 to 72°F) (Arriaza 1995:31). In the Camarones delta, modern temperatures range from 27°C in the summer to 13°C in the winter (Schiappacasse and Niemeyer 1984:6). Sea surface temperatures between the surface and 50 meters of depth range between 21 and 14°C in the summer, to 16 and 13°C in the winter. An important climatic feature produced by the cold coastal waters and warm air currents is the "camanchaca" (Schiappacasse and Niemeyer 1984:6), a dense fog that penetrates the river canyons for several kilometers and dissipates by noon each day (Figure 4). This atmospheric feature occurs almost on a daily basis, but is more pronounced during the winter months. It is believed that the camanchaca in Peru was responsible for a variety of coastal wildlife and flora during prehistoric times, which facilitated the occupation of the coast (Benfer 1990).

Figure 4. View of the Camarones Valley and the camanchaca.

The environment of the Camarones delta supports a variety of flora and fauna. The waters of the delta have created a marshy wetlands area (Figure 5). The dominating vegetation includes several varieties of rushes and reeds, *Juncus sp.*, *Equisetum gigantea*, or the horsetail rush, *Tipha angustifolia*, a type of reed commonly known in Spanish as "totora"; some varieties of grasses such as *Cortaderia sp.*, or foxtail, and *Distichlis sp.*, or the inland salt grass (Schiappacasse and Niemeyer 1984:8-9). The woody shrub *Tessaria absinthioides* grows profusely along the banks and at the mouth of the river Camarones. Trees belonging to the genus *Atriplex* also grow within the Camarones valley, as well as a pepper tree (*Schinus molle*), and a variety of willow. An edible variety of seaweed grows in the coastal waters and is harvested for consumption by modern populations.

Figure 5. Camarones delta wetlands.

There are various terrestrial animals, including the red fox, gray fox, a variety of skunk, and several species of bat, including the vampire bat (*Desmodus rotundus*) that occupy the zone of the delta as well as the interior of the Camarones valley (Schiappacasse and Niemeyer 1984:8-9). Marine mammals include the sea lion *Otaria flavescens*, a species of otter (*Lutra felina)*, and in deep water several cetaceans, which include a type of sperm whale (*Physeter catodon*), the pilot whale (*Globicephala melaena*), and the common dolphin. There are many different species of fowl, including the condor, turkey vulture, eagle, hawk, oystercatcher, booby, penguin, storm petrel, heron, osprey, penguin, cormorant, pelican, and several varieties of sea gull (Schiappacasse and Niemeyer 1984: 9-10).

By far the greatest variety of fauna can be found in the sea. In deeper waters, several varieties of perch, flounder, swordfish, and dolphin fish are found, as well as the anchovy. Many types of shellfish that have occupied habitats in the intertidal zone on the coast for thousands of years can be found in Camarones today. These species will be discussed in-depth in a later chapter. There are also several types of crustaceans, including several types of crab, shrimp, and sea urchins that are currently exploited today. The octopus is also found in the coastal waters at Camarones and generally throughout northern coastal Chile.

The overall climatic conditions and wildlife that are characteristic to modern-day northern Chile have been consistent since mid-to-late Holocene times (Crom 1993:15). The archaeological evidence points to the prehistoric occupants of this river delta as having taken advantage of many of the same terrestrial and aquatic species that are found there today. This has been verified through the analysis of the faunal contents of shell middens, campsites, and cemeteries in this area, as indicated for the sites of Camarones 8 (Belmonte et al 1994; Muñoz 1995), Camarones 9 (Muñoz 1989), Camarones 14 (Schiappacasse and Niemeyer 1984), Camarones 15 (Muñoz et al 1991; Rivera 1984), Camarones 16 and 17 (Muñoz 1989). Chemical analysis of human bone that has been recovered from many of these sites has revealed that the diet of the people of this area was consistently and predominantly marine based (Aufderheide 1992). Other cultural indicators also found at many of the sites in this area, such as shell and cactus spine fishhooks, stone line sinkers, vegetal fiber nets, bone implements for prying shellfish from rocks, and harpoon heads attest to a well-developed, long-term fishing tradition.

Background

The geographical extent of the Chinchorro culture comprised an area along the northern coast of Chile for approximately 600 miles, from the city of Arica in the north, to Antofagasta in the south (Arriaza 1995:8) (Figure 6). The major concentration of Chinchorro-type sites is found between the city of Arica and the area around the Camarones River delta to the south. Although mummies have been found further north in Peru, it is not yet clear whether the prehistoric mortuary tradition of that area can be associated with any of those known types within the spectrum of Chinchorro-style mummification techniques.

Acha Site

The earliest evidence of occupation in this region is from the site of Acha-2 in the valley of Azapa, located within the city of Arica. Here, a campsite of a semi-permanent nature, as indicated by the presence of several circular stone house foundations with multiple postholes and a central hearth was recorded with an associated human burial (Muñoz and Chacama 1993: 15-29). While this individual was not artificially mummified, as were later occupants of the region, he was found to have suffered from a certain physical pathology that has been associated with the exploitation of maritime resources. This pathology, which is also found among Chinchorro human remains and has also been identified for modern fishing populations, is the bony ear growth known as auditory exostosis (Arriaza et al 1993:50). Acha Man, as he is commonly known, has been dated to the early Holocene, at 8970 B. P.

Various chemical analysis of Acha Man's bones skin and hair, including carbon, nitrogen, and strontium isotopes, indicate that 81.5% of his diet consisted of marine fauna, including marine mammals, while only 8.3% of his diet consisted of terrestrial fauna (Aufderheide 1993:78). This evidence, coupled with the cultural materials found at this site indicates that the importance of Acha Man in Chilean prehistory supports a strong fishing tradition along this coast by at least 9000 B. P. Among the tool assemblage found at the site are several fishing implements, including harpoon heads, cactus spine fishhooks, and bone sinkers for lines, indicating a well-established adaptation to fishing and hunting marine resources (Crom 1993:37-40).

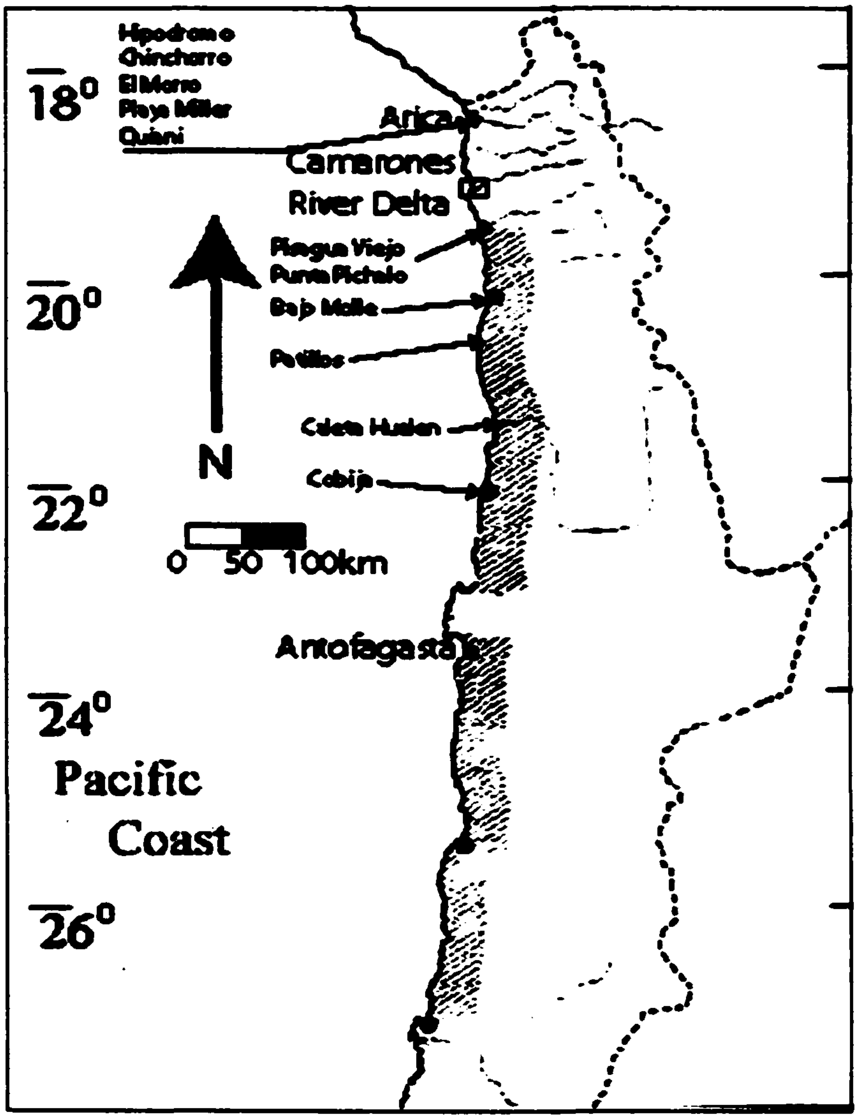


Figure 6. Geographical extent of the Chinchorro culture.

Chinchorro Sites

Chinchorro chronology has undergone several revisions since the first studies conducted by Uhle in 1917 (Arriaza 1995:125). Originally, Uhle referred to this cultural phenomenon as the Arica Aborigenes, and placed them chronologically at the beginning of the Common Era. Nuñez presented the first calibrated radiocarbon dates of the mummies from the site of Pisagua Viejo 4, to the south of the Camarones delta, which placed them around 5100 B. P (1969:114). Arriaza (1995) considers the Acha 2 natural mummy as the beginning of the Chinchorro culture, placing it at 8970 B. P., and terminating around 3450 B. P. in Arica and 3060 B. P. in Camarones. Therefore, if we concur with Arriaza's assessment of Chinchorro culture and chronology, the Chinchorro culture spanned a period of 5,910 years.

Camarones delta. Early work in the Camarones delta began in 1969 by Virgilio Schiappacasse and Hans Niemeyer (1984: 12-14). A reconnaissance of the area at that time resulted in the identification of fifteen sites. Camarones 1 and 2 are pre-ceramic sites excavated in 1978-79 that date to 3775 + 155 B. P., and 3815 + 95 B. P., respectively. Camarones 12 and 14 were also excavated by Schiappacasse and Niemeyer around the same time. Camarones 12 consisted of a late agricultural site with an earlier pre-ceramic component, the latter dating to 4335 +125 B. P. Camarones 15 consisted of ceramic campsites and an extensive cemetery. The mortuary tradition did not correspond to the Chinchorro tradition, but consisted of natural mummies buried in a fetal position. This site was post-Chinchorro, dating from 3050 B. P. to 2840 B. P.

For the purposes of this study, the chronology that will be used will be that outlined by Arriaza (1995:126-132). Arriaza divided the Chinchorro culture into five cultural epochs based on mummification technique rather than tool technology. A cross-correlation between tool technology and mummification technique has not been produced to date, due to the fact that the mummies possessed very few grave goods. Therefore, the use of mummification technique, which is the defining characteristic of the Chinchorro culture, as a chronological marker is preferred here. All five epochs are aceramic.

These five epochs are: Chinchorro Founder (8970 B. P. – 7000 B. P.), and is associated with Acha 2, Initial Chinchorro (7000 B. P. – 6930 B. P.), Classic Chinchorro (6930 B. P. – 4750 B. P.), Transitional Chinchorro (4570 B. P. – 3670 B. P.), and Late Chinchorro (3670 B. P. – 3060 B. P.). The first epoch, Chinchorro Founder, has already been discussed briefly. Besides Acha 2, several other sites correspond to this epoch, and are characterized by naturally mummified bodies that have been wrapped in reed mats. These sites include Villa del Mar in Peru, dating to 7800 B.P., Aragon (8660 B. P.), and Camarones 14 in the Camarones delta (7420 B. P.). This epoch is marked by a well-developed fishing technology, including both cactus spine and shell fishhooks and lines, and twined reed mats. The economy apparently consisted of a mixed subsistence of shellfish collecting and hunting marine and terrestrial animals. As indicated by the chemical analysis of the dietary constituents of Acha Man, a maritime subsistence economy was more productive than a terrestrial economy.

Chinchorro Chronology

Initial Chinchorro. The first evidence of artificial mummification came from the site of Camarones 14, where one of five artificially prepared mummies was dated to 7000 B.P. (Arriaza 1995:128; Schiappacasse and Niemeyer 1984:172). At this time, only children were artificially mummified. Mummification consisted of the treatment and preparation of the face and the trunk only. By the end of this epoch, however, full body preparation was practiced, and became quite elaborate. At the campsite of Camarones 14 there is evidence of a sedentary population, indicated by the first formal cemetery, basketry technology, and a fully maritime subsistence technology. This maritime technology consisted of shell and cactus spine fishhooks, sinkers, net fragments, and cords for fish lines (Schiappacasse and Niemeyer 1984:27-37). Among the lithic technology evidenced at the site are leaf-shaped projectile points, scrapers, knives, mortars and pestles.

Classic Chinchorro. This epoch marks the beginning of the most elaborately prepared mummies, known as the black mummies. The site of Camarones 17 represents the earliest manifestation of this style, dating to about 6930 B. P. (Aufderheide et al 1993). The Classic-style black mummies have been found in the Arica area at the sites of Hippodromo, Chinchorro 1, Morro 1, and Maderas Enco. Several dwelling sites corresponding to this epoch have been found along the coast, along with various middens, mostly of shell material. This evidence, along with the appearance of several cemeteries, attests to an increase in population during this epoch. There are also several sites without mummies that may be assigned to this epoch by their proximity to these cemeteries and by their corresponding dates: Quiani 9 (6370 B. P.), Camarones Punta Norte (6270 B. P.- 5600 B. P.), Quiani 1 and 2 (both from the Arica area) (6170 B. P.–5630 B. P.), Cobija (6030 B. P.- 4880 B. P.), and Caleta Huelen 42 (4780 B. P.). During this epoch, the first clear evidence of the atlatl and throwing stick appears, and the use of camelid fiber for fishing lines and fringe skirts for women. The end of this epoch appears to have been around 4750 B. P., and spanned approximately 2180 years.

Transitional Chinchorro. This epoch, which commences around 4570 B. P., and terminates around 3670 B. P. is characterized by the appearance of the red mummies, which appears to have completely replaced the black mummies. These mummies had distinct long black wigs and were buried in groups (Arriaza 1995:130). The earliest evidence for the red mummy was found in Camarones, dating to around 4635 B. P. Many sites in the Arica area contained the remains of red mummies, including Morro 1, Morro 1-5, Morro 1-6, Aragon 1. Other sites to the south include Patillos and Camarones. The site of La Capilla, in Arica, is associated with this epoch because of the unused grass skirts found inside. This cave site has been interpreted as a ceremonial cave (Arriaza 1995:130; Muñoz and Chacama 1982:119). In addition to the red mummies, several mud-coated mummies have also been found that correspond to this period. Two of these were dated to 4570 B. P.

During the Transitional Chinchorro epoch, the use of clothing, at least for the mummies, was on the rise. Evidence of clothing from both red and mud-coated mummies indicates that males used leather breach cloths and females wore grass skirts. Narrow headbands were worn over unbraided hair, and annular cranial deformation appears for the first time. The end of this epoch at 3670 B. P. marks both the end of the red mummy phase and the end of complex mummification.

Late Chinchorro. This period, which begins around 3670 B. P. is characterized by a return to naturally mummified bodies buried in an extended position. These bodies were still buried in reed mats. At the end of this epoch, around 3450 B. P., a different mortuary tradition began to emerge that did not involve artificial mummification, but which involved inhumation with a fetal-position placement of the body. Cranial deformation increased at this time, as well as hair braiding and wrapping with yarns that resembled turbans. Fine basketry appeared along with evidence of food cultivation.

Research Goals

The analysis of shell material from several shell midden cultural sites between the city of Arica and the Camarones gorge for the purpose of determining resource utilization and seasonality of resources was the focus for this research. Environmental studies are becoming increasingly important in archaeological investigation, and are valuable contributors to site interpretation. Because of the apparent importance of marine mollusks in prehistoric northern Chile, it may be possible to obtain information pertaining to subsistence strategy and seasonality of resource procurement by studying shell middens.

Two main questions characterize this research: 1) How many shellfish species were utilized in this area, and which were the most important? 2) Were shellfish exploited seasonally or was the gathering of shellfish a year-round activity? In other words, is there seasonal variation where the exploitation of shellfish is concerned, and if so, does this represent a year-round occupation of a given area?

To address the first question, an inventory of the shell material from several archaeological collections housed at the Museum of Archaeology of San Miguel de Azapa, University of Tarapaca, Arica, Chile was compiled. A database was generated in order to study and discuss the material.

For the second question, the sampling of a shell midden in the Camarones delta was conducted in the summer of 1997. A column sample from the midden was excavated, to a depth of approximately five meters. Radiocarbon dates obtained from several of the strata reveal that this portion of the midden spans almost a thousand years, from 3830 B. P., to 5300 B. P. The shell material from this sample was catalogued and shells from various strata were selected for oxygen isotope analysis. The results of this analysis provided temperature data that may be correlated with season.

Arriaza (1995) proposed that the Chinchorro represented a sedentary fishing society, while others such as Muñoz (1995) that they were only semi-sedentary, and that they ranged inland through the river valleys to obtain other goods with which to supplement their diet and the raw materials used in the manufacture of tools. The strata from the Camarones shell midden that were sampled (strata 3, 4, 5, 14 and 15) correspond to the Transitional Chinchorro (4570 - 3670 B. P.) and Late Chinchorro (3670 – 3450 B. P.) epochs, both of which were aceramic. By obtaining oxygen isotopic data from these shells, which measures the amount of oxygen 18 relative to the amount of oxygen 16 contained within the margin of the shell, the temperature of the water at the time the shells were harvested can be determined. By doing this, it can be determined whether the Chinchorro gathered shellfish year-round or only part of the year, and thus whether they established permanent or part-time residential bases. While shellfish was not the primary source of food for coastal people, they were an important source of nutrition, and shellfish remains are abundant and are useful markers to determine seasonality of resources. The following table outlines the research questions that were developed for this study, as well as the methods used in this study. Each research question will be addressed in a separate chapter, and the final results from the analysis of the materials will be addressed in a separate chapter.

Table 1 Research Objectives

OBJECTIVE	METHOD	REASON
Quantify species from shell middens in the vicinity of Quiani and the Camarones Gorge	Catalogue and analyze the material from various sites stored in the archaeological museum of San Miguel de Azapa, Arica, and materials obtained from a midden in Camarones	By comparing the various malacological remains it is hoped to verify that subsistence practices and resource preferences were consistent throughout the northern coast of Chile
Identify and quantify malacological species present at the shell midden site of Camarones	Excavate a column sample from the midden at Camarones and collect all cultural and faunal material for analysis	By analyzing material directly obtained from the midden, it is expected to establish the dominant species that were utilized and the order of importance of each in the prehistoric diet
Determine a pattern of seasonal utilization of resources	Submit shell samples from the middens of Camarones and Quiani, plus modern samples for oxygen isotope analysis to the Desert Research Institute, University Sysetem, Nevada	To test the hypothesis that pre-agricultural coastal people had the necessary year-round resources to sustain permanent residential bases.

Hypothesis

The following hypothesis has provided the framework on which this study has been based: If prehistoric marine shells obtained from archaeological sites in northern Chile demonstrates, through the application of oxygen isotope analysis of the shell margin, which correlates to the time of death of the mollusk, a wide range of temperature values, then it can be said that harvesting of these shells for food was a year-round human activity, thus signifying residential permanence of a group.

A secondary hypothesis was also applied to this study, and is the following: If continuous year-round and over-harvesting of marine shells for food occurs over several centuries, then shell maturity, as indicated by shell size.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss the historical perspective of how settlement patterns and societies have been studied. A review of contemporary studies regarding coastal groups will follow, with some propositions on how to approach the study of prehistoric societies by assessing their potential subsistence and related settlement options and choices.

Theoretical Paradigms

Sedentism vs. Mobility

During the early years of anthropology, sedentism as a phenomenon was not studied exclusively, but was regarded as a natural consequence of the process of evolution from a lower stage of cultural development to a higher one. Agriculturists, who were sedentary, conformed to the cultural norms of the day. These norms dictated that those who cultivated the soil were more civilized than those who wandered about foraging for food (Service 1971). Agriculture was the means of insuring a stable food supply for most members of a society, while mobile foraging for food implied insecurity and instability for those members of society who practiced this form of subsistence. The notion of sedentism resulting from factors other than the practice of agriculture was not considered during the early days of anthropology and archaeology.

Archaeological investigation focused on identifying those societies that possessed a highly visible and classifiable material culture. It was not until Processual studies revolutionized archaeological investigation that the characteristics that define sedentary societies were outlined, and protocols for identifying these sites on the landscape were developed.

Processual Studies

The way societies were studied changed as new theoretical perspectives were introduced to archaeology. Service's system of classification was still widely applied, however, a new scientific approach was used to explain and test what was before merely assumed. The processes whereby a cultural system developed over time was now the focus of archaeological investigation, using the scientific method of hypothesis development and testing as the vehicle by which research was conducted (Renfrew and Bahn 1996:36).

Even so, agriculture was still irrevocably tied to sedentism as the prime underlying agent that promoted settlement stability and permanence. Models that focused on culture change explained how societies developed, but always within the parameters originally established by evolutionary theory. For instance, certain models, such as Childe's "Neolithic Revolution" (McNairn 1980) explained how new technologies, such as irrigation, were developed to facilitate and maximize food production in the Near East and Mesopotamia (Maisels 1990). This resulted in a surplus of food that allowed segments of society to dedicate less time to food production and more time to the development of craft specialization. Consequently, class distinctions arose in the wake of logistically differentiated societies that required organization and a central authority to oversee the redistribution of goods and services and to maintain order and harmony over the whole.

Hunter and Gatherer Studies

A major proponent of this "New Archaeology" was Lewis Binford (1980), who studied hunting and gathering societies in terms of their patterns of mobility. Binford adopted a methodology that consisted of ethnographic analogy and the role of environmental factors to his study of settlement systems among hunter-gatherers. This he called a "diagnostic approach" to settlement pattern that was based on the ethnology of living systems (Binford 1980:5). Binford hoped to gain insight into the patterns of mobility of various hunter-gatherer groups that he could compare to the archaeological record, focusing on the causal factors that condition different patterns of intersite variability.

Binford found a strong contrast between two hunting and gathering societies that had adopted different subsistence strategies. He divided them into "foragers", who were not logistically organized, and "collectors", who were logistically organized. In essence, foragers tend to occupy environmentally homogenous or undifferentiated zones, ranging out daily from their residential bases to gather such foods as are encountered. There is great variability in terms of the size of the group (20-120 individuals), and the number of residential moves made during an annual cycle (75 - >300 miles). Highly mobile groups leave little accumulation of debris, and thus very low archaeological visibility, unless they continue to utilize the same sites regularly year after year.

The repetition of site usage is a variable that could distinguish some mobile groups from others. The greater the redundancy of the occupation of certain sites as residential camps, the more likely that groups will be tied, or "tethered" (Binford 1980:9) to specific locations such as water holes. When this happens, there is the potential for a greater buildup of archaeological remains, thus increasing visibility. Foragers "map onto" resources through residential moves and adjustments to group size.

In contrast to the forager strategy, collectors assume a logistical approach to food procurement. Binford (1980:10) developed this model from his study of the Nunamiut Eskimo, who were characterized by 1) storage of food for part of the year, and 2) logistically organized food-procurement parties. Collectors live in ecologically differentiated zones and supply themselves with specific resources through specially organized task groups. This type of strategy is necessary when consumers are near one critical resource but far from another equally critical resource. Collectors generate five types of sites based on the logistical character of their procurement strategies. These sites consist of residential bases, location sites, such as kill sites, field camps, stations, and caches. Each type of site leaves a distinct archaeological signature on the landscape, except in those cases when sites may have been multipurpose. When this happens, all logistical functions may not necessarily be independently located, which may create an overlap in site utility, hence an overlap in artifacts and cultural features that define each site type.

Binford also argued for variability of degrees of mobility and sedentism based on environmental conditions (1980:13-15). Foraging modes of production would seem to be optimal in certain environmental conditions. Based on data obtained from Murdock regarding settlement patterns, Binford demonstrated that contrary to conventional expectations, fully migratory or nomadic bands were found to occupy tropical or semitropical zones, where semi-nomadic to semi-sedentary peoples tended to occupy temperate and boreal environments. A logistical strategy such as is used by collectors is more productive in areas where there are a limited number of critical resources such as are found in temperate or marginal environments.

It is interesting to note that of the two groups defined by Binford, it is the collectors rather than the foragers who have the most potential to adopt sedentism in response to their food procurement strategy. It could be said that the collector mode of food procurement is an incipient form of sedentism, based on the fact that some or all members of the group live a sedentary lifestyle for large parts of the year, and food storage is practiced. In this case, the collector mode of settlement pattern could be interpreted as a gradient within the spectrum of possibilities that comprise the types of sedentary societies. Additionally, a sedentary society must engage in a logistical approach to food procurement and other aspects of organized cultural behavior, whether it is through plant cultivation or hunting, fishing, and gathering strategies. This entails a certain degree of labor organization, which has more often than not been associated with sedentary societies. In a later section, Binford's model will be compared to a list of traits that have been compiled by different scholars that seem to characterize fully sedentary societies.

The current trend of viewing settlement in terms of year-round occupation of an area rather than exclusively sedentarism may be the result of changing perceptions as to the nature of residential patterns and subsistence activities. There is no longer a clearly demarcated line between residential mobility and settlement permanence. It may be more practical to study settlement patterns in terms of degrees of permanence. During the Upper Paleolithic in southwest France, for instance, population densities were higher than at any other location throughout Europe (Mellars 1985). It has been suggested that groups living in this area efficiently exploited resources that were abundant and concentrated in key areas. At least a part of the population lived permanently in fixed locations while smaller groups exploited more distant resources during the summer months.

Michael Jochim defined "settlement permanence" (1981:148-149) or sedentism as an investment of time and energy in a fixed location. Fixed resources are more important in settlement decisions than variable or dispersed resources, due to their predictability in space and the relative reliability of procurement. Jochim contended that there is a strong correlation between settlement mobility and procurement strategy. Most hunters and gatherers, and pastoralists, move people to resources, while agriculturists concentrate resources around their settlements. Clustered resources will attract population aggregation because of environmental heterogeneity. Traditionally, agriculture creates environmental or resource heterogeneity by concentrating a group of resources within space. This in turn leads to increased sedentism by confining important resources to a small, controlled area. As it shall be seen later, environmental heterogeneity is not limited to agricultural situations, but can be found in specific geographical locations. This is especially relevant when studying coastal peoples such as the Chinchorro.

Robert L. Kelly (1998:19-20) views sedentism as a product of several interrelated variables, such as resource return rates, length of foraging day, time frames, amount of risk, and the use of storage for food. He states that among food foraging peoples "residential movement should cease if the anticipated return rate of the next patch minus the cost of moving is greater than the anticipated return rate of the patch currently occupied if it is feasible for the forager to remain in the current patch (either because it provides a continuous supply of resources or because a storable resource is present)".

The Archaeology of Sedentary Sites

It is a generally accepted idea that prehistoric peoples who developed into sedentary communities left a more visible impression on the landscape than their mobile counterparts. Table 2 outlines the general criteria put forth by different researchers concerning the types of cultural remains that indicate settlement permanence in archaeological sites. In many cases, how each variable is defined may differ significantly from society to society. For instance, house structure may come to mean something entirely different depending on the environment where a site is located, the materials available for construction of dwellings, and the relative ideologies of different societies regarding settlement and house types. A house constructed of wood or brush may have provided relatively permanent shelter for some societies while leaving little left on the landscape to identify after thousands of years of exposure to the elements.

Does this mean that we should take this absence of structural evidence to mean that there was no degree of permanence associated with such a site? What of other types of evidence that could be equally valid in reconstructing site typologies, such as middens? Shell middens in particular offer valuable clues about resource seasonality, cultural remains, diet, and chronology. This also will be addressed in subsequent sections, especially when discussing the Chinchorro.

Sedentism and the Rise of Agriculture

In an earlier work Binford postulated that sedentism in the Near East occurred prior to plant domestication. Rising sea levels at the end of the Pleistocene reduced the extent of the coastal plains available to hunters and gatherers. The new habitats that were created by this event offered greater access to fish and fowl, making it possible to lead a sedentary existence (Renfrew and Bahn 1996:450). This argument can be used to explain the processes by which sedentism occurred in some parts of the world, but not in all environments, particularly marginal environments such as deserts.

Table 2. Archaeological Characteristics of Sedentary Sites.

Willey and Phillips (1958)	Renfrew and Bahn (1996)
1. diversified tools	1. house structures
2. ground stone utensils	2. diversified tools
3. evidence of food production (domestic vs wild plant varieties)	3. pottery
4. permanent villages (house structures)	4. agglomerate or dispersed settlement
5. pottery	5. food storage (pottery, caches, etc.)
6. weaving	6. craft specialization
7. developed food production (irrigation)	7. ranked society (burials)
8. ceremonial centers	8. evidence of investment of labor or communal action such as public monuments or irrigation systems
9. craft specialization	9. ritual centers
10. metallurgy	10. evidence of food production
	11. secondary products

It is commonly accepted that sedentism occurred prior to the rise of agriculture in the Near East during the Epipaleolithic and early Neolithic (10,500-10,300 B. P.). There is ample evidence of permanent houses and storage facilities that were in use during these time periods, with no direct evidence of early cultigens to suggest plant domestication (Bar-Yosef and Belfer-Cohen 1992:24-25). In fact, many of these permanent facilities may have been only seasonally occupied, when the population would return after a summer season in the fields of the lowlands or pastures of the highlands. Many Early Neolithic sites have been discovered in the Sinai that are representative of a pre-agricultural permanent or semi-permanent settlement. Bar-Yosef contends that the eventual emergence of agriculture as a new subsistence strategy was a process that occurred not in marginal areas, where fluctuation in annual rainfall would yield unstable results in cultivation, but in well-watered areas such as lakeshores. The shift to an agricultural economic base was a response to increased population pressure resulting from decreased residential mobility.

Kent Flannery (1969:74) proposed a slightly different explanation to explain how agriculture came to replace hunting and collecting for subsistence. Flannery agrees with Bar-Yosef (1992) that sedentism occurred prior to plant domestication in the Middle East. Sedentism was possible when human groups adopted broad-spectrum wild resource utilization. This type of behavior yielded excellent results as long as the population maintained itself below the carrying capacity of the land. Once population started to expand beyond the extent of resource availability, a new strategy had to be implemented to deal with this change. The result was the occupation of less desirable marginal areas, where agriculture, although labor-intensive, was necessary to meet the demands of a growing population.

What is important to consider here is that sedentism was entirely possible under certain conditions without plant domestication. Agriculture was a consequence of sedentism in the Near East, and not the motivation for residential permanence. Earlier notions of the instability of hunting and gathering are based on modern ethnographic analogy of mobile populations in a world where more desirable territories are now occupied by enormous populations inhabiting crowded cities. The choice areas for sedentary living for smaller groups are by and large no longer available.

Applying ethnographic analogy to prehistoric situations may produce a biased view of prehistoric life. Many types of adaptation that are no longer practiced may have been possible and by applying a multidisciplinary approach to the study of prehistory, a more complete picture of the past can emerge. The next section will discuss the opportunities offered by coastal environments for subsistence stability.

Coastal Adaptations

Within the last two decades an increasing awareness of the possibilities associated with coastal environments for the development of human societies and adaptive strategies has prompted studies in this area of archaeology, with interesting results. The uniqueness of coastal resources has led to the reevaluation of prior notions of settlement patterns and subsistence strategies. This has inspired new methodologies that allow the objective testing of data to support or reject hypotheses. An alternative perspective on the factors that lead to sedentism has been provided by studies centered on prehistoric coastal environments. There are a number of examples of sedentism that was practiced by the Native Americans of the northwest coast of North America (Blackman 1978; Codere 1978; Renker and Gunther 1978), and by Archaic peoples of southwest Florida (Russo 1998).

Perlman (1980:257) has stated that coastal hunters and gatherers exhibit different types of cultural behaviors than do non-coastal hunters and gatherers. In an optimal coastal environment, hunters and gatherers tend to display a greater degree of sedentism, higher population densities, larger groups, and non-band social organization than their non-coastal counterparts. Perlman questioned whether these different cultural tendencies were due to demographic pressure or to opportunistic responses to a higher productivity environment. To resolve this question, Perlman presented two models. The first model described the variables that determine a coast's productivity, and the second was an optimum foraging model for hunters and gatherers. The first model, that of coastal productivity, is dependent on several variables that determine a particular coast's level of productivity. These variables include, but are not limited to a variety of environmental and physical factors such as wave stress, seasonal temperature, estuarine succession, sea level change, topography, and bathymetry (the depth of the continental shelf relative to the shoreline). The optimum foraging model states that hunters and gatherers will occupy environments according to their rank, which begins with the environments that involve the least effort and least risk to the inhabitant (Perlman 1980:258). The unifying variable between the two models is that of energy, which is measured in calories or relative time-inputs.

All coastal environments do not present conditions that favor optimal foraging strategies. Coastal systems are ranked according to variability and extent of exploitable resources (productivity). Coastal productivity varies with the local topographic, sedimentological, and hydrological conditions. The most productive type of coastal system is the estuarine environment, where freshwater and salt water merges and produces a nutrient-rich habitat for many aquatic species. Wide continental shelves are especially important in this type of environment, because of the deposition of sediments in the estuary zone that encourage the development of marshes and the growth of aquatic plants that are vital to the survival of many species. Another productive coastal system can be found in upwelling zones, where nutrient-rich cold water permeates the warmer upper levels and provides a fertile zone for all forms of marine life. This is the case in Peru and Chile, where the lack of a wide and shallow continental shelf is compensated by the presence of considerable upwelling, which has made this coastal area one of the richest in the world (Raymond 1981:806-807).

In the optimum diet model, the basic premise is that predators will select prey that provide the highest return for the least amount of effort and risk. The measures for the resources that are being optimized are usually in calories, nutrients, plant, or meat weights. Perlman considers four important variables (Figure 7) in the optimum diet decision process, that of environments that minimize costs, which is defined by the amount of effort expended in acquiring resources, and the amount of risk involved in acquiring these resources, and the return rates of the targeted resource(s). The fourth variable in this process is the group size, which for a traditional hunting and gathering group is limited in size to small bands of 25 to 50 people. In a coastal situation, where resources are diverse, clustered, and abundant, larger groups are able to effectively concentrate on these resources to produce a higher yield. All of these variables are interdependent and contribute to the ultimate choice in subsistence strategy.

High productivity environments, with numerous, abundant, large, and clustered resources should provide the least effort habitat for a hunter-gatherer social system. These environmental types are identified by the variable of return rates of resources. It is generally acknowledged that smaller prey provide much lower returns than larger prey. However, if smaller prey population densities are high and the larger prey densities are low, then the effort expended in capturing smaller prey may be considerably lower than that of taking larger prey. In a coastal area, where resources tend to be clustered, the energy expended to exploit these resources tends to be less than in an inland environment, where the hunting of larger game is more labor-intensive (Perlman 1980:284).

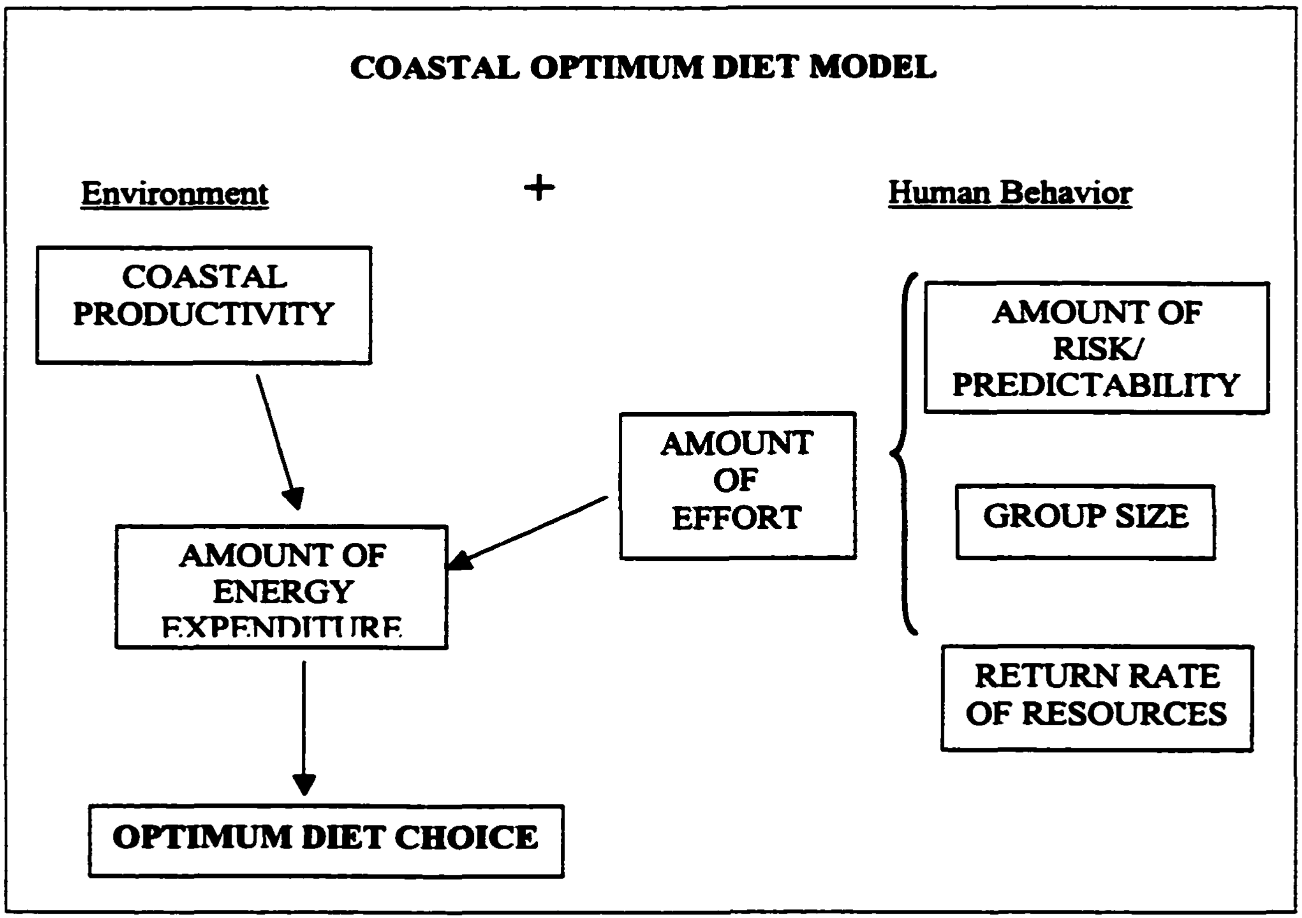


Figure 7. Coastal Optimum Diet Model

Additionally, the risk factor or resource predictability involved in these two strategies can also significantly affect subsistence choices. Perlman provides a comparison of two subsistence strategies that show how the return rate of certain activities combines with those of least effort to determine what kind of subsistence strategy may be favored. When the range of pounds returned per hour per individual from several environments were compared, Perlman found that shellfish, which is a low protein-yielding food, is harvested at an average rate of 4.5 pounds per individual per hour year round. Deer, which is a high protein-yielding food, can only be obtained during the fall and provides an average of 9 pounds of meat per individual per hour. Furthermore, shellfish are usually clustered and are fixed in space, which makes them a highly predictable food source. Deer, however, are less predictable because of their mobility. Therefore, the predictability and abundance of shellfish versus deer makes shellfish collecting less labor-intensive, involving less risk and mobility, and thus more predictable than deer hunting, and therefore an optimum choice for subsistence.

The two models that Perlman outlined generated a number of related expectations that served to focus on the question of the behaviors of coastal groups, and whether these behaviors were an opportunistic response to high coastal productivity, or due to demographic stress. These expectations could be compared to both the archaeological and ethnographic records as a means of validating the two models that have been discussed (Perlman 1980:284). These expectations are as follows:

a) In areas of high productivity, where the coastal zones are still preserved above water, there will be evidence of coastal occupation and exploitation.

b) Shellfish are a constantly available intermediate-return resource that can be used either as a buffer during periods when higher resources are not available or as a dietary supplement.

c) Storage is a strategy to minimize the year's total effort and risk for subsistence and non-subsistence resources. Some coastal-zone resources provide an opportunity to employ this strategy.

d) If modern hunter-gatherer group sizes are limited by available productivity and not by social costs, then larger group sizes are expected for more productive coastal environments. Possibly, these groups will exhibit social organizations atypical of bands.

The fulfillment of these expectations would support the notion that cultural behaviors exhibited by coastal groups are the opportunistic response to their unique situation. Later in this study these expectations will be applied to the Chinchorro culture in northern Chile in an attempt to verify if indeed the Chinchorro, as a typical coastal group, were capable of achieving the residential permanence and stability and the social organization typical of more complex societies.

Murdock performed a large-scale cross-cultural study of the relationship between economy and settlement mobility (Jochim 1981:148-149). He found that those societies who practiced a predominantly fishing economy tended to be more sedentary than those who engaged exclusively in hunting and gathering. He also found that there are other factors besides economic strategy that influence settlement mobility, such as the avoidance of enemies.

Settlement permanence is dependent on the efficiency of exploitation. Exploitation efficiency is in turn dependent on resources, spatial distribution of resources, mixture of different economic forms, and a variety of non-economic factors (Jochim 1981; Kelly 1995, 1998). It was earlier stated that groups were more prone to settlement permanence when the resources within a certain environment were heterogeneous and clustered within close proximity to the group's residence (Jochim 1981:148-149). A maritime environment can potentially fulfill the requirements that are needed for settlement permanence due to the wide variety of resources available within a relatively small area.

When discussing sedentism among coastal societies, several issues must be evaluated:

1) What constitutes a sedentary economy and how far can sedentism be defined as a category distinct from seasonal mobility?
2) How effectively can sedentism be identified in the archaeological record?

3) Under what circumstances does sedentism occur and when did it first appear in the archaeological record?
4) What are the consequences of coastal sedentism in terms of population growth and social complexity?

In response to the first question, the most crucial variable that determines settlement permanence and a sedentary economy is that of fixed resources (Jochim 1981:149). The abundance of fixed resources and the ability to store those resources will determine the degree of stability that is required for a sedentary lifestyle (Kelly 1992:53). Resources that are mobile and shifting in distribution along the landscape will increase group mobility and leave a diffuse archaeological impression that is often hard to study and interpret.

There are several ways to identify permanent coastal settlements (question 2). A factor to consider is the location of potable water. The first requirement for all types of settlement is proximity to water. Therefore, the location of many prehistoric coastal sites will be found near ancient or modern river mouths or springs. A second indicator is the location of shell middens, which is a product of human activity. A third indicator is the existence of a technology that is suited to exploiting marine resources such as tool kits containing a variety of fishing implements such as harpoon heads, sinkers, fishhooks, and nets. Cemeteries may also be a useful indicator of nearby settlements, although this may be unreliable due to varying mortuary practices.

In a previous section, several types of evidence that are commonly used to identify sedentary sites were outlined. One of these was evidence for storage, such as pottery or caches. For a maritime economy, this might not be necessary, particularly if resources are available year-round. Another is evidence for food production, which is superceded by the abundance of resources available to maritime dwellers for exploitation. The presence of permanent structures may or may not apply to coastal settlements, therefore it may be more practical to identify features such as fire hearths, occupational floors and middens rather than the remains of permanent structures.

One of the disadvantages of studying prehistoric coastal populations is that many of the known sites were established during the Holocene, at the end of the Ice Age (Bailey and Parkington 1988:2). The retreat of the glaciers and subsequent rising of sea level during the late Pleistocene and early Holocene may have covered many significant coastal sites that may have been present during the Ice Age, and thus have not been identified.

In response to the third question, sedentism is possible when a wide variety of exploitable resources are concentrated within an area that is easily accessible to a settlement (Jochim 1981; Kelly 1995; Mellars 1985). These resources should be either available year-round, or the group must have the ability to adequately store sufficient food to feed them during times of scarcity. In the case of coastal resources, it has been established that there is great diversity in resources that fulfill the required conditions to promote sedentism.

The fourth question pertains to the consequences of coastal sedentism in terms of demography, and the potential for social complexity developing as a result of increasing sedentism. As is the case for most pre-agricultural societies, smaller groups are more successful in adapting to a sedentary lifestyle than larger groups. As noted, both Flannery (1969) and Bar-Yosef (1992) stated that the driving force behind the rise of agriculture was population pressure. Population growth simply exceeded the carrying capacity of the land. This is inevitably true for coastal populations as well. Lanning

1967) and Moseley (1975) contended that the great Andean civilizations of central Peru were founded on a maritime economy. While population aggregation may have been possible due to a reliance on a marine-based diet, coastal resource exploitation in itself would not be sufficient to sustain indefinitely the size of population that was necessary to carry out the great works of construction that have been found in central Peru. Sedentism for pre-agricultural coastal societies would have been possible within certain parameters that preclude increased population densities that characterized the later socially and politically complex Andean societies.

In terms of social complexity, a group that practices a maritime economy may, as a result of the decrease in time and effort needed to procure food and thus a decrease in residential mobility, have the necessary impetus to develop craft specialization. Craft specialization is often viewed as a precursor to social complexity. For the Chinchorro of northern Chile, artificial mummification can be viewed as a type of craft specialization, due to the elaborateness of the finished product and the time involved in producing a mummy (Arriaza 1995).

Because of the unique circumstances presented by coastal settlements, the study of prehistoric coastal adaptation has been very successful in supporting the notion of an alternate means to achieving sedentism among non-agricultural societies. The following archaeological sites are examples of successful prehistoric sedentary coastal societies, all of which lack evidence of agriculture (Table 3).

Table 3. Prehistoric Sedentary Coastal Sites

Country	Site/Culture Name	Site Type	Time Period	Material Culture	Citation
Brazil	Boa Vista I	Shell midden, settlement	3480 B. P.	Habitational structures w/ burials, specialized maritime tool kit (lithic, bone, and shell), groundstone	Gaspar 1994; Barbosa et al. 1994
Norway	Younger Stone Age	Settlement	6000-5500 B.P.	Permanent structures, slate tools, ceramics, specialized maritime tool kits (lithic and bone), trade goods, burial mounds	Renouf 1988
Panama	Monagrillo	Settlement, shell midden	7000-3000 B. P.	Permanent structures, tools of shell, bone, and stone, pottery, groundstone	Ranere and Hansell 1978
Japan	Jomon Culture	Settlements, thousands of shell middens	12,500 B. P-3000 B. P.	Permanent wood structures, ceramics, food storage, maritime tool kits	Crawford and Bleed, 1998; Fagan 1989; Koike 1975
Peru	Paloma	Settlement	6500 B. P.	Marine mammal remains, shellfish remains, formal burials	Benfer 1990
Peru	Ring Site	Shell midden	10,575- 7675 B. P.	Bone harpoons, shellfish, fish, bird, and marine mammal remains	Sandweiss et al 1989
SE U.S. - Florida	Horr's Island Useppa Island Marco Island	Settlements w/ shell middens	7200-3600 B.P.	Residential living areas w/hearths, ceremonial mounds, shell processing areas, shell tool technology	Russo 1998

The Chinchorro Culture

In northern Chile, a complex picture of Archaic coastal life has emerged within the last two decades. A sophisticated fishing and gathering technology coupled with an intricate mortuary tradition has given rise to the notion that sedentism had been practiced for millennia before the introduction of agriculture to the area.

The Chinchorro culture, which is represented by many sites along the northern coast of Chile, is the earliest-known maritime culture of this region (Llagostera 1979). The epicenter of this cultural group is focused around the city of Arica, and radiates southward almost to Antofagasta, the southernmost coastal city of the Atacama Desert.

Sites such as Quiani, near Arica, and Camarones, in the gorge bearing the same name, date to many millennia before the present day. These sites are the loci of long-term fishing traditions that began at least 9,000 years ago. Some of the earliest evidence for a maritime economy comes from the site of Acha 2, where the remains of fish, shellfish, sea mammals, and tools geared for exploiting these resources were found (Aufderheide 1993:65-80). This is the site where the oldest human remains of the area was discovered, and was dated to approximately 9,000 years B. P. The remnants of several habitation areas were also found at this site (Muñoz and Chacama 1993).

At the site of Quiani 9, which dates to 6370 B. P., many examples of the fishing gear used to exploit the coast were also found (Muñoz and Chacama 1982). These consisted of cactus spine fishhooks, detachable harpoons with lithic points, nets, weights for fishing lines, and special instruments made from bone for prying shellfish from the rocks. These same types of tools are common among the sites situated along this coast, as well as certain variations of the fishhooks, which were also elaborated from shell. There is also evidence for domestic habitation such as was found at Acha 2.

This pattern of cultural materials, structural remains, and organic debris is repeated at many sites along the coast. One of the more significant of these sites is at Camarones 14, where in addition to the previously mentioned types of remains, cemeteries with artificially mummified bodies have been found (Schiappacasse and Niemeyer 1984). The cactus spine fishhook tradition that dominates the fishing assemblage at Quiani is replaced at Camarones by a shell fishhook. This site predates Quiani 9 by almost a thousand years, at 7420 B. P.

Extensive shell middens also dominate the coastline, with deposits that reach up to five meters in depth (Arriaza 1995). These middens represent tremendous chronological depth and subsistence continuity. Many different types of animal remains comprise the debris of the midden, including several species of shellfish, fish, mammals such as sea lion, otter, and whale, and several species of birds. Cultural remains are also preserved within the midden, such as lithic and bone tools, fishing gear, remnants of reed mats, fire hearths, and burials. In the upper strata that represent later times, ceramics can also be found, which indicate that fishing was an important activity even after agriculture was initiated.

In addition to a highly developed and long-standing fishing tradition, there is evidence of social complexity and settlement permanence based on the elaborate mortuary tradition that developed there about 7000 years B. P. The Chinchorro artificially mummified their dead using time-consuming procedures that involved an in-depth understanding of human anatomy. This procedure included the removal of all viscera, organs, and muscle from the body, and replacing these with other materials such as straw, sand, or clay. After this had been completed, the body was covered in an ash paste, remodeled in clay, and painted, or the skin was replaced and covered with clay and painted (Arriaza 1995; Nuñez 1969). This practice persisted for over four thousand years, demonstrating a remarkable consistency and continuity rarely seen in so-called primitive societies. There are many cemeteries that contain these mummies along the coast, and new discoveries continue to be made in this area.

There is ample evidence to argue for early sedentism in coastal Chile. First and foremost, these ancient people lived in a marginal environment that did not change significantly over time. The Atacama Desert is one of the driest deserts in the world today, with little or no annual precipitation. The only potable water can be obtained from largely ephemeral rivers and streams that flow from the Andes to drain into the Pacific Ocean. Resource heterogeneity was found along the coast, where a more diverse range of resources were found concentrated in fixed locations. River deltas such as the convergence of the Camarones River with the Pacific Ocean would have been favored spots for prehistoric populations, with a ready supply of potable water, edible plants, small land mammals, birds, aquatic mammals, fish, shellfish, and seaweed in a relatively confined space. Presently, the weather is relatively mild, with daytime temperatures ranging from 60 to 72° F year-round (Arriaza 1995:31). The coastal environment of northern Chile and southern Peru has not changed significantly from prehistoric times, except for perhaps a greater degree of seasonal climatic variation (Sandweiss et al 1989:62-63). All of this combined made for ideal conditions for permanent settlement on the coast.

If Jochim's (1983) contention that settlement permanence is dependent on fixed resources in fixed locations, then the prehistoric panorama of coastal northern Chile lends credence to this idea. The conditions that are found in this region fit this particular profile. To further support this idea, the presence of cemeteries and the elaboration of intricate mummy styles that could be interpreted and accepted as a type of craft specialization indicate of a degree of stability that would not be possible with a mobile band.

At the least, this coastal Andean society could be interpreted as practicing the type of economy that Binford had defined as collectors (Binford 1980). Even though many of the resources that were exploited were concentrated and fixed in space, the collecting of these resources would have required a great deal of logistical planning that relied on the acquired knowledge of, and an intimate relationship with the surrounding environment. If we can regard collectors as one possibility within a spectrum of various sedentary lifestyles, rather than classifying them as mobile, then we can begin to consider the Chinchorro society as an early sedentary society.

As a sedentary society, why did the Chinchorro not turn to plant cultivation as a means of increasing their subsistence base? If we consider Bar-Yosef's (1992) contention that agriculture in the Near East began as a response to population pressure in fertile areas rather than in marginal ones, we can begin to understand the answer to this question. The Chinchorro inhabited a marginal area, the Atacama Desert. The marginality of this area could efficiently sustain only small groups of people simultaneously; therefore, as long as the population density remained below the carrying capacity of the land, the environment provided sufficient resources for permanent settlement.

The study of sedentism among prehistoric peoples has undergone many changes throughout the history of archaeology as a discipline. Earlier notions of cultural evolution have been replaced by an environmental assessment approach. Studies by Louis Binford, Kent Flannery, Bar-Yosef, Stephen Perlman, Michael Jochim, and Robert Kelly have made this possible by allowing researchers to carefully structure research and to prepare models of human behavior that can be used to continuously formulate and test hypotheses. The following table emphasizes the conditions that these authors have stated that are required for sedentism to be possible.

Table 4. Characteristics of Non-Agricultural Sedentism

Characteristics of Non-Agricultural Sedentism	
Binford (1980)	Fixed resources
Flannery (1969)	Broad-spectrum wild resource utilization
Jochim (1983)	Heterogeneous and clustered resource environment
Kelly(1995, 1998)	Local abundance in a context of regional scarcity
Perlman (1980)	Optimal foraging of fixed and concentrated resources (higher productivity areas)

These criteria will be compared later in this study to the Chinchorro culture when examining the question of the settlement pattern and subsistence strategy of this group.

Human adaptation is not static. Coastal environments are but one type of adaptation to a particular situation that differs from the traditional hunter-gatherer stereotype. With new technologies and approaches to archaeological investigation, it may be possible to discover a wider diversity of cultural and environmental adaptations that preclude agriculture.

Along with a change in perspective on traditional economic adaptations for pre-agricultural societies we may also begin to change our notions of social complexity. Perhaps the Chinchorro culture represents a society that was complex in certain ways, without becoming stratified in a hierarchical class structure. The social complexity may have been manifested in a series of parallel, rather than hierarchical classes, or even in situational shifts in social roles. According to Arriaza (1995), no hierarchical ranking of individuals has been detected in any of the sites studied to date. There is no differentiation in burials, or in mummification, that would indicate a ranked society. All members of this society were mummified, including infants and fetuses.

Earlier in this paper, a set of criteria was presented to identify sedentary archaeological sites. All of these criteria are valid indicators of a sedentary population. However, other criteria could be added to the list as additional indicators to keep in mind when evaluating the nature of a site (Table 5). Some additional indicators not yet discussed, such as pathologies associated with sedentary living, should be used when the data presents itself for study. Not all conditions are required before a site is judged as sedentary.

There should be considerable flexibility when weighing the evidence of any site because of the enormous capability humans have always displayed for variability when responding to different situations. It seems that, in the case of coastal societies, the development of sedentism is a unique response to the coastal environment. All of the examples mentioned in this paper pertaining to coastal adaptations have in common a specific type of coastal environment that was conducive to the exploitation of various resources. Many of these sites are situated in areas where upwelling, which is the process where cold, plankton-rich waters permeate surface waters, is present. This type of environment is extremely favorable for many aquatic species that are consumed by humans (Bailey and Parkington 1988). Research in the area of prehistoric coastlines and ocean currents may provide valuable clues as to the location of ancient sites.

In many respects, sedentary coastal economies are set apart from the more traditional hunter and gathering economies by distinct physical features, such as shell middens, that characterize coastal groups and their environments.

Table 5. Additional Archaeological Characteristics of Sedentary Sites.

Willey & Phillips (1958)	Renfrew & Bahn (1996)	Additional Criteria Binford (1980), Flannery (1969), Jochim (1983), Kelly (1995, 1998), Perlman (1980)
*1. diversified tools	*1. house structures	*1. environmental heterogeneity
*2. ground stone utensils	*2. diversified tools	*2. refuse and shell middens
3. evidence of food production (domestic vs wild plant varieties)	3. pottery	*3. fixed resources
*4. permanent villages (house structures)	4. agglomerate or dispersed settlement	*4. complex crafts that are not trade items or luxury items
5. pottery	5. food storage (pottery, caches, etc.)	*5. continuity of traditions for long periods of time
*6. weaving	*6. craft specialization	*6. pathologies associated w/sedentary living
7. developed food production(irrigation)	7. ranked society (burials)	
8. ceremonial centers	*8. evidence of investment of labor or communal action such as public monuments or irrigation systems	
*9. craft specialization	9. ritual centers	
10. metallurgy	10. evidence of food production	
	11. secondary products	

- *indicates those traits found in Chinchorro sites

Methodologically, there are certain advantages to studying archaeological coastal environments. First and foremost, coastal environments present a highly structured and visible pattern of resource availability that allow for a variety of archaeological interpretation (Bailey and Parkington 1988:2). There are many marine species that inhabit the coastal edge that are greatly diverse in their behavior patterns and accessibility to human predation, and are specific in terms of their habitat requirements. The wide range of exploitable species along the coast necessitates a similarly wide range of cultural requirements in order to take advantage of all available resources. To obtain some species, such as large sea mammals or large fish, a degree of social collaboration and more specialized technology on the part of humans is required. Conversely, solitary individuals can collect other types of species, such as mollusks. There are local geophysical variations, such as rocky points versus sandy beaches, and bays that offer different opportunities for exploitation, with distinctive faunal and floral communities. Another factor influencing the exploitation of coastal resources is that of temporal cycles at a variety of scales: tidal, seasonal, and inter-annual. All of these characteristics offer two distinct advantages to the study of coastal environments: 1) a detail of archaeological reconstruction, and 2) a measure of the degree to which available resources were made use of and integrated within a subsistence economy.

Mollusks comprise a wide range of edible species with a variety of distinctive features, such as habitat requirements, size, nutritional values, and so on. Because of the differences in habitats that they occupy within the intertidal zone, accessibility to different species may be limited to different times of day, or in the extreme, to specific times of the year. Waselkov has defined the shell midden, or refuse heap as "a cultural deposit of which the principal visible constituent is shell." (1987:95). Shell middens offer the opportunity to study several aspects of human activity, of which food gathering strategies is a predominant focus.

Another area of study where the application of shell midden research is highly relevant is in environmental reconstruction. Through the use of several different analytical techniques, it is possible to study climatic change or anomalies, landscape alterations, etc. In addition to faunal assemblages, floral assemblages may be reconstructed as well. Changes in molluscan species through time may reflect changes in sea surface water temperatures and other types of environmental pressures such as tectonic movement, and population dynamics.

Other marine species offer similar opportunities for the study of seasonal patterns of exploitation and changes in environment. Many species of fish and sea mammals have strong migratory patterns that indicate at which time of the year they would be available in offshore waters or along a particular stretch of coastline. The presence of fish and mammal bones in shell middens and other cultural contexts are useful indicators of seasonal exploitation and dietary reconstruction. What makes the exploitation of marine resources ultimately attractive to humans is that the food supply migrates through the residential area of the group, which in turn means that the group does not need to relocate to other areas for different resources.

Because this study is an environmental approach to subsistence practices and their relationship to the settlement patterns of the pre-agricultural Chinchorro culture, it is necessary to understand the analytical techniques that have been used in similar studies. The next chapter will focus on these techniques as applied to the study of prehistoric coastal sites.

CHAPTER 3

SHELL MIDDEN ANALYSIS: APPLICATIONS AND TECHNIQUES USED TO RECONSTRUCT PALEOENVIRONMENTS

There are many marine species that occur along intertidal (the area between low tide and high tide) shores that are accessible to humans for consumption. This is possible because of the many specific habitat requirements, spatial and temporal controls that these organisms depend on for survival and propagation.

Because there is great variability of the species, habitats, and environmental requirements for survival and reproduction, the study of the use of mollusks within cultural contexts offers a unique view of human adaptability. The reconstruction of dietary choices, settlement patterns in terms of seasonal occupation of coastal sites, and the degree to which these resources were actually made use of and integrated within a subsistence economy have been made possible through the application of scientific techniques in biochemistry and marine biology.

Another area of study where the application of shell midden research is highly relevant is in environmental reconstruction. Through the use of several different analytical techniques, it is possible to study climatic change or anomalies through time, landscape alterations, etc. In addition to the faunal remains that are represented within a shell midden, floral species can be determined as well.

This chapter will discuss the advantages of and techniques used for shell midden analysis in paleoenvironmental reconstruction. These techniques include shell microgrowth analysis, oxygen isotope analysis, and shell meat weight ratios.

Shell Midden Archaeology

The procurement of shellfish as a food resource has occurred among coastal peoples for several millennia. Most of the molluscan species that were exploited prehistorically were those that occupy habitats close to the shore, in the intertidal and subtidal (area below low tide to a depth of 100m) zones (Glantz 1996). These habitats can vary from rocky shores to sandy beaches.

Shell midden archaeology has also been used to study seasonality of resources in order to understand population mobility and settlement patterns. Because shellfish are relatively small the energy expended in gathering and transporting sufficient quantities to a base camp that is not situated close to the source usually exceeds that gained from the food.

Therefore, an underlying assumption about this type of subsistence strategy is that campsites will be located near the shore (Waselkov 1987).

Some of the earliest investigations of shell middens in the United States have been conducted in California (Stein 1992:7). It was here that researchers began to view shell middens as a means to estimate site chronology, prehistoric diet, and population. In the latter half of the twentieth century a special emphasis was placed on the study of the shell in terms of food supply.

According to Ambrose (Stein 1992:7-8) there are the five main types of research questions addressed by examining shell middens. These five types are:

1. Examining shellfish remains in terms of available food supply (reconstructing meat weights and calories).
2. Plotting variations is shellfish species, as measured from column samples in shell middens, to infer changes in ecological conditions within nearby aqueous habitats (noting shifts from abundant rocky-bottom bay shellfish species to abundant soft-bottom bay species.
3. Delineating ancient shoreline locations by plotting geomorphic positions of shell middens, and inferring that the location of the shell midden indicates the location of the paleoshorline.
4. Ignoring the shellfish remains in the site and constructing cultural historical sequences by analyzing artifacts only.
5. Examining the shell midden in terms of its depositional and postdepositional processes.

There have been several criticisms aimed at the use of shellfish remains as indicators of diet and seasonality. One of the main concerns about this type of research is the reliability of the assumptions behind dietary and seasonality interpretations (Stein 1992:8). Seasonality studies using shellfish can be problematic due to past and present fluctuations in climate and environment. Additionally, there may be sampling biases on the part of the archaeologist. Changes of species within a midden can be due to several factors, such as shifts in shellfish habitats and gathering sites, a change in cultural dietary preference, overexploitation of certain types of shellfish, changes in the environment, etc. This is often hard to interpret archaeologically because changes in shell midden composition can be multi-causal.

Post-depositional processes may also affect the interpretations of prehistoric events

(Thomas and Thompson 1992:61). These include compaction, inundation, translocation of small-sized objects, bioturbation, and reoccupation and land disturbance during the historic period. This last process has been documented in post-contact records. During Colonial times in Mexico, many shell middens were mined to use the shell material for lime plaster (Meighan 1976:164). In many eastern Pacific coastal sites, tectonic uplift and other processes such as intense flooding caused by the El Niño event have altered the landscape, and changed or destroyed many midden sites.

At the British Camp site located in Garrison, San Juan Island, a later historical camp heavily disturbed a previously occupied Native American site. The surface of this particular shell midden, upon which rests the historical camp, is very flat. The shell middens of nearby areas were all characterized by having cultural features such as earthworks, circular depressions, semicircular trenches, or mounds. Thomas and Thompson (1992: 66-68) found that the effect of the British occupation of this site around 1860 was immediate. The initial encampment was a combination of tents and buildings. Early photos of the area illustrate a waterfront parade ground, where cutting and filling had taken place during the initial five years of the British occupation. Roads or paths were also cut into the shell midden between buildings.

This historical incident of post-depositional landscape alteration due to successive occupation of the site is an example of just one type of perturbation that can hinder shell midden investigation and interpretation. Other types of alterations that can occur include natural events such as seismic activity and tectonic uplift, rising sea levels, flooding, and animal activity.

Another important consideration in the examination of shell middens is the use of stratigraphy in excavation and sampling. Traditional archaeological stratigraphy is insufficient to define shell midden deposits because the main criteria for its use is to classify cultural chronological units rather than geomorphological or biomorphological units. Stein (1992:72) suggests that multiple criteria are necessary to define shell midden stratigraphy, which are divided into three main areas: physical lithology, artifact content, and time. These types of strata are broad in scope and should be used as a general guideline, because stratigraphy can be interpreted from many different perspectives. Physical lithology encompasses those units that are defined by changes in physical attributes. For a shell midden, this should include changes in the types of fossil faunal species represented as well as changes in the lithic, sedimentary or soil matrix. Ethnostratigraphic units consider changes in artifact content, including changes in cultural features. Finally, shell middens can also be subdivided stratigraphically into chrono- and geochronostratigraphic units, which are used to reckon time. Chronostratigraphic units are based on rocks formed during the same span of time, and can be based upon the same time span of a bio-, litho-, or ethnostratigraphic unit. Each of these divisions represents analytic units created to serve different analytical needs.

Stein et al. (1992) have provided procedures that would allow archaeologists to separate the stratification caused by cultural events from that caused by depositional and postdepositional events. This methodology results in better interpretations of site formation and clearer regional correlations. The stratigraphy of the British Camp site resulted in several small lithographic units or facies, large lithographic units or layers, which encompassed the facies, ethnostratigraphic units, which were facies that contained cultural remains, and lastly chronostratigraphic units which were temporal units that encompassed facies and/or ethnostratigraphic units.

Oxygen Isotope Analysis

Isotopes are two or more atoms that have the same atomic number, and hence the same element, but differing in mass number. Most elements in their natural state consist of a mixture of two or more isotopes. Isotopic ratios of elements in natural materials on the earth were either constant in time and space or varied as a result of radioactive decay or geochemical fractionation (Herz 1990:585-593). In the case of oxygen-isotopes, the fractionation is temperature dependent. The analysis of the carbonate fraction of prehistoric shell material can be used as a type of paleothermometer, resulting in information on paleoclimatic conditions at the time the shells were harvested. This can also be used as a type of proxy data that will help determine seasonality of site occupation.

The measurement of isotopic ratios is carried out using a mass spectrometer, and data are reduced by comparison to an accepted international standard (Herz 1990:593). Dissolved oxygen in the ocean is enriched in ^{18}O relative to atmospheric oxygen (Hoefs 1987:132). Enrichment of ^{18}O occurs due to the preferential consumption of ^{16}O by bacteria that exist in colder waters. This makes the enrichment factor temperature dependent, therefore, the higher the ratio of ^{18}O to ^{16}O, the colder the temperature. The value of ^{18}O is measured in parts per mil, up to about $14^{0}/_{00}$. As sea temperatures rise, the $^{16}O/^{18}O$ ratio is reduced at a rate of $0.2^{0}/_{00}$ for each degree Celsius (Monks 1981:215).

There are some problems associated with this method that should be taken into account before its application (Herz 1990:593). First, some sources of error can come from the chemical and mineral composition of shell material, such as organic protein, aragonite, and dolomite, each of which possess different ^{18}O enrichment factors than calcite. Another error can result from a difference in the isotopic composition of the water in the past. Post-depositional isotopic exchange can occur as the result of diagenetic and weathering processes involving recrystallization that can change the oxygen isotopic composition of the original carbonate of the shell. Yet another error that may arise when interpreting ^{18}O data is that no two shells may produce exactly the same quantity of isotope, regardless of whether the shells are of the same population and killed on the same day (Claassen 1998:150).

Rollins et al. (1990:470) have stated that the use of oxygen isotope profiles should be accompanied by a controlled study of modern representatives of a targeted midden, including information on the habitat and behavior of the species. Some researchers such as Bailey argue that the high degree of variation in isotopic values among individuals provides an untrustworthy datum for high-resolution paleoseasonality determination unless in situations where a close correlation between temperatures in successive years could be demonstrated.

In Rollins et al. (1987) study of the effects of the 1982-83 El Niño episode on molluscan populations, a representative suite of 15 samples of *Chione subrugosa* and *Trachycardium procerum* were analyzed for deviations in ^{18}O. During an El Niño event, sea surface temperatures can increase anywhere between 2°-10°C above normal temperatures (Glantz 1996:24). In Peru, where this study was conducted, sea surface temperatures rose to 8°C above normal. For the shell sample composed of *Chione subrugosa* the elemental analysis resulted in anomalous or insignificant chemical differences between pre- and post-El Niño events. This was due to the nature of the habitat of this species, which corresponds to intertidal mud flats. These mud flats are subject to frequent localized episodic temperature spikes that would render an element analysis indecipherable in terms of temperature patterns.

The results for *Trachycardium procerum* were quite different. The isotopic composition of this species appeared to reflect the physiochemical conditions of the ambient seawater (Rollins et al. 1987:192). The ^{18}O values were lighter in post-El Niño precipitated shell carbonate, which can be attributed to warmer waters. The calculated water temperature increased from a pre-El Niño average of 17°C to 22°C after the incursion of the warm tropical counter current.

Shakleton (1973) was a pioneer in the use of oxygen isotope analysis for paleoenvironmental reconstruction. He discussed several prerequisites that were necessary in order to use this method effectively, such as:

a) Shell deposition should occur under conditions of isotopic equilibrium.

b) The species under analysis should be from a stable isotopic environment, which excludes such habitats as intertidal mud flats or pools, or environments involving short-term temperature and salinity variation.

c) Samples should be composed of shells whose growth occurs at rapid rates so that adequate sampling of shell increments preserves a record of temperature variation.

d) The annual seasonal temperature variation should be greater than a week-to-week temperature variation.

The species found in the Camarones delta appear to conform to these requisites. The environment of this area is composed of a combination of intertidal rocky shores, and a wide, intertidal sandy beach. The shells also appear to preserve a record of rapid growth rates, and there is a marked annual seasonal temperature variation, both on land and in the water (Schiappacasse and Niemeyer 1984:5-6).

The subsequent chapters will focus on the use of some of the analytical techniques discussed in this chapter to examine the seasonal utilization of marine resources by the Chinchorro culture in the Camarones delta and the Quiani settlements. This may help shed some light on the nature of their settlement patterns. The theoretical framework is based on a combination of works already discussed in previous chapters. Because the Chinchorro were a non-agriculturally based society, then Binford's model of the logistical nature of collectors (1980:5) is considered an important starting point from which to investigate and understand Chinchorro subsistence and settlement patterns. However, due to the uniqueness of coastal adaptations, Jochim's definition of settlement permanence based on fixed resources (1981:148-149) and Perlman's model of coastal productivity and optimum foraging for hunters and gatherers (1980:257-258) are the dominant paradigms that have driven this research.

CHAPTER 4

METHODOLOGY

This chapter will discuss the methodology utilized to address the research questions presented in Chapter 1. The following will be discussed at length:

1) Collection and identification of :
    a) modern shells.
    b) prehistoric shells.

2) Excavation of shell midden:
    a) by the author at Camarones.
    b) previous by various investigators at Quiani.

3) Radiocarbon dating of shell midden.

4) Oxygen isotope analysis of modern and prehistoric shells.

5) Morphoscopy of modern and prehistoric shells.

Three distinct levels of investigation were necessary in order to address the research objectives presented at the beginning of this study. First, it was necessary to establish the identity of all known modern malacological intertidal species from the areas in and between the city of Arica and the Camarones delta. The resulting database would facilitate the identification of species found at the archaeological sites in this study. Second, the identification of those species that were used as food prehistorically was accomplished by classifying and quantifying samples from previously excavated shell middens. Third, testing of a shell midden through excavation was performed to gather new data pertaining to those species that were present at a fixed location (Camarones), with a substantial chronological sequence, as provided by a stratified shell midden, in order to determine seasonal availability of these resources.

Collection and Identification of Shells

Modern species

The first level of investigation entailed the gathering of live shellfish from their natural habitats and the collection of shells from the shoreline. The first was accomplished by employing underwater divers who ventured out from several locations in and around the city of Arica in the intertidal zone to collect live shellfish. Shellfish were collected from two main sites.

The first site was located at the beach called La Capilla, a rocky beach that is a favorable habitat for several varieties of shellfish. This area lies approximately 1.5 miles to the south of downtown Arica. This area is significant because it is situated near several major prehistoric sites.

The second area where shellfish samples were collected lies directly beneath the cliff known as El Morro, an area of great prehistoric and historic significance. Several prehistoric cemeteries have been found at the Morro site, and during historic times, El Morro was the site of a key battle for dominance of the area between Chile and Peru during the latter half of the 19th century (Burr 1974). This area consists of a rocky beach that is used by local fisherman, called El Onda. The species that dominate these habitats tend to be of the rocky shore variety; however, the divers also collected sand dwelling species from the sandy substratum of the beach. Additional shells were obtained by walking the shoreline and collecting beached samples. The beaches that were covered by pedestrian reconnaissance included Camarones, El Alacrán, and Arenillas Negras. All species were disinfected by washing them in a 4:1 solution of water and bleach and were then catalogued and measured. Several classification guides were used to identify the different species. A manuscript compiled by Corrales and Belmonte (1990) was helpful in identifying the various species, and was supplemented by Abbot and Dance's (1986), and Wye's (1991) shell identification guides. McClean's manuscript on the genus *Fissurella* (1984) was used to further distinguish the different species within this genus, as these have consistently been an important food source both prehistorically and in modern times.

Table 6 lists the malacological species that were collected from these locations during the 1996 and 1997 season. Those specimens collected from the beaches of Arenillas Negras, Alacrán, and Camarones were non-living beached shells, while those collected from the sites of La Capilla and El Onda were live shells obtained from their natural habitats. A total of 26 different species were collected from the different locations around Arica and at Camarones. Twenty of the twenty-six different species that were identified were found at Camarones. However, all of the samples collected from Camarones were beached. not live shells. At the location of El Onda, seven out of the twenty-six identified species were obtained live from their natural habitat.

Table 6. Malacological Species from Five Loci in Northern Chile

Species Name	Common Name	Habitat	Provenience				
			Alacran*	Arenillas Negras*	Camarones*	El Onda**	La Capilla**
Argopecten purpuratus	Purplish Scallop	sandy		x	x		
Aulacomya ater	Black-ribbed Mussel	rocky	x	x	x		
Calyptrea trochiformis	Peruvian Hat	rocky	x	x			
Choromytilus chorus	Chorus Mussel	rocky	x	x	x		
Collisella orbignyi	Limpet	rocky		x			
Concholepas concholepas	Rock Barnacle	rocky	x	x	x	x	x
Crassilabrum crassilabrum	-	rocky	x				
Crepidula dilatata	Dilated Slipper	rocky	x	x	x		
Fissurella crassa	Keyhole Limpet	rocky	x	x	x		
Fissurella latimarginata	Keyhole Limpet	rocky	x		x		x
Fissurella maxima	Keyhole Limpet	rocky	x	x	x		x
Glycemeris ovata	Bittersweet	sandy			x		
Hiatella solida	-	sandy			x		
Littorina peruviana	-	rocky			x		
Macrocallista pannosa	Clam	sandy	x	x		x	
Mesodesma donacium	Giant Wedge Clam	sandy	x	x		x	
Oliva peruviana	Peruvian Olive	sandy			x		
Perumytilus purpuratus	-	rocky	x	x	x	x	
Priene ruda	-	rocky			x		
Protothaca thaca	Thaca Venus Clam	sandy	x	x	x		x
Scurria viridula	Green Chilean Limpet	rocky	x		x	x	
Semele solida	Solid Semele Clam	sandy	x	x	x		
Semimytilus algosus	Mussel	rocky		x			
Tegula atra	-	rocky	x	x	x	x	
Thais chocolata	Chocolata Rock Shell	rocky	x	x	x	x	
Turritella cingulata	Banded Turritella	rocky/sandy			x		

* beached samples ** live samples

As indicated in Table 6, there is more variety of species among the non-living beached species than the live species that were collected. The reasons for this discrepancy could include the fact that the live specimens were collected during the 1997

El Niño episode, when the sea surface temperatures were elevated. This could have harmed many temperature-sensitive species, and inhibited the reproduction of many species, making them difficult to find and collect. Another reason for the discrepancy could be that the areas where the live shells were collected were also favored areas for local exploitation by both individuals and commercial fisherman.

Prehistoric species

The second level of investigation involved the identification and compilation of a database of those malacological species that were consumed by humans prehistorically. Once the modern species were collected and identified, a survey of prehistoric species was undertaken. Information about the prehistoric malacological species was obtained from an extensive literature search of prehistoric coastal sites of the extreme north of Chile. This yielded consistent information about the coastal resources that were exploited through time (Tables 7 & 8). Table 7 lists the sites previously excavated and recorded, along with the type of site and chronometric date, and Table 8 lists the shell species that have been recorded for various coastal sites in northern Chile.

Table 7. Prehistoric Sites of Coastal Northern Chile with Fossilized Shell

Site	Reference	Site Type	Date
Camarones 14	Schiappacasse & Niemeyer 1984	Campsite	7420 ± 225 B. P.
Camarones 15	Muñoz et al 1991	Cemetery	2840 ± 100 B. P.
Camarones 8	Belmonte et al 1994; Muñoz 1995	Campsite	4600 B. P.
Quiani 1	Bird 1943	Campsite & Shell Midden	6170 ± 120 B. P.
Quiani 9	Muñoz & Chacama 1982	Campsite & Shell Midden	6370 ± 540 B. P.
La Capilla 4	Muñoz 1984	Campsite & Shell midden	1250 ± 100 - 690 ±100 B. P.
Acha 2	Vilaxa & Corrales 1993	Campsite	8970 ± 255 B. P.

Table 8. Malacological Species Listed for Seven Prehistoric Sites

Species Name	Cam 14	Cam 15	Cam 8	Q i 1	Q 9	LC4**	Acha 2
Argopecten purpuratus	-	-	-	-	-	+	+
Aulacomya ater	-	-	-	-	-	+	-
Choromytilus chorus	+	+	+	+	+	+	+
Collisella orbignyi	-	-	+	-	-	-	-
Concholepas concholepas	+	+	+	+	+	+	+
Crassilabrum crassilabrum	-	-	-	-	-	-	-
Crepidula dilatata	+	-	+	-	-	-	-
Fissurella crassa	-	-	-	-	-	+	+
Fissurella latimarginata	-	-	-	-	-	-	+
Fissurella maxima	-	-	-	-	-	-	+
Fissurella sp.	+	+	+	+	-	+	-
Mesodesma donacium	+*	-	+	-	-	+	-
Oliva peruviana	-	-	-	-	-	+	+
Perumytilus purpuratus	+*	-	+	-	-	-	+
Protothaca thaca	+*	+	+	-	-	+	+
Semele solida	-	-	+	-	-	-	-
Tegula atra	+*	-	+	-	-	-	-
Thais chocolata	+*	-	+	-	-	-	+

+ = presence; - = absence of or not reported in report * = few in number ** = agricultural group (Cam=Camarones; Q=Quiani; LC=La Capilla)

Not surprisingly, the dominant species that were recorded in many of the archaeological sites included the intertidal univalves *Concholepas concholepas*, several of the *Fissurellids*, and the intertidal bivalves *Choromytilus chorus*, and *Protothaca thaca* (Figures 8-15). These species have consistently proved to be the dominant malacological species exploited over the last 9,000 years in this region (Llagostera 1979). It is only during the last twenty years, after the El Niño episode of 1982-83, that the species *Choromytilus chorus* has not been seen in the coastal waters around northern Chile.

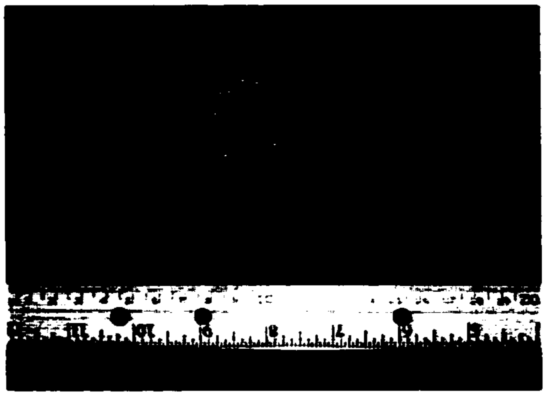


Figure 8. *Concholepas concholepas* and *Fissurella maxima*, Quiani.

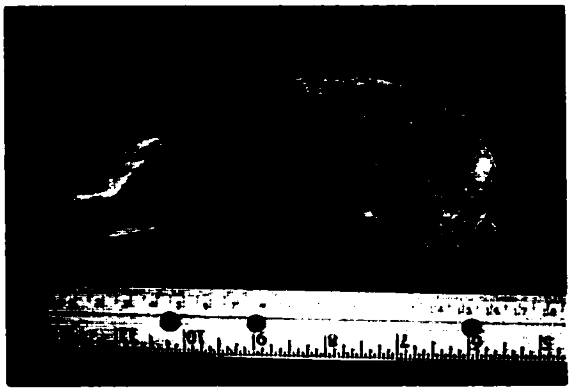


Figure 9. *Choromytilus chorus*, Quiani.

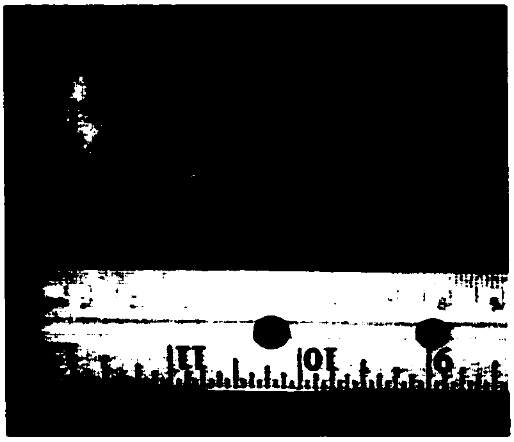


Figure 10. *Perumytilus purpuratus*, Quiani

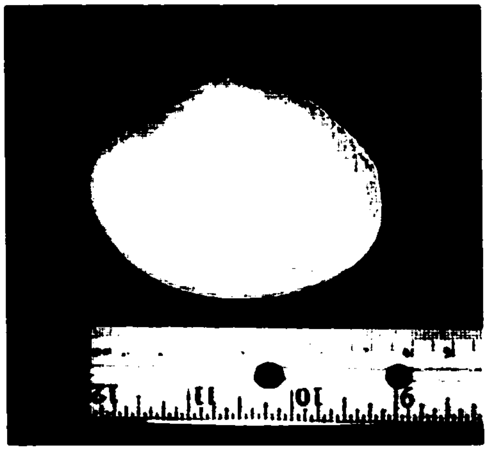


Figure 11. *Protothaca thaca*, Quiani.

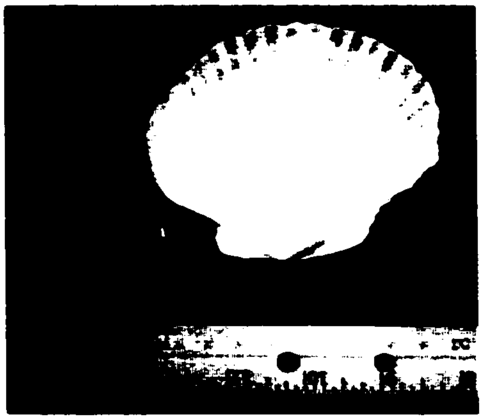


Figure 12. *Argopecten purpuratus*, specimen. Quiani.

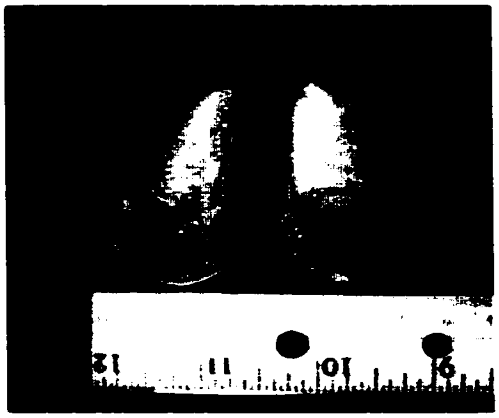


Figure 13. *Aulacomya ater*,Modern

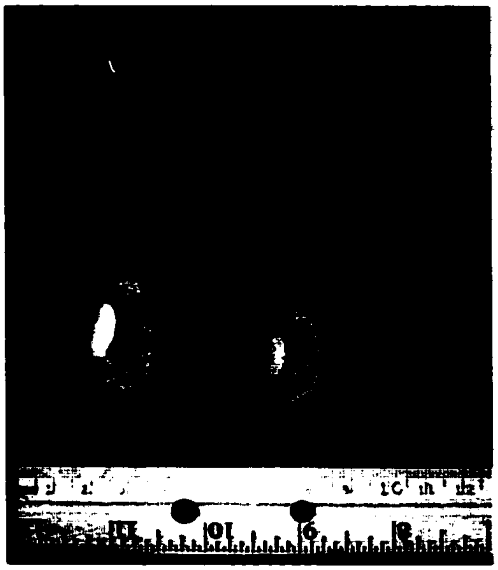


Figure 14. Fissurellids, Quiani.

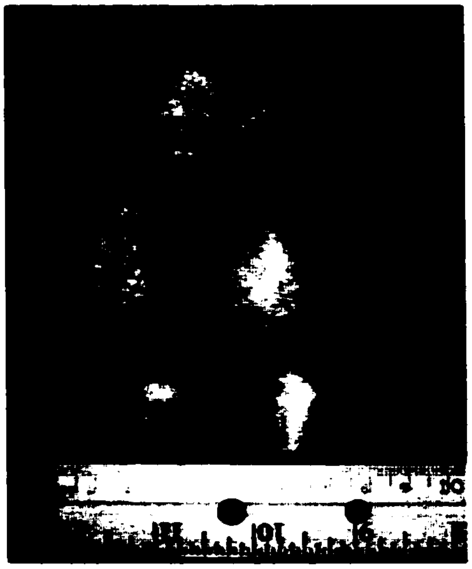


Figure 15. Top to bottom: *Crepidula dilatata, Calyptrea trochiformis, Oliva peruviana,* Quiani.

Additional information about prehistoric malacological species was obtained from collections that have been stored at the Museo Arqueológico de San Miguel Azapa from previous excavations. The specimens were never catalogued; therefore it was necessary to do this before any information could be incorporated into this report. The species that were collected from these various sites were assigned a temporary number, and were catalogued, weighed, and measured. The collections that were catalogued included those species taken from the sites Camarones 8 (Belmonte et al 1994), Quiani 1, Quiani 9 and 10, and Punta Baquedano (Arriaza 1996) (Table 9).

Table 9. Archaeological Malacological Species

	Site				
Species	C 8	Q1	Q9	Q10	P.B.
Acanthina sp				x	
Aulacomya ater		x	x		x
Calyptrea trochiformis		x	x		
Choromytilus chorus	x	x	x		x
Colisella orbyngi			x		x
Concholepas concholepas	x	x	x	x	
Crepidula dilatata	x	x	x	x	x
Diloma nigerrima		x			
Fissurella crassa	x	x	x	x	x
Fissurella latimarginata	x	x	x	x	x
Fissurella maxima		x	x	x	x
Littorina peruviana					x
Mesodesma donacium	x				
Oliva peruviana	x	x	x		x
Perumytilus purpuratus	x	x	x	x	
Protothaca thaca	x	x	x	x	x
Scurria scurra			x		
Scurria parasitica	x	x			
Sea urchins	x	x	x		
Semele solida					x
Semimytilus alghosus		x			
Tegula atra		x	x	x	x
Tegula luctuosa		x	x		
Tegula tridentata	x				
Thais chocolata		x	x	x	x
Thais haemastoma		x	x		

When compared to the modern taxa, it is evident that with few exceptions the intertidal malacological community has changed little over the millennia. Some species, such as the scallop *Argopecten purpuratus* (Figure 12), are more visible today than prehistorically, because of the emergence of deepwater fishing. *Argopecten purpuratus* is a species that generally inhabits deeper waters, and would have been less accessible, although not unknown to prehistoric peoples. There are other species, such as *Turritella cingulata* and *Littorina peruviana*, that appear in the modern tabulation of species, but are absent in the prehistoric record, and may not have been used as a food source due to their small size.

Excavation at Camarones

Camarones West Shell Midden

The third level of investigation involved the sampling of a shell midden in the Camarones delta. Before discussing the methodology employed in sampling this midden, it is important to first mention site formation processes and how this influenced sampling. Waselkow (1987) pointed out that the number one assumption made by archaeologists' approach to the study of shell middens is that midden sites are homogeneous. On the contrary, due to the diversity in shell gathering strategies and other independent variables, such as movements caused by earthquakes, sand movement, etc., shell middens are usually quite complex in both structure and composition (Claassen 1998; Waselkow 1987). The accretion of shell, organic, and cultural material usually results in discrete depositional events, or heaps. This was certainly the case in the Camarones delta, where the surface area of the entire midden measured approximately 72,670m^2. Therefore, it was necessary to identify a discrete heap and designate that as the sampling universe. The heap that was chosen for sampling was one that had been previously excavated by Rivera (1984), and measured approximately 4.0m in length x 2.6m in width x 5m in depth. This particular heap had exposed profiles that were ideal for quick sampling, which was necessary due to time constraints (Figure 16). The shell midden at Camarones is located on a steep east-west trending slope terminating in a high cliff over the Pacific

Ocean. The angle of the slope ranged from 20° to 30°. Over the years, several small terraces no more than 30 cm wide traverse the midden at various levels, creating small trails that facilitated travel through the midden. The bottom of the midden terminates in a cliff overlooking the ocean that drops approximately 100m to the surface of the water. It is possible that during the time of prehistoric occupation, the sea level was higher and the heap that was chosen as the site for sampling was closer to the shore than it is today.

Figure 16. Project site, view to the north

The sampling strategy that was applied to this shell midden was the column sampling technique, which was first developed by Steenstrup (Waselkow 1987:151). This method is relatively simple and can sample stratified deposits in a probabilistic or a non-probabilistic manner. Three columns, measuring 20cms wide by 20cms in depth were excavated. Column 1 was located on the east profile of the heap, and was sampled to a depth of 1.18 meters (Figure 17).

Column 2 was located on the west profile of the heap, and was sampled from the terminus of the previous column to a depth of 2.66 meters, at which point it met with the ground surface (Figure 18). Column 3 was shifted 2.10 meters to the south of Column 2, where a previously excavated hole still lay exposed. Column 3 was sampled from -2.66 meters to a depth of 4.45 meters, where the deposition was culturally sterile and did not contain any type of shell or other marine material (Figure 19). All materials were sifted through a 1/8' screen, and both faunal and cultural materials were collected.

Figure 17. East profile, column 1 view from above

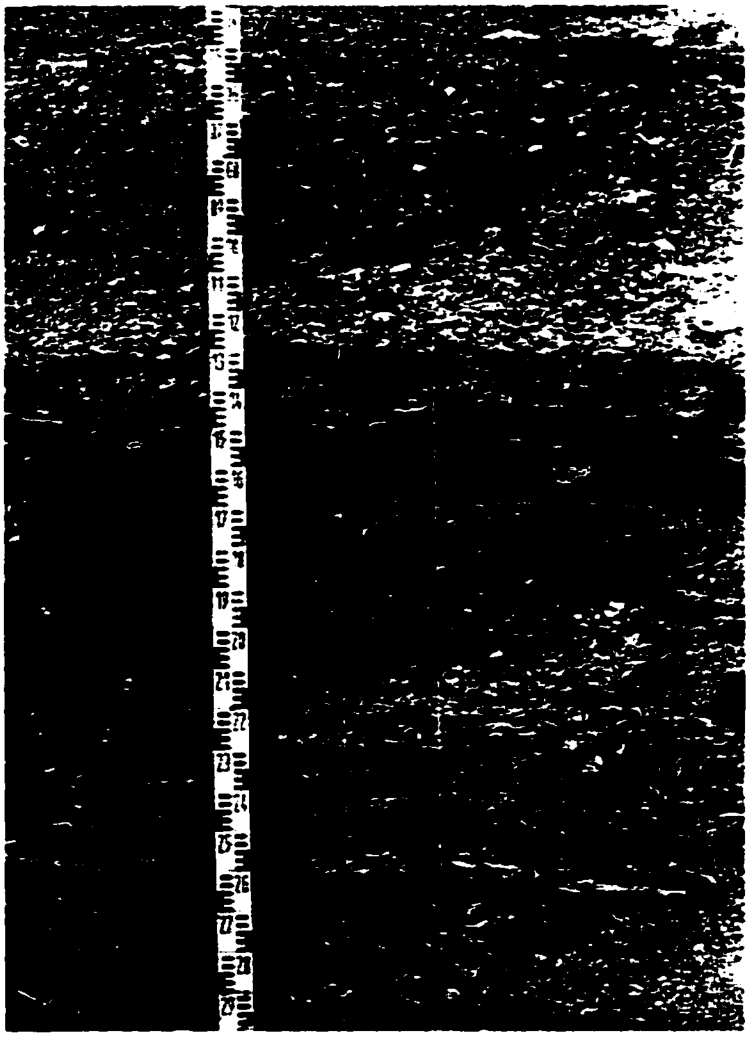


Figure 18. West profile, column 2.

This technique was chosen for several reasons. First, by excavating columns, a sense of chronological depth and stratigraphy could be ascertained so that species through time could be compared. Second, the sampling of the midden by columns would allow for the recovery of unevenly distributed populations of shellfish and other materials. Third and last, this technique was used for simple expediency, because the discrete heap that was chosen as the most favorable location for excavation had been made in previous years, and had left exposed several profiles from which columns could be taken.

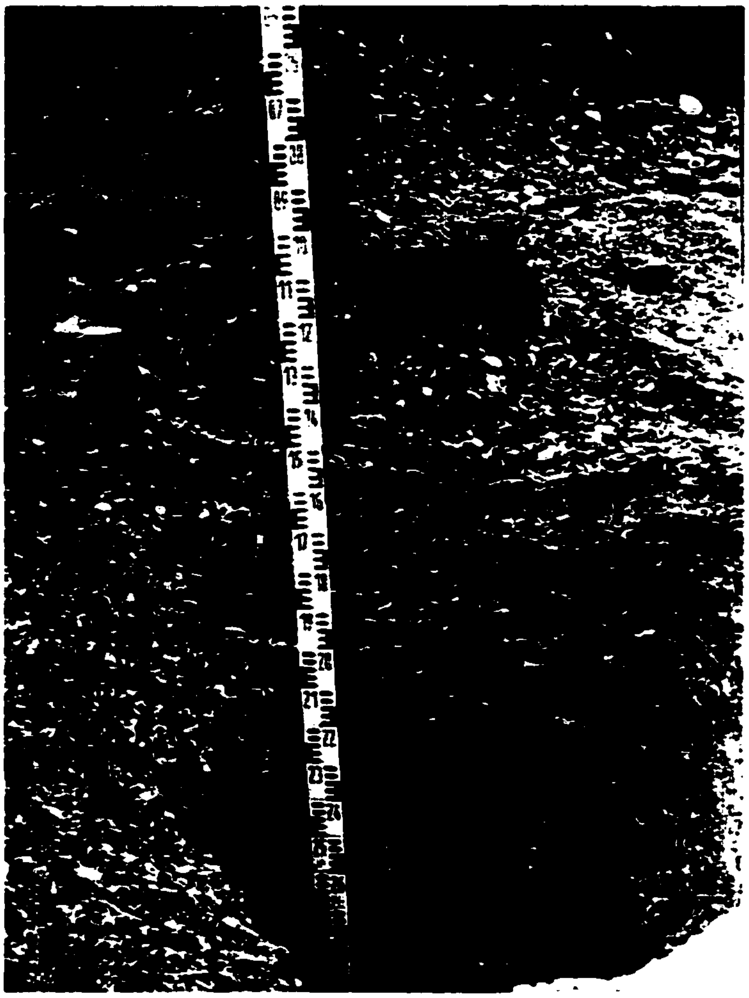


Figure 19. West profile, column 3.

The method that was used to identify and differentiate the stratigraphic levels for sampling was based on the work of Stein (1992). To identify the separate strata, the criteria that were applied to the midden were physical lithology and artifact content. In physical lithology, differences observed in soil matrix and shell type and densities were treated as separate strata. For artifact content, the presence of cultural materials such as reed matting or fiber was also treated as a separate stratum.

The entire sampling process was accomplished in three days, after which all of the excavated materials were transported to the Museo Arqueológico de San Miguel de

Azapa to be curated. Of the twenty-four strata sampled, shells from five different strata were brought back to the United States for oxygen isotope analysis (^{18}O). These strata were chosen on the basis of shell content and density (Figure 20).

Chronology of Camarones West

Six charcoal samples obtained from the shell middens natural strata were radiocarbon dated at the Desert Research Institute (Table 10). The corrected dates were calibrated using OxCal version 2.0. As we can see in Table 10, using one sigma, strata 3 yielded the youngest calibrated date, ranging from 2112-1887 B.C. The oldest age corresponded to strata 10 with a calibrated date of 3640-3340 B.C. These dates correspond to the Transitional and Chinchorro Classic epochs (Arriaza 1995). Rivera (1994) produced an uncalibrated date for the deepest stratum of his excavation. The material dated was from charcoal at 4.97m in depth, and is the oldest date from this heap, at 5640 ± 160 B. P. (Cal 4690-4330 BC. 1 sigma). This date places the beginning of this midden heap within the Classic Chinchorro epoch.

Table 10. Radiocarbon data from Camarones West

Strata	Lab No.	Material	Corrected Date (BP)	1Sigma	Calibrated Dates (1 sigma) OxCal V2.0
3	3483	Vegetal fibers	3624	64	2112-1887 B.C.
5	3488	Ashes & mollusk fragments	4150	73	2872-2617 B.C.
10	3487	Ashes/hearth	4693	123	3640-3340 B.C.
10.1	3484	Reeds	4282	95	3032-2696 B.C.
13	3486	Reeds/charcoal	4082	144	2872-2465 B.C.
15	3485	Vegetal fibers	4510	67	3338-3100 B.C.

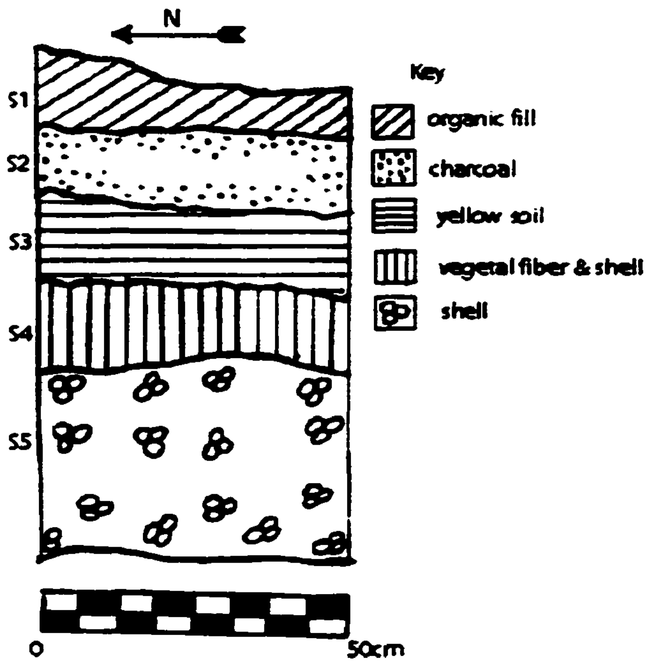


Figure 20. Column 1 profile. Shell samples removed for ^{18}O analysis from strata 3, 4 and 5. Samples for C_{14} taken from strata 3 and 5.

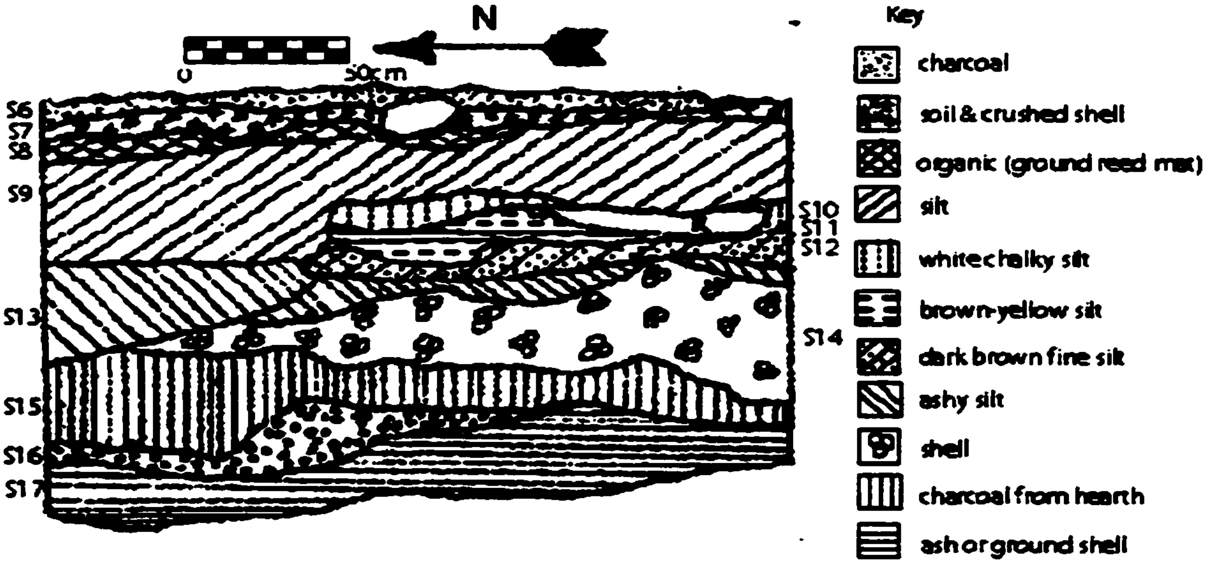


Figure 21. Column 2 profile. Samples for ^{18}O analysis taken from strata 14 and 15. Samples for C14 analysis taken from strata 10, 13, and 15.

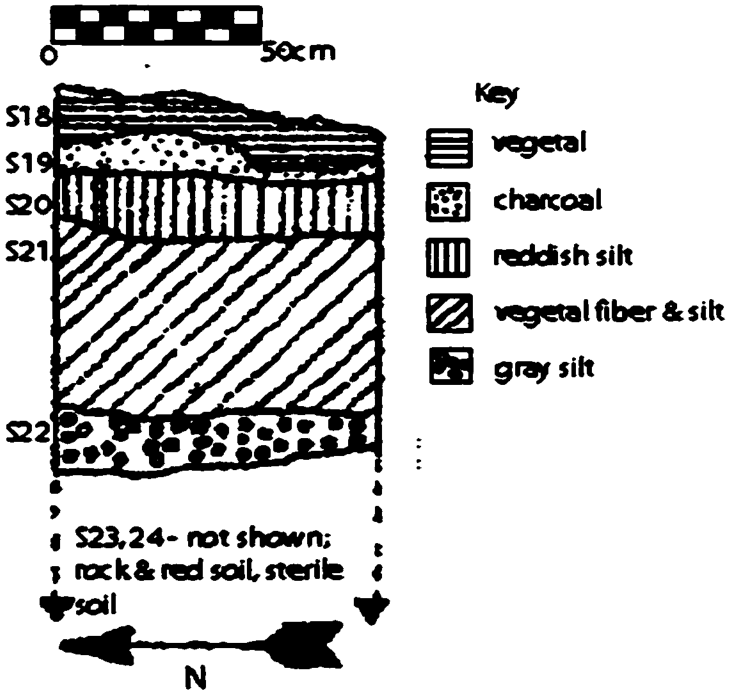


Figure 22. Column 3 profile.

Oxygen Isotope Analysis

The shell samples had to be prepared for analysis by removing deposits of calcium and other potential contaminants prior to processing. This was done by briefly submerging or etching the shell in a solution of 0.04% hydrochloric acid. Only those shells with an intact anterior border, or the margin of growth of the shell, were selected for ^{18}O analysis. Grinding of the anterior margin (Figure 23) to collect 15 milligrams of shell material was done using a fine steel file.

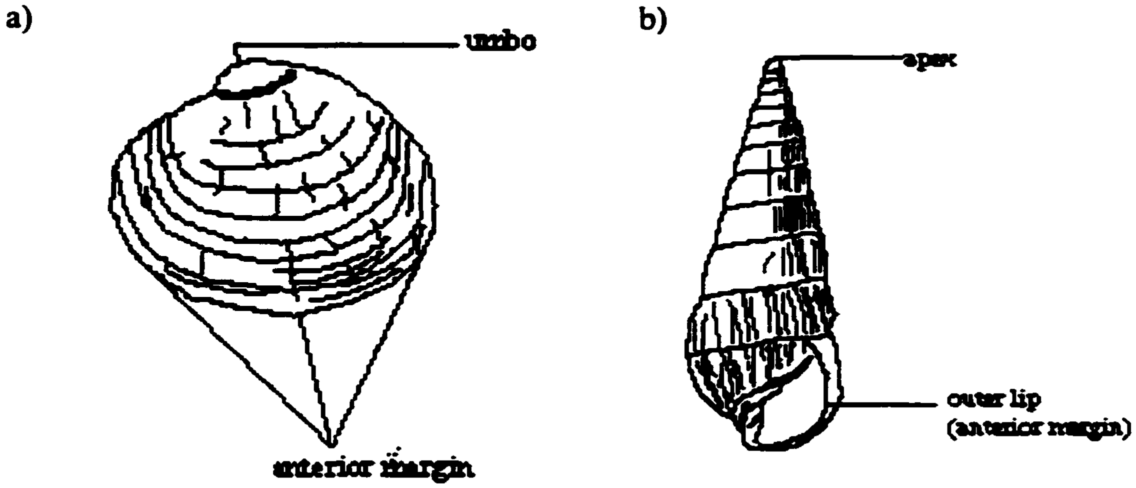


Figure 23. Diagram of: a) a bivalve, and b) a univalve, showing the anterior margin.

Each sample was cataloged and submitted to the isotope laboratory at the Desert Research Institute, along with a sample of the seawater from the Camarones delta for ^{18}O analysis. The resulting values that were achieved were transformed into degrees Celsius by using two different regression formulas for aragonitic shells. Shells are composed of either calcium carbonate or aragonite. Shells from the Andean coast are primarily aragonitic in composition (Sandweiss, personal communication), therefore, regression formulas appropriate for these types of shells were obtained from two main sources:

1) $T^\circ(C)=19.0-3.52(^{18}O_A-^{18}O_W)+0.03(^{18}O_A-^{18}O_W)2$ (Brand and Morrison 1987)

2) $T^\circ(C)=21.8-4.69(^{18}O_A-^{18}O_W)$ (Grossman and Ku 1986)

($^{18}O_A$ = oxygen isotopic value of the shell; $^{18}O_W$ = oxygen isotopic value of the seawater)

Shell Morphoscopy

In addition to obtaining oxygen isotope data for the samples recovered at Camarones, a review of the compilated data was performed to obtain information about shell quantity.

By using this approach, it was hoped that inferences could be made about food preferences and the order of importance of shellfish utilization.

In addition to the oxygen isotope analysis, the Quiani sample was subjected to further analysis to examine size trends of shells through time. Because the shells that were recovered from the Quiani sites tended to be more complete than those found at Camarones, this presented an opportunity to apply different analytical techniques to these faunal assemblages. Working under the assumption that consistent intense exploitation of shells from one area through time should reflect a progressive decrease in shell size, an index of mean shell sizes per species and stratum was created. The Pearson's r for ordinal data was applied to the index scores to determine the correlation of the ranked scores to the stratum, assuming that the deeper deposits correspond to older occupations, and thus the larger the shell. Two of the Quiani loci, Quiani 1 and Quiani 9, were subjected to this test. The results of this test will be discussed in the next chapter.

Additionally, modern shells that were collected by divers and samples from a shell midden excavated at the site of Quiani were also brought to the United States for analysis.

For the Quiani samples, an index score was obtained for the mean size of each species per stratum by multiplying the width and length of the mean shell size per stratum, and dividing the result by 100 (WxL/100). For bivalves and those univalves with similar shapes to that of bivalves, such as *Choromytilus* and *Fissurella*, the width of the shell was determined by measuring the widest part laterally of the shell (Figure 24). The length was determined by measuring from the umbo or apex, to the anterior margin.

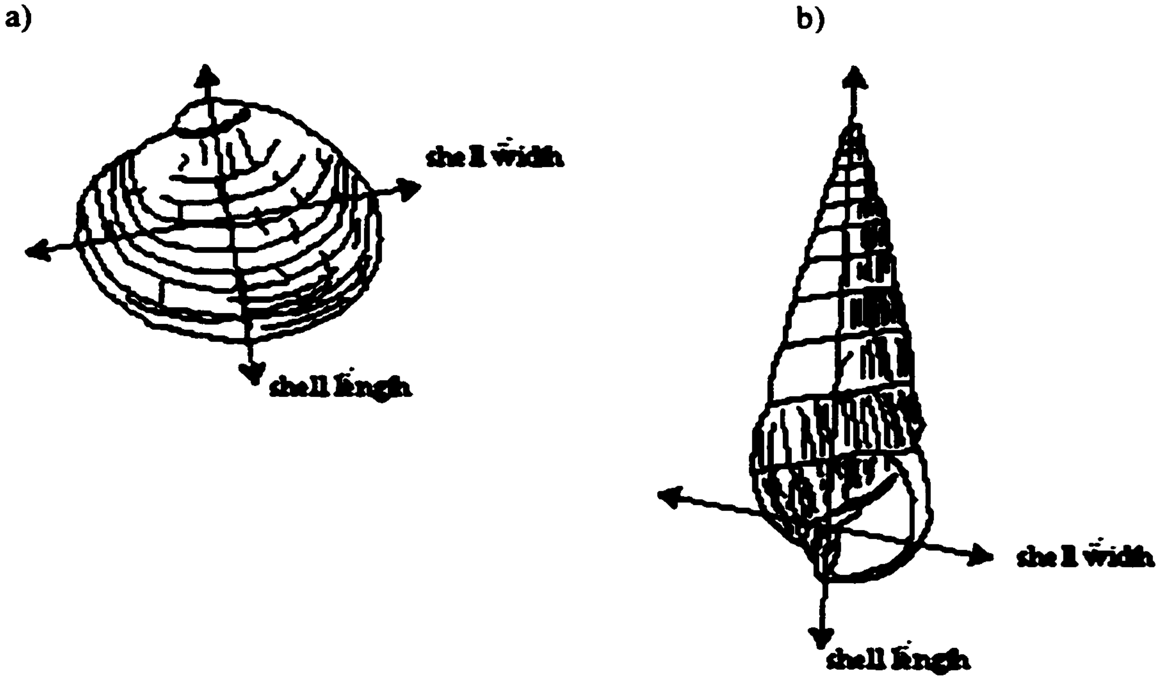


Figure 24. Diagram of the width and length of a) a bivalve, and b) a univalve.

CHAPTER 5

DISCUSSION

The following discussion focuses on the results of the ^{18}O analysis of shell materials recovered from the Camarones shell midden, from the site of Quiani 1, and from the modern shells that were collected in 1997. The results of the Pearson's r for Quiani 1 and 9 will be discussed as well.

Camarones Oxygen Isotope Results

Five strata were tested for ^{18}O analysis from the Camarones midden. These strata were chosen on the basis of the large quantity of shell material recovered from each. The following table summarizes the results of the analysis (Table 11). The first set of temperature values was obtained by using the regression formula by Brand and Morrison 1987:

$T^{\circ}(C)=19.0-3.52(^{18}O_{A}-^{18}O_{W})+0.03(^{18}O_{A}-^{18}O_{W})^{2}$

The second set was obtained from Grossman and Ku 1986:

$T^{\circ}(C)=21.8-4.69(^{18}O_{A}-^{18}O_{w})$

The first set of values shows a temperature range between 11.2°C and 16.1°C, while the second set indicates a slightly wider temperature range, from 11.2°C to 18.0°C. The temperature difference between the five strata does not exceed 4.9°C for the first set of values, and 6.8°C for the second set.

Table 11. Camarones Midden Oxygen Isotope and Temperature Values

Species	Level	Date	^{18}O	T1 (Celsius)	T2 (Celsius)
Choromytilus chorus	3	3624 +64 B.P.	0.96	15.4	17
Concholepas concholepas	3	3624 +64 B.P.	1.52	13.5	14.4
Fissurella crassa	3	3624 +64 B.P.	1.29	14.3	15.5
Choromytilus chorus	4	unknown	1.01	15.3	16.8
Concholepas concholepas	4	unknown	2.2	11.2	11.2
Crepidula dilatata	4	unknown	1.9	12.2	12.6
Fissurella crassa	4	unknown	1.02	15.2	16.7
Fissurella latimarginata	4	unknown	1.1	15	16.4
Choromytilus chorus	5	4150 +73 B.P.	1.09	15	16.4
Concholepas concholepas	5	4150 + 73 B.P.	1.63	13.1	13.9
Fissurella latimarginata	5	4150 + 73 B.P.	0.76	16.1	18
Protothaca thaca	5	4150 + 73 B.P.	1.19	14.6	16
Choromytilus chorus	14	unknown	0.93	15.6	17.2
Concholepas concholepas	15	4510 + 67 B.P.	1.71	12.9	13.5

When the temperature values between same species from different strata were compared, the results were consistent. The species that displayed the lowest temperature regardless of strata was that of *Concholepas concholepas*. The temperature ranges from 11.2 to 13.5°C for the first set of values, to 11.2 to 14.4°C for the second set of values. The species displaying the highest temperature values was *Choromytilus chorus*, ranging from 15.0 to 15.6°C for the first set of values, and from 16.4 to 17.2°C for the second set of values.

The following graph groups each species together and shows the range of temperature values that characterized each species. Figures 25 and 26 show the temperatures obtained by using the regression formula by Grossman and Ku (1986) and Brand and Morrison (1987).

This chart illustrates the temperature trends of each species, and how consistently *Choromytilus* registers higher temperatures as opposed to *Concholepas*, with the lowest values. The exception is the species *Crepidula d.*, of which there was only one sample.

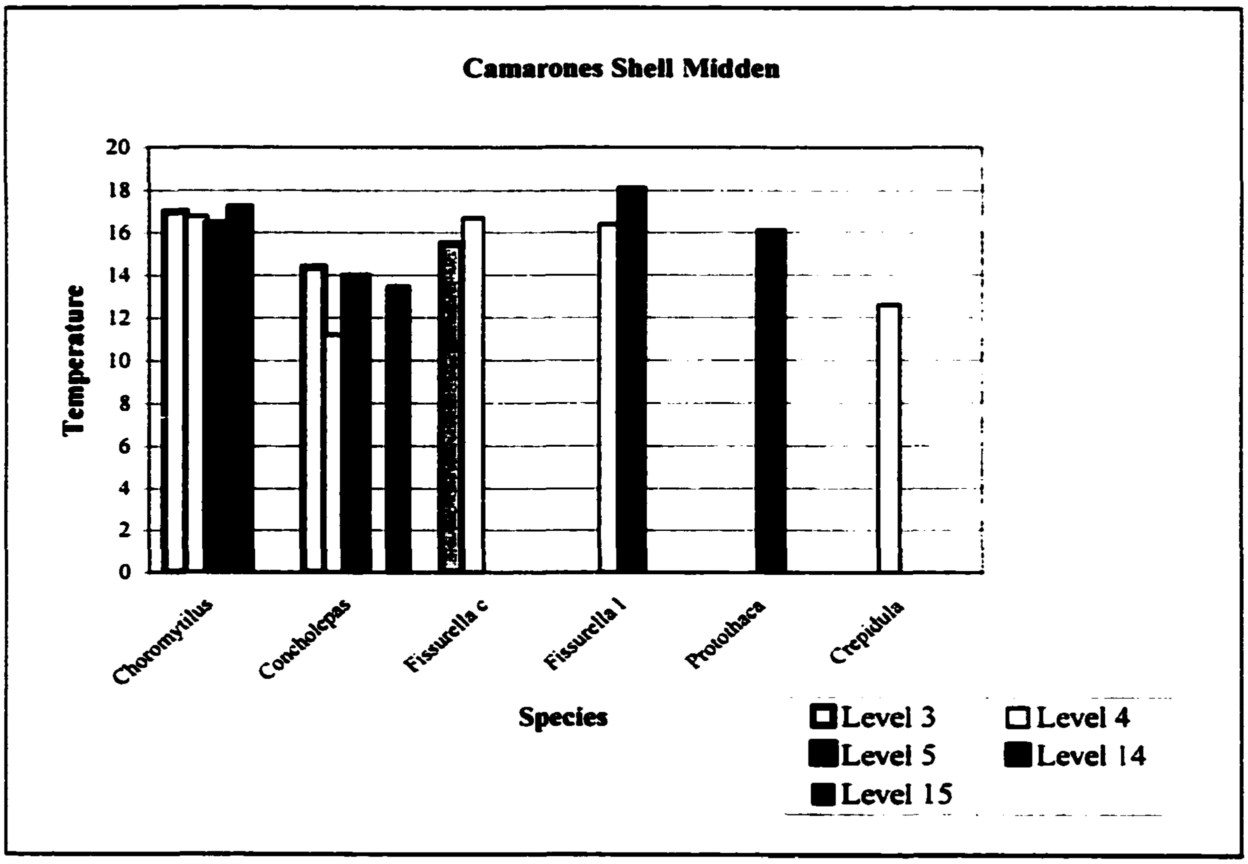


Figure 25. Temperature variations per species at Camarones using Grossman and Ku's (1986) regression formula.

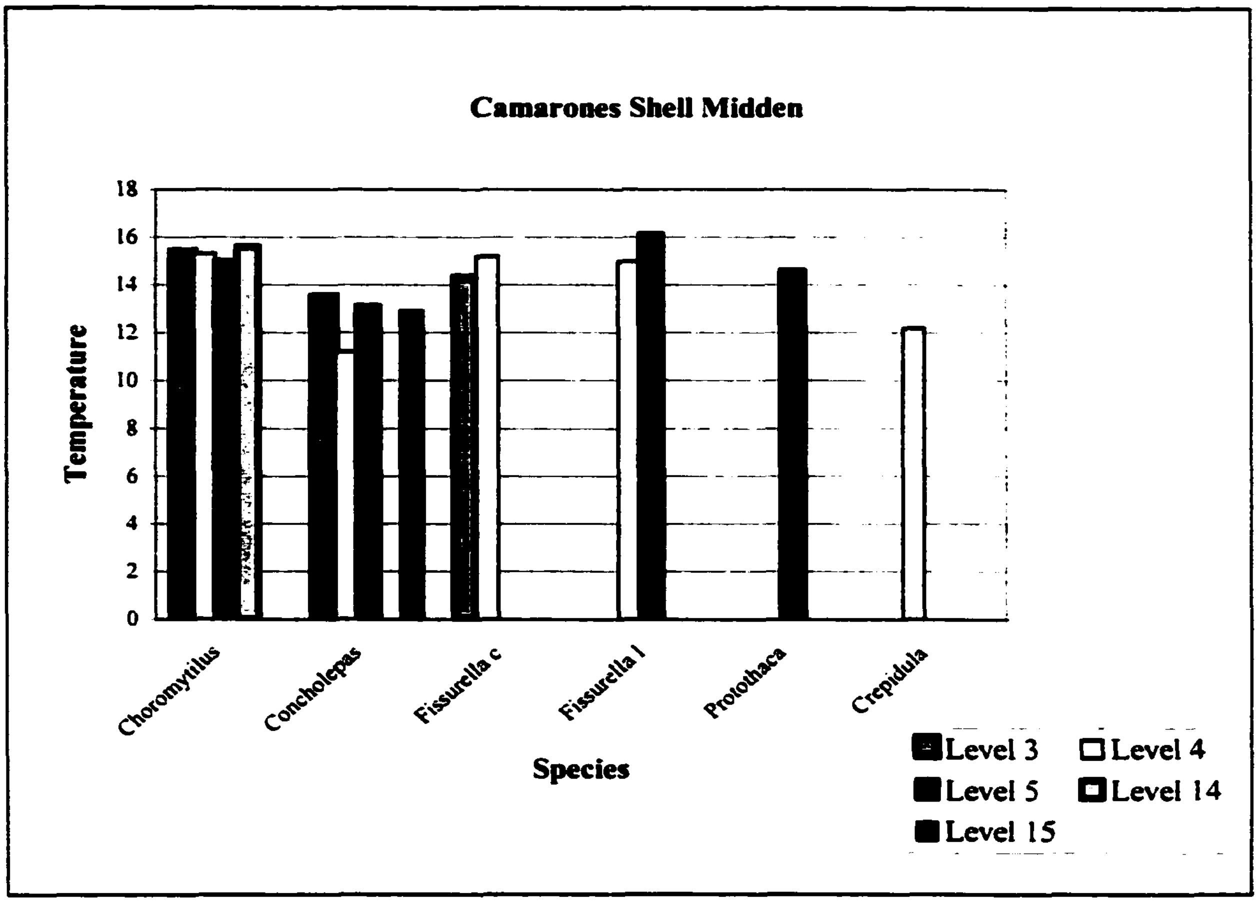


Figure 26. Temperature variation per species at Camarones using Brand and Morrison's (1987) regression formula.

Temperature variations within strata between different species was also examined and revealed that although there were differences within each stratum, these differences, in most cases, did not exceed 3°C. The following charts illustrate the point in case.

Figure 27 shows that in stratum 3, the species *Choromytilus chorus* ranks the highest in temperature, followed by *Fissurella crassa*, and last, *Concholepas concholepas*. The temperature difference between *Choromytilus* and *Concholepas* for both sets is less than 3°C.

Figure 28 shows that in stratum 4, the highest-ranking shell according to temperature is again *Choromytilus chorus*, followed closely by the *Fissurellids*, and lastly by *Concholepas*. Here again, temperature differences do not exceed 4°C for either set of temperatures.

Figure 29 indicates a slightly different trend showing the gastropod *Fissurella latimarginata* registering the highest temperature value, at 16.1 and 18°C. respectively. Both *Choromytilus* and the bivalve *Protothaca thaca* register similar temperature values, the former at 15 (T1) and 16.4°C (T2), and the latter at 14.6 (T1) and 16°C (T2).

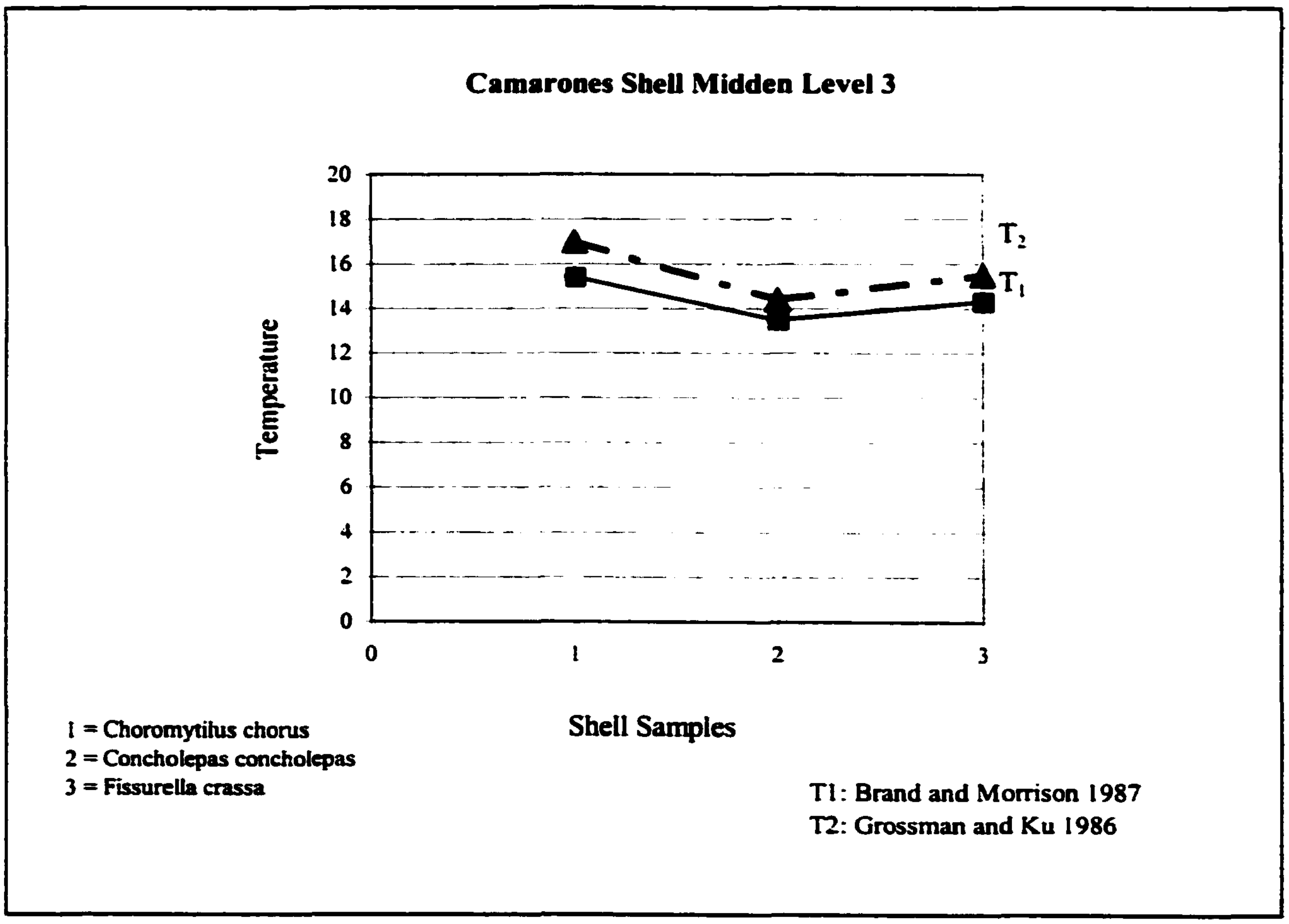


Figure 27. Comparison of temperature values per species, level 3, Camarones.

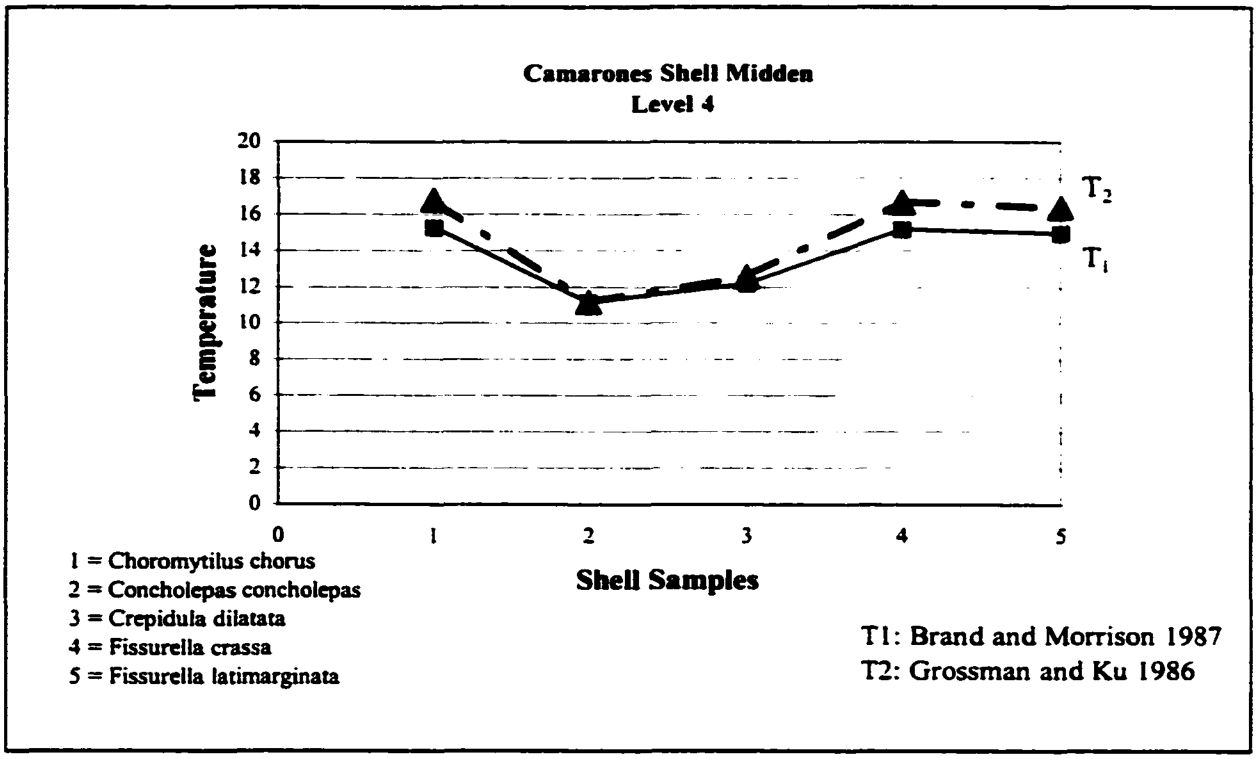


Figure 28. Comparison of temperature values per species, level 4, Camarones.

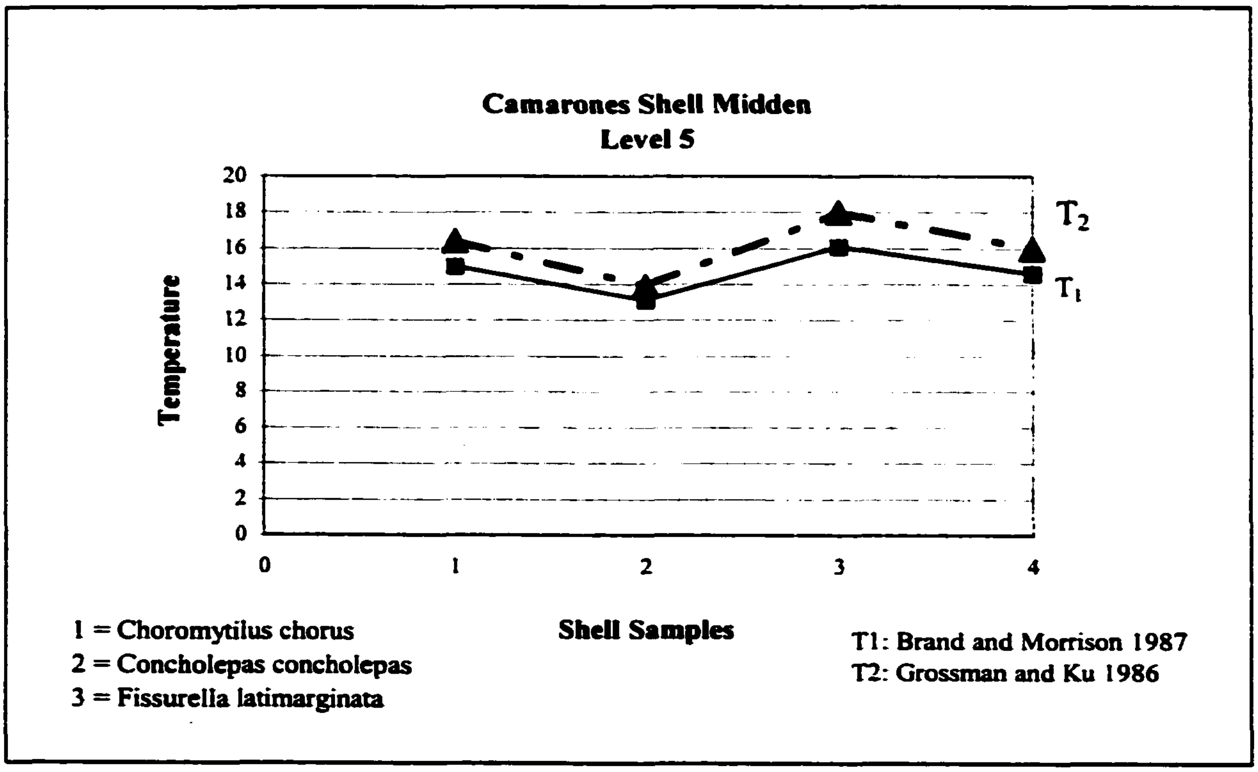


Figure 29. Comparison of temperature values per species, level 5, Camarones.

Concholepas continues the trend of registering the lowest temperature, at 13.1 (T1) and 13.9°C (T2). The temperature difference for the T1 values is 3°C, while for the T2 set the difference is slightly higher, at 4.1°C.

For levels 14 and 15 there was only one sample tested for each stratum, however, these continue to show the same trends in temperature as the upper levels. In level 14, the one species tested for ^{18}O was *Choromytilus*, and registered a temperature of 15.6 (T1) and 17.2°C (T2). In level 15, *Concholepas* continued its trend toward lower temperature values, registering at 12.9 (T1) and 13.5°C (T2).

The results from the ^{18}O analysis of both the Quiani shell midden and the modern samples seem to mirror the results of the Camarones analysis. Particularly in the case of the modern shells, when the season of collection was the late fall/early winter (May-June), the results of the ^{18}O analysis indicate that for each species there is a difference in temperature that has little to do with seasonal variance in temperature. In the modern control sample, the species *Concholepas c.* was noted as registering the lowest temperature, while the bivalve *Protothaca* and the gastropod *Fissurella* registered higher temperatures. These shells were collected on the same day, therefore indicating that the temperature values per species are influenced by factors other than season of the year.

For Quiani 1 there is only one date that is presently known, that of 6170 +/- 120 B.P. (Muñoz and Chacama 1982). Unfortunately the stratum that corresponds to this date is unknown. What is evident, however is that this site is older than the loci at the Camarones midden, by roughly 1,660 years. Quiani 1 corresponds to the Classic Chinchorro epoch, 6930-4750 B. P. This is important in establishing a chronological pattern of the usage of marine resources in this region.

The following tables summarize the ^{18}O analysis for the modern sample and for the site of Quiani 1. For Quiani 1, level 7 indicates the same basic pattern that the samples from Camarones followed, which is that *Concholepas c.* registers the lowest temperature. at 14.3°C (T1), while *Choromytilus* and *Protothaca t.* register highest, at 16.6 and 16.8°C (T1), respectively.

Table 12. Quiani 1 Oxygen Isotope and Temperature Values

Species	Level	Date	^{18}O	T1 (Celsius)	T2 (Celsius)
Protothaca thaca	1	unknown	-0.01	18.8	21.6
Concholepas concholepas	4	unknown	0.71	16.3	18.2
Fissurella sp.	5	unknown	0.74	16.2	18
Protothaca thaca	7	unknown	0.57	16.8	18.5
Choromytilus chorus	7	unknown	0.64	16.6	15.5
Concholepas concholepas	7	unknown	1.28	14.3	16.9
Fissurella sp.	7	unknown	0.98	15.3	18.8
Concholepas concholepas	8	unknown	1.29	14.3	15.5

The next table (Table 13), which contains the ^{18}O data for the modern control sample, is similar with two exceptions. The first is that there were no samples of *Choromytilus* due to the fact that the species has disappeared in recent years, reputedly due to the El Niño episode of 1982-83 (Tomicic 1985). The second exception is the actual temperature values themselves, which may have been affected by the rising sea surface temperatures due to the El Niño episode that occurred in South America in 1997. Aside from that, the patterns in temperature distribution remain consistent with both the Camarones shell midden and Quiani 1.

Table 13. Modern Control Sample Oxygen Isotope and Temperature Values

Species	Date	^{18}O	T1 (Celsius)	T2 (Celsius)
Concholepas concholepas	5/30/97	0.85	15.8	17.5
Fissurella maxima	5/30/97	-0.04	18.9	21.7
Fissurella sp.	5/30/97	0.27	17.8	20.3
Protothaca thaca	5/30/97	-0.34	19.9	23.1
Chlamys (Argopecten) purpuratus	5/30/97	1.46	13.7	14.7

For this sample, the lowest temperature registered was from *Argopecten purpuratus*, a type of scallop. There were no *Argopecten* samples from either Camarones or Quiani to compare with the modern sample, possibly due to the fact that *Argopecten* is found often in deeper subtidal waters (Abbot and Dance 1982), and therefore were not easily obtained by the prehistoric inhabitants of these sites. All other species exploited prehistorically were intertidal species.

The ^{18}O analysis for all three samples revealed that temperature values for individual species remained constant, following a similar pattern of distribution that was not directly associated to seasonal change. This indicates that for these set of data there is no support for the premise that utilization of resources in the prehistoric sites of Camarones and Quiani 1 was a year-round enterprise; at best, the results are inconclusive. This is not to say, however, that year-round exploitation of coastal resources at fixed loci did not occur. The data should be interpreted with caution because of the small sample size.

A major problem when working with oxygen isotope values of shells is that two or more shells may not produce the same quantity of isotope, even when the shells are from the same population and killed on the same day. Another contributing factor is the age of the mollusk itself. In older mollusks, several months, and even years are compacted at the edge of the margin, making the mollusk's last days difficult to determine. Thus, it is preferable to utilize younger adults rather than older ones.

Claassen (1998:150-151) recommends that in order to more accurately establish the season of death of a mollusk an individual life profile of each specimen must be made. To do this, several samples of shell material should be obtained from the umbo of the shell to the anterior margin of the shell. By plotting the isotope values of each sample a pattern of water temperatures that can be translated into years and seasons is created. This technique was not utilized in this study because the information was not available at the time the analysis was performed. In order to amass enough data to make this technique feasible, a sufficient number of specimens of each of the major species encountered at the archaeological midden must be collected, plus an individual life profile of each specimen for each species also must be created.

Shell Demography Results

Shell demography and size was used to test year-round occupancy of coastal site in northern Chile. The premise of this method is that within a shell midden site with an established stratigraphy, if site utilization had been consistently year-round, it would be reflected in the size classes of the shells. Over an extended period of time, it is conceivable that resources at that loci would slowly deteriorate, shellfish would not have the time to mature to the same degree as in earlier times which would be indicated by a decrease in shell size over time. Therefore, sizes of shells were measured in each stratum, and a mean shell size was obtained for each species in each of the strata.

The shell midden at Camarones was not suitable for this type of analysis because the shells extracted from the column samples were very fragmented. Therefore another site was used to test this idea. The middens at Quiani yielded very good specimens of whole shells for many species, and were consequently considered as a viable sample to test this hypothesis. The specimens that were used were derived from the sites of Quiani 1 and Quiani 9, where whole shells were abundant and records on the stratigraphy was adequate for this test. For Quiani 1 there were a total of 7 strata that contained shell material for testing. These strata were numbered 1-5, 7 and 8. Stratum 6 was not used because any information recorded was lost between the time the site was excavated by Bird and Mostny (1943), and the present. Many of the collections from this time period, in particular the malacological specimens, were not catalogued and had the original provenience tags from the first excavation. A catalogue was created in the summer of 1997, but many of the provenience tags were badly rotted and difficult to decipher. There was no provenience record for stratum 6, and thus was omitted from this analysis. For Quiani 9 there was a total of 10 strata, however there was information on only 6 of the strata, numbers 1-5 and 10. The results of the statistical analysis must be viewed with caution because of the gaps in the record for both of these sites.

The statistic that was used to compare the relationship between the level and the size of the shells was the Spearman's Correlation Coefficient for Ranked Data (r_s). The shells from the sites of Quiani 1 and 9 had previously been divided according to species and measured. An index of these measurements was created, and then ranked according to size from smallest to largest, and according to the stratum from which they were collected. The Spearman's, or rather the Pearson's r formula was applied to the ranked data in order to correlate the size index score with the stratum. The formula that was used was as follows:

$$r = \frac{N\Sigma XY-(\Sigma X)(\Sigma Y)}{\sqrt{(N\Sigma X^2-(\Sigma X)^2)(N\Sigma Y^2-(\Sigma Y)^2)}}$$

The strength of the covariance between the two variables, size of shells and stratum or level below ground surface, was indicated by a range of values from –1 to +1, the latter signifying that the deeper the stratum, the larger the shell size would be. This would be the optimal result of the statistical analysis. The following table discloses the results of the Spearman rho analysis for both Quiani 1 and 9:

Table 14. Spearman's rho Results for the Malacological Samples Quiani 1 and Quiani 9

Species	Spearman's rho Quiani 1	Spearman's rho Quiani 9
Aulacomya ater	0.2	-0.5
Concholepas concholepas	0.4	-0.66
Choromytilus chorus	-1	0
Crepidula dilatata	0	--
Fissurella crassa	0.4	0.6
Fissurella latimarginata	0.8	-0.4
Perumytilus purpuratus	--	0.1
Protothaca thaca	-0.4	-0.8
Tegula atra	-1	--

As indicated by the preceding table, there were no strong positive correlations between shell size and stratum, signifying that there was not a decrease in shell size over time. Instead, the size of the shells seems to fluctuate over time, rather than either increasing or decreasing (See Appendix). This could be interpreted in many ways, such as periodic intensification of exploitation, selective exploitation of certain caloric high yielding species, or other factors such as environmental disruptions like the El Niño phenomenon.

Once again, the data does not support the notion of intensification over time of the exploitation of resources. However, caution must be exercised when reviewing the data, for several reasons, the first and foremost being that the provenience of the specimens collected is dubious and had to be gleaned from the original provenience tags. These were very old and hard to read, and therefore might not be accurate. Also, as discussed previously, when studying a shell midden, it is important to consider that only a small portion of the midden has actually been studied due to the composition of the midden itself into discrete piles or heaps. In the case of Camarones, less than 2% of the entire site was sampled. Thus, when studying sites of the size of Quiani or Camarones, only a small portion of a much larger picture emerges. To gain a better understanding of the cycle of past activities, a much larger sample should be analyzed. In the case of Camarones, more of the heaps that constitute this enormous midden should be identified and sampled.

CHAPTER 6

CONCLUSIONS

The results of the study, as obtained from oxygen isotope analysis of samples from the Camarones and Quiani shell middens, did not yield supporting evidence for year-round occupancy of these sites. While the data were not entirely discouraging, more study is required to answer the question of residential permanence more concretely. Some temperature variability was observed between the different species of these samples, but not enough variability was noticed to support the hypothesis. The main variability was observed as occurring between different species, and not within any one species.

Temperature variability within same species of more than 5° +/- would have been a stronger indicator of year-round exploitation than variation between different species. This is because variation between different species is expected due to the fact that different species may not produce the same quantity of isotope, resulting in temperature discrepancies having little to do with seasonal changes.

The second component of the analysis of data dealing with shell demographics also fell short of supporting the notion of year-round occupancy of a site. While the shells were not from the Camarones shell midden locus, but to the suite of sites known as Quiani, it can be assumed that the inhabitants practiced the same type of subsistence.

The results of this study should not completely negate the notion of coastal sedentism or residential permanence of these sites. Other sources of evidence strongly favor this idea, such as the presence of formal cemeteries at many of the coastal sites, especially in the Camarones delta, where Chinchorro cemeteries have been found (Arriaza 1995). Chemical analysis of the mummy bones and the residual contents of stomach and intestines reveal that the Chinchorro diet consisted primarily of marine resources (Aufderheide 1993; Aufderheide and Allison 1992). A total of 62 Chinchorro mummies were sampled for strontium analysis, and revealed that 89% of the diet consisted of marine foods.

The practice of artificial mummification is in itself a time-consuming affair, which, if practiced for all segments of the population, including infants and fetuses, necessitates the involvement of full-time practitioners. During the preparation of a mummy, the person or persons involved would not be able to engage in subsistence activities, because of the lengthy preparation of not only the body, but of all materials used for mummification, including the ores and pigments used as the final steps of preparation for the mummy. Arriaza suggests that the mummy formed an integral part of the group, and was kept with the group for long periods of time, followed by periods of time where subsequent generations made repairs on mummies (Arriaza 1995:105). If later Andean traditions are consistent with much older traditions, then it is possible that the mummy was considered as part of the group, rather than separate from the group. If a group is mobile, having to carry even one mummy would hamper movement.

Kelly (1992) proposes that sedentism and residential mobility depend on an array of variables that are not all environmental. Cultural factors may also influence a group's decisions to settle down or move. Later Andean peoples, both coastal and inland, were tied to the landscape for a variety of reasons, many of which were subject to their cosmology. Both ancestral and nature spirits were thought to inhabit the landscape in various forms (Arriaza 1995:24, 133-134, 138). If these beliefs were derived from ancient sources, then it is possible to think of the mummy not only as a deceased member of the group, but also as a spiritual feature of the landscape that the group would naturally tie itself to.

Another reason to support residential permanence among the Chinchorro is the practice of maritime subsistence. While marine resources are abundant along the Pacific coast of Chile and Peru, an intense knowledge of not only the different organisms that inhabit coastal waters but also of the coastal environment are necessary in order to optimize food procurement. Knowledge of the rhythm of the tides and the seasons were essential to obtaining food. The cold Pacific waters tend to be very rough, especially during the winter months. The type of knowledge needed to efficiently exploit the various coastal resources would be a process that was gleaned from a lifetime's observation and involvement with the sea. High residential mobility, even if it were parallel to the coast, would not afford sufficient opportunity to obtain this knowledge.

Kelly (1992:) not only supports a spectrum of degrees of mobility and residential permanence, but also supports the multidimensionality of these as well. For instance, Hapke (1996) proposed that women were responsible for the preparation and elaboration of the group's mummies. If this were true, it may also be possible that women, and probably children, remained at fixed locations year-round, and men left for extended periods of time in search of complementary resources, such as sea lions and other marine mammals and large fish. Many Chinchorro sites are located in coastal wetlands, where access to multiple resources for food and other necessities are close at hand. If basic subsistence can be maintained by the procurement of shellfish, seaweed, birds and small mammals and reptiles, then it is very possible that women and children could have achieved residential permanence in these areas.

Regarding the other objectives of this study, of quantifying and determining the number of species harvested at Chinchorro sites, these were more easily accomplished and yielded the expected results. It has been determined that the practice of shellfish procurement has remained consistent in this area for many millennia, and the species that were exploited prehistorically remain the same that are exploited in the present (Table 15). The most prominent exceptions include the species *Choromytilus chorus*, a large mussel that has not been collected in this area since the El Niño episode of 1982-83, and *Argopecten (Chlamys) purpuratus*, a deep water scallop that was not found at Camarones at the time specimens were collected for this study. While *Argopecten* has been found in the archaeological record in northern Chile, it may not have been a dominant species because of the fact that it could only be obtained from waters deeper than ten meters (Abbot and Dance 1982; Wye 1991). Thus harvesting this species would have been hazardous without the more modern technologies employed today. In fact, *Argopecten* was not among the species found in the control sample collected by the divers for this study, who used techniques that may have been more in line with what the Chinchorro used.

Table 15. Malacological Species of the Extreme North of Chile, Prehistoric and Modern

Species Name	Common Name	Prehistoric	Modern
Acanthina sp.		+	-
Argopecten purpuratus	Purplish Scallop	-	+
Aulacomya ater	Black-ribbed Mussel	+	+
Calyptrea trochiformis	Peruvian Hat	+	+
Choromytilus chorus	Chorus Mussel	+	+
Collisella orbignyi	Limpet	+	+
Concholepas concholepas	Rock Barnacle	+	+
Crassilabrum crassilabrum	-	-	+
Crepidula dilatata	Dilated Slipper	+	+
Diloma nigerrima		+	-
Fissurella crassa	Keyhole Limpet	+	+
Fissurella latimarginata	Keyhole Limpet	+	+
Fissurella maxima	Keyhole Limpet	+	+
Glycemeris ovata	Bittersweet	-	+
Hiatella solida	-	-	+
Littorina peruviana	-	+	+
Macrocallista pannosa	Clam	-	+
Mesodesma donacium	Giant Wedge Clam	+	+
Oliva peruviana	Peruvian Olive	+	+
Perumytilus purpuratus	-	+	+
Priene ruda	-	-	+
Protothaca thaca	Thaca Venus Clam	+	+
Scurria viridula	Green Chilean Limpet	-	+
Scurria scurra		+	-
Scurria parasitica		+	-
	Sea Urchin	+	+
Semele solida	Solid Semele Clam	+	+
Semimytilus algosus	Mussel	+	+
Tegula atra	-	+	+
Tegula luctuosa		+	-
Thais chocolata	Chocolata Rock Shell	+	+
Thais haemastoma		+	-
Turritella cingulata	Banded Turritella	-	+

+ = present; - = absent

Recommendations For Future Research

The following is a list of recommendations for the future study of the Camarones shell midden and river delta:

a) A complete surface survey and mapping of the Camarones shell midden should be undertaken in order to identify the quantity and location of important features, such as discrete shell heaps, burials, etc.

b) Shell heaps at the Camarones shell midden should be sampled to conduct a cross-comparison of species and associated artifacts.

c) The stratigraphy and chronology of each heap should be recorded and compared.

d) Samples from the strata of each heap should be radiocarbon dated to get a better idea of the length of occupation and usage of the Camarones shell midden.

e) The terraces above the shell midden ascending the mountain parallel to the coast should be surveyed and mapped to ascertain the presence and types of sites.

f) Collection of live shell specimens should be conducted throughout the year, in order to gain a better understanding of the temperature cycles that are registered within the shell matrix year-round.

g) A mapping of a shell's life cycle should be conducted to optimize the results of oxygen isotope analysis, as recommended by Claassen (1998 150-151).

h) Ring growth analysis should be applied to specimens as a means of better understanding oxygen isotopic data.

APPENDIX I

DATA TABLES

Camarones Shell Midden Inventory

Date	Level	Material	Name/Species	Amount	Weight-gms	Measurements (lXw mm)**
7/5/97	3	shell	Choromytilus chorus	1v, mult. f.	66.36	99.5x50.0
"	3	"	Fissurella crassa	1v	7.66	50.5x30.5
"	3	"	Concholepas concholepas	2v, 1f	56.77	58.5x57.0/49.5x53.0
"	3	"	Crepidula dilatata	8	8.29	25.0x20.5/14.0x10.0
"	3	"	Thais sp.	9f	37.56	-
"	3	"	Scurria sp.	2	0.28	10.5x8.5
"	3	"	Perumytilus purpuratus	1v, 11f	4.49	30.0x15.5
"	3	"	Chiton	3f	4.54	-
"	3	"	Sea Urchin	11f	3.97	-
"	3	bone	-	4f	1.52	-
"	3	tooth	-	1	0.07	-
"	3	shell	Unknown species	1f	0.35	_
"	4	"	Choromytilus chorus	-	324.65	-
"	4	"	Fissurella latimarginata	1	11.7	56.0x34.5
"	4	"	Fissurella crassa	2v, 2f	92.54	41.0x24.5/39.0x22.0
"	4	"	Concholepas concholepas	2v, 3f	126.44	70.5x76.0/57.0x54.0
"	4	"	Crepidula dilatata	18v, 11f	47.88	33.5x31.0/15.0x12.0
"	4	"	Tegula luctuosa	1v	0.74	11.0x10.0
"	4	"	Tegula sp.	1f	1.35	-
"	4	"	Thais chocolata	1f	4.85	-
"	4	"	Scurria sp.	1v	0.27	13.5x10.0
"	4	"	Chiton	1f	0.89	-
"	4	"	Sea Urchin	6f	2.24	-
"	4	bone	tooth (not human)	1	-	-
7/5/97	5	shell	Choromytilus chorus	-	471.24	-
"	5	"	Fissurella crassa	1f	1.55	-
"	5	"	Concholepas concholepas	2f	8.74	-
"	5	"	Protothaca thaca	2f	5.67	-
"	5	"	Tegula atra	1v, 1f	12.09	24.0x23.5
"	5	"	Crepidula dilatata	8v, 3f	39.28	42.0x37.0/20.5x17.0
"	5	"	Choromytilus chorus	-	737.86	-
"	5	"	Crepidula dilatata	21v	16.86	32.0x24.5/5.0x4.0
"	5	"	Crassilabrum crassilabrum	1v	0.16	10.5x5.5
"	5	"	Fissurella sp.	-	8.78	-
-	5	bone	-	-	2.45	-
"	5	shell	Chiton	-	0.62	-
"	5	"	Sea Urchin	-	2.58	-

Date	Level	Material	Name/Species	Amount	Weight-gms	Measurements (lXw mm)**
"	5	bone	-	-	1.59	-
"	5	shell	Choromytilus chorus	-	609.35	-
"	5	"	Unknown univalve	2f	-	-
"	5	"	Fissurella crassa	1v	9.77	58.5x32.5
"	5	"	Concholepas concholepas	2v, 3f	23.94	36.0x36.0/35.0x38.5
"	5	"	Crepidula dilatata	19v	26.29	40.0x34.0/9.5x8.0
"	5	"	Crassilabrum crassilabrum	1	1.51	23.0x13.0
"	5	"	Unknown species	2f	3.77	-
"	5	"	Chiton	1f	0.79	-
"	5	bone	Otolith	1	0.2	-
"	5	shell	Sea Urchin	9f	1.44	-
"	5	bone	-	-	-	-
"	5	wood	-	-	-	-
"	5	shell	Choromytilus chorus	-	568.51	-
"	5	"	Concholepas concholepas	3v, 1f	68.01	62.0x79.0/40.5x45.0
"	5	"	Fissurella sp.	1 f	7.11	-
"	5	"	Tegula atra	2 v	14.59	27.5x27.5/25.0x24.0
"	5	"	Crepidula dilatata	14 v	82.47	40.5x37.0/15.58x11.5
"	5	"	Protothaca thaca	1f	0.63	-
"	5	"	Scurria sp.	1v	0.1	9.0x6.0
"	5	"	Chiton	2f	2.88	-
"	5	lithic/flake	-	1	2.88	-
"	5	shell	Choromytilus chorus	-	513.08	-
"	5	"	Concholepas concholepas	3v, 2f	47.72	48.5x57.5/42.5x45.5
"	5	"	Protothaca thaca	4f	21.04	-
"	5	"	Scurria viridula	1v	4.25	37.0x32.0
"	5	"	Tegula atra	1v	1.37	16.5x15.5
"	5	"	Thais sp.	1f	6.66	-
"	5	"	Crepidula dilatata	16v	124.8	43.5x39.0/25.0x19.5
"	5	shell	Choromytilus chorus	-	549.7	-
"	5	"	Fissurella crassa	2v	16.16	55.0x31.0/42.0x23.5
"	5	"	Fissurella latimarginata	1v, 2f	10.28	41.0x30.5
"	5	"	Fissurella sp.	6f	15.86	-
"	5	"	Concholepas concholepas	2v, 7f	34	50.0x58.5/28.0x34.0
"	5	"	Protothaca thaca	1v, 10f	32.11	40.0x48.0
"	5	"	Crepidula dilatata	3v	10.76	28.5x25.0/27.0x18.5
"	5	"	Scurria viridula	1v	2.9	30.5x24.5
"	5	"	Thais sp.	2f	10.36	-

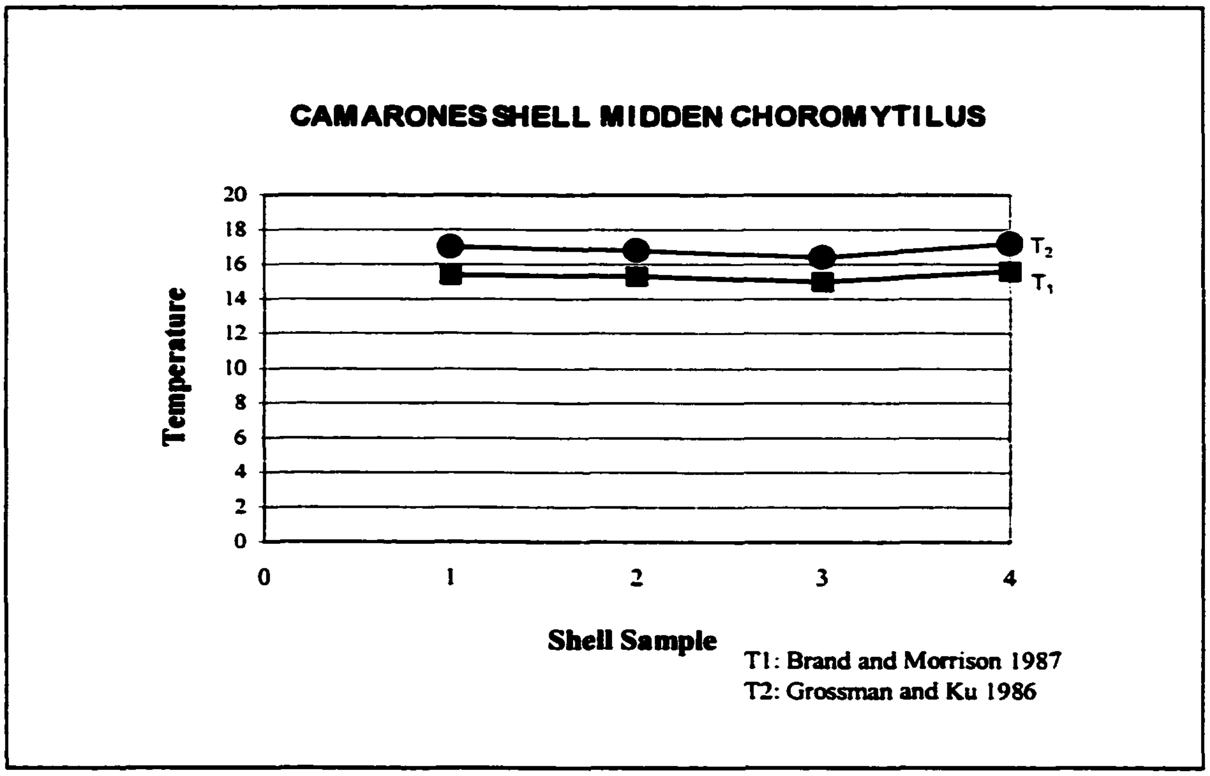
Date	Level	Material	Name/Species	Amount	Weight-gms	Measurements (lXw mm)**
"	5	"	Perumytilus purpuratus	1v	0.41	19.0x10.5
"	5	"	Chiton	7f	12.5	-
"	5	"	Tegula sp.	10f	9.88	-
"	5	bone	Crustacean	1f	2.25	-
"	5	bone	-	4f	1.59	-
"	5	"	Choromytilus chorus	-	554.56	-
"	5	"	Concholepas concholepas	1v, 3f	28.17	41.0x59.0
"	5	"	Fissurella latimarginata	1v	12.5	56.0x37.5
"	5	"	Fissurella sp.	9f	16.82	-
"	5	"	Crepidula dilatata	5	10.58	32.0x29.5/15.0x14.5
"	5	"	Protothaca thaca	1f	2.88	-
"	5	"	Tegula atra	1v, 3f	7.53	26.0x24.0
"	5	"	Choromytilus chorus	-	302.15	-
"	5	"	Fissurella sp.	6f	5.84	-
"	5	"	Concholepas concholepas	3f	3.9	-
"	5	"	Protothaca thaca	8f	14.42	-
"	5	"	Tegula atra	4f	7.32	-
"	5	"	Chiton	3f	4.68	-
"	5	"	Choromytilus chorus	-	350	-
"	5	"	Concholepas concholepas	3v,3f	37.5	48.5x52.5/32.536.5
"	5	"	Fissurella crassa	1	5.34	42.5x23.5
"	5	"	Fissurella sp.	1f	3.38	-
"	5	"	Protothaca thaca	8f	16.9	-
"	5	"	Crepidula dilatata	6	24.4	33.0x34.5/29.5x28.5
"	5	"	Tegula atra	6f	5.26	-
"	5	"	Scurria sp.	2	0.24	9.50x6.50
"	5	"	Chiton	5f	8.15	-
"	5	otoliths	-	2	0.3	-
"	5	projectile pt	-	1	1.17	21.0x09.0
"	5	bone	-	-	3.2	-
"	5	shell	Choromytilus chorus	-	448.7	-
"	5	"	Concholepas concholepas	2v,13f	44.06	41.0x44.0/360x44.5
"	5	"	Crepidula dilatata	3	4.5	24.5x17.5/17.0x13.0
"	5	"	Fissurella sp.	3f	2.91	-
"	5	"	Scurria viridula	1f	1.56	-
"	5	"	Protothaca thaca	10f	9.46	-
"	5	"	Tegula atra	3f	4.09	-

Date	Level	Material	Name/Species	Amount	Weight-gms	Measurements (lXw mm)**
"	5	"	Chiton	17f	23.05	-
"	5	burned bone	-	21f	7.16	-
"	5	otolith	-	1	0.11	-
"	14	shell	Choromytilus chorus	9v, mult. f	145.03	42.0x21.5 (smallest only)
"	14	"	Concholepas concholepas	3v, 2f	49.71	46.5x57.5/40.5x40.5
"	14	"	Protothaca thaca	1v	8.24	38.0x45.5
"	14	"	Crepidula dilatata	1v	1.33	26.5x21.5
"	14	shell	Choromytilus chorus	-	813.41	-
"	14	"	Protothaca thaca	1f	0.63	-
"	14	"	Crepidula dilatata	2v	1.03	16.5x14.5/13.0x14.0
"	14	"	Concholepas concholepas	1f	2.09	-
"	14	"	Tegula atra	1f	-	-
"	14	"	Chiton	1f	-	-
"	14	"	Sea Urchin	1f	-	-
"	14	tooth	unknown	1	-	-
"	14	shell	Choromytilus chorus	-	720.4	-
"	14	"	Fissurella sp.	1f	7.58	-
"	14	"	Concholepas concholepas	1f	5.05	-
"	14	"	Chiton	4f	7.34	-
"	14	lithic/flake	-	2	11.03	-
"	14	bone	-	2f	0.25	-
"	14	shell	Choromytilus chorus	-	750.06	-
"	14	"	Concholepas concholepas	1f	2.38	-
"	14	"	Perumytilus purpuratus	1v	1.36	32.5x15.5
"	14	"	Tegula luctuosa	1v	0.98	12.0x10.5
"	14	burned bone	-	-	2	-
"	14	shell	Unidentified Univalve	2f	0.19	-
"	14	shell	Choromytilus chorus	-	840.97	-
"	14	"	Fissurella sp.	1f	3.7	
"	14	"	Choromytilus chorus	-	786.14	-
"	14	"	Concholepas concholepas	3f	8.38	-
"	14	"	Tegula sp.	1f	1.65	-
"	14	"	Protothaca thaca	1f	1.3	-
"	14	"	Crepidula dilatata	1f	0.32	
"	14	"	Chiton	2f	2.59	-
"	14	"	Fissurella latimarginata	1f	1.3	-
"	15	shell	Choromytilus chorus	-	162.61	-
"	15	shell	Concholepas concholepas	7f	13.9	-
"	15	shell	Tegula sp. (possibly atra)	2f	2.74	-
"	15	shell	Chiton	1f	3.75	-

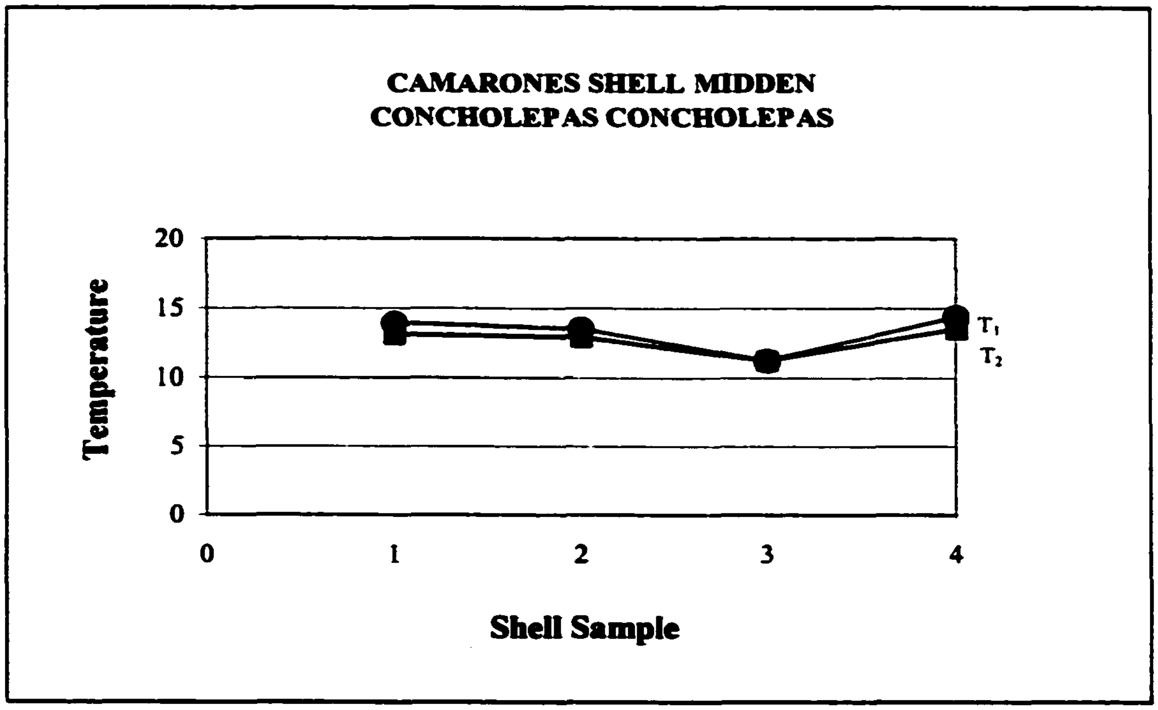
Camarones Oxygen Isotope Data

SPECIES	^{18}O	T1(°C)	T2(°C)	LEVEL	DATE
Choromytilus chorus	0.96	15.4	17	3	3624 +/- 64 B.P.
Concholepas concholepas	1.52	13.5	14.4	3	3624 +/- 64 B.P.
Fissurella crassa	1.29	14.3	15.5	3	3624 +/- 64 B.P.
Choromytilus chorus	1.01	15.3	16.8	4	unknown
Concholepas concholepas	2.2	11.2	11.2	4	unknown
Crepidula dilatata	1.9	12.2	12.6	4	unknown
Fissurella crassa	1.0[illegible]	15.2	16.7	4	unknown
Fissurella latimarginata	1.1	15	16.4	4	unknown
Choromytilus chorus	1.09	15	16.4	5	4150 +/- 73 B.P.
Concholepas concholepas	1.63	13.1	13.9	5	4150 +/- 73 B.P.
Fissurella latimarginata	0.76	16.1	18	5	4150 +/- 73 B.P.
Protothaca thaca	1.19	14.6	16	5	4150 +/- 73 B.P.
Choromytilus chorus	0.93	15.6	17.2	14	unknown
Concholepas concholepas	1.71	12.9	13.5	15	4510 +/- 67 B.P.

Camarones Shell Midden Comparison of Temperature Values, *Choromytilus chorus*



Camarones Shell Midden Comparison of Temperature Values, *Concholepas concholepas*



Quiani 1 Shell Midden

SPECIES	LEVEL	AMOUNT	WEIGHT*	LXW (LARGEST)**	LXW (SMALLEST) **
Aulacomya ater	1	4v	130.88	67.5 x 38.5	52.5 x 28.5
Aulacomya ater	1	3v	24.78	70.5 x 35.0	61.0 x 32.5
Choromytilus chorus	1	15f	111.89	-	
Choromytilus chorus	1	2f	34.61	-	-
Choromytilus chorus	1	1f	6.74	-	-
Concholepas concholepas	1	1v, 1f	11.49	31.0 x 40.0	-
Concholepas concholepas	1	5v	102.43	44.5 x 53.0	-
Concholepas concholepas	1	8v	60.46	49.0 x 51.0	-
Crepidula dilatata	1	1v	0.29	12.5 x 11.0	-
Diloma nigerrima	1	1v	1.13	13.5 x 11.5	-
Fissurella crassa	1	1v	5.8	46.0 x 25.0	-
Fissurella crassa	1	1v	2.72	35.0 x 19.5	-
Fissurella latimarginata	1	1v	8.26	47.5 x 29.5	-
Perumytilus purpuratus	1	3v	5.23	34.0 x 17.0	25.5 x 12.0
Perumytilus purpuratus	1	10v	18.85	32.0 x 14.0	27.0 x 15.0
Protothaca thaca	1	9v, 8f	230.38	62.5 x 73.0	39.0 x 42.0
Protothaca thaca	1	5v	67.81	46.0 x 55.0	41.0 x 50.0
Semimytilus alghosus	1	2v	2.32	34.0 x 16.0	28.5 x 14.0
Tegula atra	1	1f	2.57	-	-
Thais sp	1	5f	50.06	-	-
Calyptrea trochiformis	2	1v	0.69	-	-
Choromytilus chorus	2	3f	21.29	-	-
Choromytilus chorus	2	8f	37.79	-	-
Concholepas concholepas	2	13v	107.79	45.5 x 55.5	23.5 x 27.0
Crepidula dilatata	2	6v	18.95	34.5 x 32.5	25.0 x 22.5
Crepidula dilatata	2	5v	27.04	34.5 x 35.0	27.0 x 22.0
Crepidula dilatata	2	1v	2.89	29.0 x 25.5	-
Fissurella crassa	2	5v	27.38	54.5 x 30.5	37.0 x 19.5
Fissurella latimarginata	2	1v	2.38	30.5 x 19.5	-
Oliva peruviana	2	1v	4.37	30.5 x 15.0	-
Perumytilus purpuratus	2	26v	30.11	32.0 x 18.5	18.5 x 10.5
Protothaca thaca	2	2f	9.21	-	-
Protothaca thaca	2	1v	31.07	54.5 x 62.0	-
Thais sp	2	3v	23.74	42.0 x 28.5	-
Calyptrea trochiformis	3	1v	3.23	26.0 x 23.5	
Choromytilus chorus	3	14f	92.96	-	
Choromytilus chorus	3	19f	111.35	-	-
Choromytilus chorus	3	104f	260.26	-	-
Choromytilus chorus	3	51f	112.15	-	-
Concholepas concholepas	3	6v	183.84	70.0 x 76.5	
Concholepas concholepas	3	12v, 8f	101	51.5 x 55.5	37.0 x 40.0

SPECIES	LEVEL	AMOUNT	WEIGHT*	LXW (LARGEST)**	LXW (SMALLEST) **
Concholepas concholepas	3	8v, 5f	191.84	52.0 x 59.5	37.5 x 40.5
Concholepas concholepas	3	1v	81.83	77.5 x 83.5	-
Crepidula dilatata	3	4v	21.1	36.5 x 32.5	20.0 x 28.0
Crepidula dilatata	3	3v	10.21	25.0 x 34.5	17.5 x 21.5
Fissurella crassa	3	1v	5.58	42.5 x 24.0	
Fissurella crassa	3	2v	9.56	47.0 x 27.5	36.5 x 20.5
Fissurella crassa	3	1v	3.05	38.0 x 21.0	-
Fissurella latimarginata	3	3v	14.56	47.0 x 30.5	22.5 x 12.5
Fissurella latimarginata	3	1v	1.36	25.0 x 14.5	-
Fissurella latimarginata	3	2v	6.95	-	-
Protothaca thaca	3	1v	9.61	-	
Protothaca thaca	3	2v, 5f	34.91	40.5 x 47.5	32.5 x 36.0
Protothaca thaca	3	4f	7.72	-	-
Tegula atra	3	1v	1.3	16.5 x 14.5	-
Choromytilus chorus	4	2f	9.09	-	-
Concholepas concholepas	4	10v	173.82	78.0 x 70.0	32.0 x 35.0
Crepidula dilatata	4	2v	15.13	4.0 x 29.5	29.5 x 28.0
Fissurella sp.	4	1f	1.58	-	-
Oliva peruviana	4	2v	4.26	20.5 x 11.0	17.0 x 9.0
Perumytilus purpuratus	4	11v	16.73	30.5 x 15.0	17.0 x 12.0
Protothaca thaca	4	1f	9.36	-	-
Thais chocolata	4	4v, 1f	82.19	-	-
Thais haemastoma	4	1v	1.99	24.0 x 13.0	-
Unknown univalve	4	1v	12.36	49.5 x 2.45	-
Aulacomya ater	5	1f	9.39	-	
Calyptrea trochiformis	5	1v	17.85	50.5 x ?	
Calyptrea trochiformis	5	2v	33.54	47.0 x 40.0	39.0 x 37.5
Choromytilus chorus	5	2v	36.71	-	
Choromytilus chorus	5	7f	65.51	-	-
Choromytilus chorus	5	1f	9.16	-	-
Concholepas concholepas	5	22v	668.78	77.0 x 56.0	
Concholepas concholepas	5	11v	286.56	72.5 x 75.0	34.5 x 46.5
Concholepas concholepas	5	2v	24.56	42.0 x 46.5	-
Crepidula dilatata	5	1v	8.07	39.5 x 33.5	
Crepidula dilatata	5	2v	14.9	37.5 x 31.5	37.5 x 30.5
Fissurella crassa	5	1v	4.45	40.5 x 24.0	
Fissurella crassa	5	1v	2.43	31.0 x 16.0	-
Fissurella latimarginata	5	9v	56.46	52.5 x 33.5	
Fissurella latimarginata	5	5v	37.08	53.5 x 33.5	41.5 x 24.5
Perumytilus purpuratus	5	41	92.58	36.6 x 20.0	
Perumytilus purpuratus	5	34v	66.61	38.5 x 19.0	24.5 x 15.5
Perumytilus purpuratus	5	1v	1.7	30.0 x 17.5	-
Scurria parasitica	5	1v	0.18	12.0 x 8.0	
Tegula atra	5	4v	27.98	32.5 x 30.05	

SPECIES	LEVEL	AMOUNT	WEIGHT*	LXW (LARGEST)**	LXW (SMALLEST) **
Tegula atra	5	7	20.2	27.5 x 27.0	14.5 x 13.0
Thais chocolata	5	2v	65.98	-	
Thais chocolata	5	7f	211.11	-	-
Thais chocolata	5	2v	54.23	-	-
Thais haemastoma	5	1f	5.82	-	-
Aulacomya ater	7	4v	40.93	76.0 x 45.0	
Choromytilus chorus	7	1v, 6 f	123.24	127.1 x 56.10	-
Choromytilus chorus	7	1v, 5f	205.7	149.0 x 61.5	-
Concholepas concholepas	7	17v	517.08	59.5 x 64.0	46.0 x 53.0
Concholepas concholepas	7	28v, 3f	941.46	69.0 x 85.0	36.5 x 44.0
Crepidula dilatata	7	2v	10.43	34.0 x 30.5	
Crepidula dilatata	7	1v	23.34	57.0 x 52.0	-
Fissurella crassa	7	1v	4.98	42.0 x 22.5	-
Fissurella crassa	7	3v	10.93	46.0 x 26.5	33.5 x 17.5
Fissurella latimarginata	7	7v	53.69	52.0 x 33.5	31.5 x 19.5
Fissurella maxima	7	4v	85.54	74.0 x 43.5	-
Fissurella sp.	7	1v	19.67	64.5 x 33.5	-
Perumytilus purpuratus	7	5v	8.36	30.30 x 17.0	
Protothaca thaca	7	3v	131.67	72.0 x10.0	-
Protothaca thaca	7	2v	19.44	44.0 x 52.0	30.5 x 35.0
Tegula atra	7	9v	43.94	35.5 x 35.5	
Tegula luctuosa	7	1v	1.8	19.9 x 17.5	
Thais chocolata	7	6v	184.6	60.5 x 46.0	
Thais haemastoma	7	9v	42.75	35.6 x 23.7	
Aulacomya ater	8	1v	8.9	66.0 x 36.0	-
Choromytilus chorus	8	10f	118.09	-	-
Concholepas concholepas	8	1v	1.27	22.0 x 20.0	-
Concholepas concholepas	8	40v	1270.41	100.0 x 107.5	28.5 x 33.0
Crepidula dilatata	8	3v	11.43	35.0 x 30.0	20.5 x 17.5
Crepidula dilatata	8	2v	33.9	49.5 x 44.0	42.0 x 36.0
Fissurella crassa	8	4v	14.5	42.0 x 24.0	33.0 x 19.0
Fissurella latimarginata	8	8v	66.94	57.5 x 35.0	32.5 x 19.5
Fissurella maxima	8	3v	50.6	80.0 x 50.5	36.5 x 22.5
Perumytilus purpuratus	8	7v	17.13	35.0 x 20.0	28.0 x 15.0
Protothaca thaca	8	2v, 1f	50.38	55.0 x 65.0	47.0 x 55.0
Tegula atra	8	4v	9.43	19.5 x 19.5	17.5 x 17.0
Thais chocolata	8	5v	146.84	58.0 x 44.0	-
Thais haemastoma	8	7v	75.13	36.5 x 27.5	36.0 x 23.0
Choromytilus chorus	-	50+v	288.46	-	-
Choromytilus chorus	-	10f	46.18	-	-
Concholepas concholepas	-	21v	403.84	74.0 x 77.0	34.0 x 36.0
Concholepas concholepas	-	24v	514.87	62.0 x 69.5	36.5 x 38.0
Crepidula dilatata	-	8v	31.87	39.0 x 35.0	22.5 x 21.0
Crepidula dilatata	-	2	14.17	33.0 x 39.0	18.0 x 21.0

SPECIES	LEVEL	AMOUNT	WEIGHT*	LXW (LARGEST)**	LXW (SMALLEST) **
Diloma nigerrima	-	1v	1.49	16.0 x 14.5	-
Donacium peruviana	-	2v	2.39	13.5 x 24.5	
Fissurella crassa	-	-	13.51	43.5 x 26.5	33.0 x 19.5
Fissurella crassa	-	1v	4.19	40.5 x 22.0	-
Fissurella latimarginata	-	4v	19.48	45.0 x 27.0	16.0 x 9.5
Fissurella latimarginata	-	3v	16.44	44.5 x 26.0	40.5 x 27.5
Perumytilus purpuratus	-	16v	39.7	38.5 x 21.0	23.0 x 14.5
Protothaca thaca	-	6	31.34	37.0 x 44.0	30.0 x 36.5
Tegula atra	-	2	5.69	25.0 x 25.0	13.0 x 12.1
Thais chocolata	-	9f	248.99	-	-
Choromytilus chorus	hearth	6f	12.37	-	-
Concholepas concholepas	hearth	3V, 1F	47.01	45.0 X 53.5	28.5 X 33.0
Fissurella crassa	hearth	1f	6.83	43.5 x 28.5	-
Fissurella latimarginata	hearth	1f	4.09	-	-
Fissurella maxima	hearth	1v	24.8	80.5 x 45.0	-
Perumytilus purpuratus	hearth	22v	32.91	34.5 x 20.5	20.0 x 12.5
Protothaca thaca	hearth	4f	15.46	-	-
Thais chocolata	hearth	3f	49	-	-

Quiani 1 Oxygen Isotope Data

SPECIES	^{18}O	*T1°(C)	T2(°C))	LEVEL	DATE
Protothaca thaca	-0.01	18.8	21.6	1	~4000-6000 B.P.
Concholepas concholepas	0.71	16.3	18.2	4	~4000-6000 B.P.
Fissurella sp.	0.74	16.2	18	5	~4000-6000 B.P.
Choromytilus chorus	0.64	16.6	18.5	7	~4000-6000 B.P.
Concholepas concholepas	1.28	14.3	15.5	7	~4000-6000 B.P.
Fissurella sp.	0.98	15.3	16.9	7	~4000-6000 B.P.
Protothaca thaca	0.57	16.8	18.8	7	~4000-6000 B.P.
Concholepas concholepas	1.29	14.3	15.5	8	~4000-6000 B.P.

Quiani 1 Index Scores

Concholepas concholepas

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1	1	53	51	1	103.92
2	6	44.07	39	6	113
3	5	57.5	51.62	5	111.39
4	2	49.9	47.3	2	105.49
5	3	54.79	50.88	3	107.68
7	4	57.1	51.73	4	110.38
8	7	56.71	50.15	7	113.08

Tegula atra

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
5		24.25	25.62	2	94.65
7		20.71	21.57	1	96.01

Protothaca thaca

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		55.03	46.19	3	119.13
3		47.5	40.5	2	117.28
7		78.5	60.66	4	129.64
8		51.75	44.75	1	115.64

Aulacomya ater

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		31.87	59.37	1	53.68
5		38	67	4	56.71
7		40.5	72.83	3	55.6
8		36	66	2	54.54

Fissurella latimarginata

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		29.5	47.5	2	62.1
2		19.5	30.5	3	63.93
3		14.5	25	1	58
5		28.27	44.05	4	64.17
7		23.83	36	6	66.19
8		33.16	50.66	5	65.45

Fissurella crassa

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		25	46	1	54.34
2		24.3	42.9	6	56.64
3		21	38	2	55.26
5		20	35.75	4	55.94
7		21.75	39	3	55.76
8		22.66	40.5	5	55.95

Choromytilus chorus

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
7		57	129	2	44.18
8		61	146	1	41.78

Crepidula dilatata

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
3		28.5	31	3	91.93
5		33.5	39.5	1	84.81
7		29	31.5	4	92.06
8		35.83	41.83	2	85.65

Quiani 1 Pearson's r Correlation Coefficient for Ranked Data

RANK w/ Substitution ***Concholepas concholoepas***

N	X	Y	X2	Y2	XY
7	1	1	1	1	1
	2	6	4	36	12
	3	5	9	25	15
	4	2	16	4	8
	5	3	25	9	15
	6	4	36	16	24
	7	7	49	49	49
SIGMA	28	28	140	140	124
SIGMA X/Y2	784	784			
Pearson	0.428571429				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
7	1	103.92	1	10799.37	103.92
	2	113	4	12769.00	226.00
	3	111.39	9	12407.73	334.17
	4	105.49	16	11128.14	421.96
	5	107.68	25	11594.98	538.40
	6	110.38	36	12183.74	662.28
	7	113.08	49	12787.09	791.56
SIGMA	28	764.94	140	83670.05	3078.29
SIGMA X/Y2	784	585133.2036			
Pearson	0.39251463				

RANK w/ Substitution ***Tegula atra***

N	X	Y	X2	Y2	XY
2	1	2	1	4	2
	2	1	4	1	2
SIGMA	3	3	5	5	4
SIGMA X/Y2	9	9			
Pearson	-1				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
2	1	94.65	1	8958.62	94.65
	2	96.01	4	9217.92	192.02
SIGMA	3	190.66	5	18176.54	286.67
SIGMA X/Y2	9	36351.2356			
Pearson	1				

RANK w/ Substitution ***Protothaca thaca***

N	X	Y	X2	Y2	XY
4	1	3	1	9	3
	2	2	4	4	4
	3	4	9	16	12
	4	1	16	1	4
SIGMA	10	10	30	30	23
SIGMA X/Y2	100	100			
Pearson	-0.4				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	119.13	1	14191.96	119.13
	2	117.28	4	13754.60	234.56
	3	129.64	9	16806.53	388.92
	4	115.64	16	13372.61	462.56
SIGMA	10	481.69	30	58125.69	1205.17
SIGMA X/Y2	100	232025.2561			
Pearson	0.038679438				

RANK w/ Substitution ***Aulacomya ater***

N	X	Y	X2	Y2	XY
4	1	1	1	1	1
	2	4	4	16	8
	3	3	9	9	9
	4	2	16	4	8
SIGMA	10	10	30	30	26
SIGMA X/Y2	100	100			
Pearson	0.2				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	53.68	1	2881.54	53.68
	2	56.71	4	3216.02	113.42
	3	55.6	9	3091.36	166.80
	4	54.54	16	2974.61	218.16
SIGMA	10	220.53	30	12163.54	552.06
SIGMA X/Y2	100	48633.4809			
Pearson	0.14459269				

RANK w/ Substitution ***Fissurella latimarginata***

N	X	Y	X2	Y2	XY
6	1	2	1	4	2
	2	3	4	9	6
	3	1	9	1	3
	4	4	16	16	16
	5	6	25	36	30
	6	5	36	25	30
SIGMA	21	21	91	91	87
SIGMA X/Y2	441	441			
Pearson	0.771428571				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
6	1	62.1	1	3856.41	62.10
	2	63.93	4	4087.04	127.86
	3	58	9	3364.00	174.00
	4	64.17	16	4117.79	256.68
	5	66.19	25	4381.12	330.95
	6	65.45	36	4283.70	392.70
SIGMA	21	379.84	91	24090.06	1344.29
SIGMA X/Y2	441	144278.4256			
Pearson	0.53724805				

RANK w/ Substitution ***Fissurella crassa***

N	X	Y	X2	Y2	XY
6	1	1	1	1	1
	2	6	4	36	12
	3	2	9	4	6
	4	4	16	16	16
	5	3	25	9	15
	6	5	36	25	30
SIGMA	21	21	91	91	80
SIGMA X/Y2	441	441			
Pearson	0.371428571				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
6	1	54.34	1	2952.84	54.34
	2	56.64	4	3208.09	113.28
	3	55.26	9	3053.67	165.78
	4	55.94	16	3129.28	223.76
	5	55.76	25	3109.18	278.80
	6	55.95	36	3130.40	335.70
SIGMA	21	333.89	91	18583.46	1171.66
SIGMA X/Y2	441	111482.5321			
Pearson	0.41785528				

RANK w/ Substitution *Choromytilus chorus*

N	X	Y	X2	Y2	XY
2	1	2	1	4	2
	2	1	4	1	2
SIGMA	3	3	5	5	4
SIGMA X/Y2	9	9			
Pearson	-1				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
2	1	44.18	1	1951.87	44.18
	2	41.78	4	1745.57	83.56
SIGMA	3	85.96	5	3697.44	127.74
SIGMA X/Y2	9	7389.1216			
Pearson	-1				

RANK w/ Substitution *Crepidula dilatata*

N	X	Y	X2	Y2	XY
4	1	3	1	9	3
	2	1	4	1	2
	3	4	9	16	12
	4	2	16	4	8
SIGMA	10	10	30	30	25
SIGMA X/Y2	100	100			
Pearson	0				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	91.93	1	8451.12	91.93
	2	84.81	4	7192.74	169.62
	3	92.06	9	8475.04	276.18
	4	85.65	16	7335.92	342.60
SIGMA	10	354.45	30	31454.83	880.33
SIGMA X/Y2	100	125634.8025			
Pearson	-0.381586766				

PRESENCE OF SHELLS PER LEVEL								
SPECIES	LEVEL							
	1	2	3	4	5	6	7	8
Aulacomya ater	x	-	-	-	x	-	x	x
Calyptrea trochiformis	-	x	x	-	x	-	x	-
Choromytilus chorus	x	x	x	x	x	-	x	x
Concholepas concholepas	x	x	x	x	x	-	x	x
Crepidula dilatata	x	x	x	x	x	-	x	x
Fissurella crassa	x	x	x	-	x	-	x	x
Fissurella latimarginata	x	x	x	-	x	-	x	x
Fissurella maxima	-	-	-	-	-	-	x	x
Oliva peruviana	-	x	-	x	-	-	-	-
Perumytilus purpuratus	x	x	-	x	x	-	x	x
Protothaca thaca	x	x	x	x	-	-	x	x
Tegula atra	x	-	x	-	x	-	x	x
Thais chocolata	-	-	-	x	x	-	x	x
Thais haemastoma	-	-	-	x	x	-	x	x

Quiani 9 Shell Midden

SPECIES	STR/LVL	QUANTITY	WEIGHT	LXW (LARGEST)	LXW (SMALLEST)
Choromytilus chorus	1	5v, 50f-		120.0 x x57.0	95.5 x 44.5
Concholepas concholepas	1	11v	292.22	56.5 x 74.0	16.5 x x19.0
Fissurella crassa	1	1v	7.91	-	-
Fissurella latimarginata	1	3v	36.84	55.0 x 38.5	-
Fissurella maxima	1	1v	13.11	63.5 x36.0	-
Perumytilus purpuratus	1	1v, 1f	3.37	31.0 x 16.5	-
Protothaca thaca	1	7v	129.35	69.5 x 88.5	35.5 x 44.5
Tegula atra	1	2v	17.15	-	-
Aulacomya ater	2	1v	2.07	37.0 x 22.5	-
Aulacomya ater	2	1v	3.7	47.0 x 26.5	-
Calyptrea trochiformis	2	1v	4.18	32.5 x 28.5	-
Choromytilus chorus	2	4f	64.44	-	-
Choromytilus chorus	2	1f	1.67	-	-
Choromytilus chorus	2	18f	182.09	-	-
Choromytilus chorus	2	1, 7f	63.43	120.0 x 49.0	-
Colisella orbyngi	2	1v	0.23	12.0 x 8.5	-
Concholepas concholepas	2	19v	361.62	58.5 x 74.5	29.5 x 32.5
Concholepas concholepas	2	11v	389.17	58.0 x 59.5	40.5 x 52.0
Concholepas concholepas	2	13v, 2f	512.25	65.5 x 81.5	35.5 x 40.5
Crepidula dilatata	2	16v	42.36	37.0 x 32.5	19.5 x 14.5
Fissurella crassa	2	1v	5.31	45.5 x 25.0	-
Fissurella crassa	2	2v	7.74	42.5 x 22.0	-
Fissurella crassa	2	2v	9.54	44.0 x 24.0	40.0 x 22.0
Fissurella latimarginata	2	4v	23.59	47.5 x 30.5	38.5 x 18.5
Fissurella latimarginata	2	1v	2.43	33.0 x 18.5	-
Fissurella latimarginata	2	6v	25.31	48.0 x 29.5	20.5 x 10.5
Fissurella maxima	2	1v	1.87	34.5 x 13.5	-
Perumytilus purpuratus	2	2v	4.74	32.0 x 20.5	30.5 x 17.0
Perumytilus purpuratus	2	1v, 1f	2.87	28.5 X 17.0	-
Protothaca thaca	2	9v	181.11	66.5 x 84.5	35.5 x 44.5
Protothaca thaca	2	3v, 3f	16.51	24.0 x 28.5	
Scurria scurra	2	1v	1.12	-	-
Tegula atra	2	1v	10.58	-	-
Aulacomya ater	3	1v	4.35	52.0 x 30.5	-
Aulacomya ater	3	1v	3.2	45.0 x 24.5	-
Calyptrea trochiformis	3	1v	0.96	15.0 x 16.0	-
Calyptrea trochiformis	3	2v	16.08	42.0 x 41.0	32.5 x 32.5
Choromytilus chorus	3	11v, 3f	126.24	106.0 x 52.5	30.5 x 36.5
Choromytilus chorus	3	1v	12.12	-	-

SPECIES	STR/LVL	QUANTITY	WEIGHT	LXW (LARGEST)	LXW (SMALLEST)
Choromytilus chorus	3	4f	37.04	-	-
Choromytilus chorus	3	3v, 17f	172.57	-	-
Choromytilus chorus	3	8f	51.91	-	-
Choromytilus chorus	3	3v, 2f	83.71	-	-
Choromytilus chorus	3	16f	124.41	-	-
Choromytilus chorus	3	2v, 50f	310.72	137.5 x 60.0	-
Choromytilus chorus	3	9v, 8f	224.8	103.5 x 46.0	82.0 x 41.0
Concholepas concholepas	3	6v	105.31	46.5 x 52.5	-
Concholepas concholepas	3	22v	789.86	76.5 x 84.0	36.5 x 41.5
Concholepas concholepas	3	13v, 2f	558.36	81.0 x 86.5	30.0 x 41.5
Concholepas concholepas	3	23v, 7f	275.82	47.0 x 51.5	27.5 x 29.5
Concholepas concholepas	3	4v	128.39	73.0 x 84.5	-
Concholepas concholepas	3	8v, 3f	172.61	52.5 x 61.5	29.5 x 35.0
Concholepas concholepas	3	5v, 4f	170.69	54.5 x 57.5	27.0 x 33.0
Concholepas concholepas	3	10v	454.95	80.0 x 89.5	40.5 x 46.0
Crepidula dilatata	3	1v	2.53	26.5 x 23.0	-
Crepidula dilatata	3	1v	9.1	33.5 x 30.5	-
Crepidula dilatata	3	5v	15.9	33.0 x 28.5	17.5 x 14.0
Crepidula dilatata	3	2v	12.33	36.5 x 32.0	30.5 x 28.0
Crepidula dilatata	3	3v	18.79	33.5 x 30.0	25.0 x 25.0
Crepidula dilatata	3	1v	2.76	28.5 x 25.0	-
Crepidula dilatata	3	4v	13.57	31.5 x 26.0	25.0 x 19.5
Fissurella crassa	3	1v	4.33	42.5 x 24.0	-
Fissurella latimarginata	3	2v	13.71	53.0 x 33.0	23.5 x 13.0
Fissurella latimarginata	3	2v	14.98	50.5 x 32.5	-
Fissurella latimarginata	3	1v	1.93	27.5 x 11.5	-
Fissurella latimarginata	3	4v	35.31	58.5 x 39.5	40.5 x 27.5
Fissurella latimarginata	3	4v	37.28	60.0 x 39.0	38.5 x 23.5
Fissurella latimarginata	3	1v	9.76	50.0 x 30.0	-
Fissurella latimarginata	3	2v	10.15	42.5 x 26.0	32.5 x 19.0
Fissurella maxima	3	1v	13.69	57.5 x 37.5	-
Fissurella maxima	3	1f	12.07	-	-
Fissurella sp	3	1f	4.17	-	-
Oliva peruviana	3	1v	4.1	23.5 x 13.5	-
Oliva sp	3	1v	4.05	23.0 x 13.5	-
Perumytilus purpuratus	3	2v	5.24	40.5 x 16.5	26.5 x 15.5
Perumytilus purpuratus	3	55v, 3f	101.81	31.0 x 16.0	20.5 x 11.0
Perumytilus purpuratus	3	2v	5.22	34.5 x 16.5	29.5 x 14.5
Protothaca thaca	3	1v	7.71	-	-
Protothaca thaca	3	7v, 2f	154.75	68.0 x 89.0	27.5 x 34.5
Protothaca thaca	3	1v	9.66	38.5 x 48.0	-
Protothaca thaca	3	1f	1.54	-	-
Protothaca thaca	3	4v, 1f	43.73	45.5 x 52.5	36.5 x 43.5
Protothaca thaca	3	1v	25.28	50.0 x 58.0	-

SPECIES	STR/LVL	QUANTITY	WEIGHT	LXW (LARGEST)	LXW (SMALLEST)
Protothaca thaca	3	2v, 1f	19.31	33.0 x 39.0	32.0 x 37.5
Protothaca thaca	3	3v, 1f	26.08	37.0 x 45.5	-
Protothaca thaca	3	3v	45.78	58.5 x 71.0	31.5 x 37.0
Scurria scurra	3	1	0.56	14.0 x 11.5	-
Tegula atra	3	1v	14.43	37.0 x 36.0	-
Tegula atra	3	1v	3.64	20.0 x 17.5	-
Tegula atra	3	1	3.06	21.0 x 19.0	-
Tegula luctuosa	3	1	0.92	11.5 x 11.0	-
Thais chocolata	3	1f	27.11	-	-
Thais chocolata	3	4f	46.8	-	-
Thais haemastoma	3	1v	4.49	27.0 x 17.5	-
Choromytilus chorus	4	7f	66.53	-	-
Choromytilus chorus	4	5v, 22f	286.36	122.0 x 54.0	87.5 x 44.0
Choromytilus chorus	4	10f	79.2	-	-
Concholepas concholepas	4	3v	51.49	53.0 x 55.5	44.5 x 50.5
Concholepas concholepas	4	10v	262.27	53.0 x 59.5	40.0 x 44.5
Concholepas concholepas	4	7v, 5f	212.25	49.0 x 61.5	38.0 x 39.5
Concholepas concholepas	4	2f	16.06	-	-
Crepidula dilatata	4	2v	6.72	30.5 x 28.0	21.5 x 21.5
Crepidula dilatata	4	1v	3.94	29.5 x 26.0	-
Fissurella crassa	4	1v	2.78	33.5 x 18.5	-
Fissurella latimarginata	4	1v	8.97	50.0 x 30.5	-
Fissurella latimarginata	4	2v	10.59	40.5 x 24.0	-
Fissurella maxima	4	1v	19.06	-	-
Fissurella sp.	4	1f	4.48	-	-
Oliva peruviana	4	1v	4.28	23.5 x 14.0	-
Perumytilus purpuratus	4	3v	9.58	35.5 x 16.5	30.5 x 16.5
Perumytilus purpuratus	4	1v	1.5	28.5 x 17.0	-
Perumytilus purpuratus	4	2v	2.32	25.0 x 14.5	25.0 x 14.5
Protothaca thaca	4	19v, 1f	204.66	48.5 x 53.5	27.0 x 31.5
Protothaca thaca	4	3v	58.12	59.0 x 73.5	46.0 x 51.0
Protothaca thaca	4	9v	137.72	51.0 x 59.5	34.5 x 40.0
Protothaca thaca	4	2f	3.41	-	-
Tegula atra	4	1v	12.78	-	-
Aulacomya ater	5	1v	7.05	60.5 x 34.5	-
Choromytilus chorus	5	10f	50.46	-	-
Concholepas concholepas	5	4v	109.02	55.5 x 60.5	40.5 x 47.5
Fissurella crassa	5	1v	4.58	42.5 x 24.0	-
Fissurella latimarginata	5	1v	5.83	-	-
Protothaca thaca	5	1v, 2f	12.38	35.5 x 41.0	-
Choromytilus chorus	10	6f	20.33	-	-
Choromytilus chorus	10	8f	21.84	-	-
Choromytilus chorus	10	9f	27.8	-	-
Concholepas concholepas	10	1v	5.18	34.0 x 37.0	-
Concholepas concholepas	10	2v, 3f	38.22	44.0 x 47.0	39.5 x 43.0

SPECIES	STR/LVL	QUANTITY	WEIGHT	LXW (LARGEST)	LXW (SMALLEST)
Concholepas concholepas	10	2v	44.94	53.0 x 64.5	-
Concholepas concholepas	10	2v	17.16	36.5 x 41.0	-
Crepidula dilatata	10	1v	2.98	24.5 x 23.0	-
Crepidula dilatata	10	1v	1.57	22.0 x 17.0	-
Fissurella latimarginata	10	1v	6.02	4.5 x 29.5	-
Perumytilus purpuratus	10	13v, 2f	17.58	33.0 x 17.0	22.0 x 13.0
Perumytilus purpuratus	10	1v	1.53	28.5 x 15.5	-
Protothaca thaca	10	6v	66.26	44.5 x 52.0	29.5 x 35.0
Protothaca thaca	10	1v	7.78	36.0 x 43.0	-
Protothaca thaca	10	2f	5.43	-	-
Thais sp	10	1v	5.22	-	-
Choromytilus chorus	-	17f	11.29	-	-
Choromytilus chorus	-	22f	85.88	-	-
Choromytilus chorus	-	5v, 58f	497.77	109.5 x 49.5	48.5 x 30.5
Concholepas concholepas	-	3v	181.23	59.5 x 43.5	35.5 x 46.5
Concholepas concholepas	-	7v, 1f	111.08	54.0 x 58.5	27.0 x 29.5
Crepidula dilatata	-	2v	3.63	-	-
Protothaca thaca	-	1v	7.91	-	-
Protothaca thaca	-	1v, 3f	40.82	42.5 x 50.5	-
Protothaca thaca	-	5v, 1f	42.06	52.0 x 60.5	28.5 x 36.5
Choromytilus chorus	1 & 3	2v, 4f	173.55	163.00 x 70.00	-
Concholepas concholepas	1 & 3	11v, 2f	228.06	45.5 x 56.5	-
Fissurella latimarginata	1 & 3	1v	4.77	40.5 x 24.5	-
Fissurella maxima	1 & 3	1f	6.52	-	-
Fissurella sp	1 & 3	1v	1.51	24.5 x 15.00	-
Protothaca thaca	1 & 3	1v	84.67	75.5 x 99.35	-
Thais chocolata	1 & 3	1f	30.01	-	-
Choromytilus chorus	surface	18f	70.58	-	-
Concholepas concholepas	surface	3v, 1f	30.56	44.5 x 53.0	41.5 x 39.5
Crepidula dilatata	surface	1v	3.75	30.0 x 27.5	-
Fissurella latimarginata	surface	3v	23.5	57.5 x 31.5	41.5 x 20.5
Perumytilus purpuratus	surface	3v	5.53	31.5 x 16.0	28.5 x 14.5
Protothaca thaca	surface	1v, 4f	36.77	54.0 x 60.5	-
Tegula atra	surface	1f	1.56	-	-
Thais chocolata	surface	1f	9.28	-	-
Calyptrea trochiformis	unknown	1v	3.17	21.5 x 19.0	-
Concholepas concholepas	unknown	9f, 1f	237.43	55.0 x 68.5	35.5 x 40.5
Crepidula dilatata	unknown	12v	31.37	31.0 x 27.5	22.0 x 20.5
Fissurella latimarginata	unknown	6v	34.83	55.5 x 35.0	30.5 x 17.5
Thais chocolata	unknown	1v	66.05	60.0 x 51.0	-

Quiani 9 Index Scores

Choromytilus chorus

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		50.75	107.75	3	47.09
2		53.5	123.5	1	43.31
3		46.78	96.5	4	48.47
4		49.5	106.6	2	46.43

Aulacomya ater

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
2		22	37.5	2	58.66
3		29	49.25	3	58.88
5		34.5	60.5	1	57.02

Perumytilus purpuratus

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		16.5	31	1	53.22
2		18.75	32	5	58.59
3		16.05	29.18	4	55
4		15.8	29.1	2	54.29
10		15.16	27.83	3	54.47

Protothaca thaca

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		57.9	47.4	6	122.15
2		53.1	44.9	3	118.26
3		54.82	45.6	5	120.21
4		53.66	45.08	4	119.03
5		41	35.5	1	115.49
10		43.33	36.66	2	118.19

Concholepas concholepas

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		59.6	51.25	6	116.29
2		56.8	49.9	5	113.82
3		53.8	50.29	1	106.97
4		52	46.13	4	112.72
5		54	48	3	112.5
10		46.5	41.4	2	112.31

Fissurella latimarginata

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
1		38.5	55	4	70
2		23.14	39.35	1	58.8
3		27.96	44.88	3	62.29
4		27.5	45.25	2	60.77

Fissurella crassa

Level	Rank Order	Mean Width	Mean Length	Rank Order	W/L*100
2		20.87	42.75	1	48.81
3		24	42.5	3.5	56.47
4		18	33	2	54.54
5		24	42.5	3.5	56.47

Quiani 9 Pearson's r Correlation Coefficient for Ranked Data

RANK w/ Substitution *Choromytilus chorus*

N	X	Y	X2	Y2	XY
4	1	3	1	9	3
	2	1	4	1	2
	3	4	9	16	12
	4	2	16	4	8
SIGMA	10	10	30	30	25
SIGMA X/Y2	100	100			
Pearson	0				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	47.09	1	2217.47	47.09
	2	43.31	4	1875.76	86.62
	3	48.47	9	2349.34	145.41
	4	46.43	16	2155.74	185.72
SIGMA	10	185.3	30	8598.31	464.84
SIGMA X/Y2	100	34336.09			
Pearson	0.1881196				

RANK w/ Substitution *Aulacomya ater*

N	X	Y	X2	Y2	XY
3	1	2	1	4	2
	2	3	4	9	6
	3	1	9	1	3
SIGMA	6	6	14	14	11
SIGMA X/Y2	36	36			
Pearson	-0.5				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
3	1	58.66	1	3441.00	58.66
	2	58.88	4	3466.85	117.76
	3	57.02	9	3251.28	171.06
SIGMA	6	174.56	14	10159.13	347.48
SIGMA X/Y2	36	30471.1936			
Pearson	-0.806822				

RANK w/ Substitution ***Perumytilus purpuratus***

	N	X	Y	X2	Y2	XY
	5	1	1	1	1	1
		2	5	4	25	10
		3	4	9	16	12
		4	2	16	4	8
		5	3	25	9	15
	SIGMA	15	15	55	55	46
	SIGMA X/Y2	225	225			
Pearson		0.1				

RANK w/ Index

	N	X	Index	X2	Index	XINDEX
	5	1	53.22	1	2832.37	53.22
		2	58.59	4	3432.79	117.18
		3	55	9	3025.00	165.00
		4	54.29	16	2947.40	217.16
		5	54.47	25	2966.98	272.35
	SIGMA	15	275.57	55	15204.54	824.91
	SIGMA X/Y2	225	75938.8249			
Pearson		-0.1389702				

RANK w/ Substitution ***Protothaca thaca***

	N	X	Y	X2	Y2	XY
	6	1	6	1	36	6
		2	3	4	9	6
		3	5	9	25	15
		4	4	16	16	16
		5	1	25	1	5
		6	2	36	4	12
	SIGMA	21	21	91	91	60
	SIGMA X/Y2	441	441			
Pearson		-0.7714286				

RANK w/ Index

	N	X	Index	X2	Index	XINDEX
	6	1	122.15	1	14920.62	122.15
		2	118.26	4	13985.43	236.52
		3	120.21	9	14450.44	360.63
		4	119.03	16	14168.14	476.12
		5	115.49	25	13337.94	577.45
		6	118.19	36	13968.88	709.14
	SIGMA	21	713.33	91	84831.45	2482.01
	SIGMA X/Y2	441	508839.6889			
Pearson		-0.702466				

RANK w/ Substitution *Concholepas concholepas*

N	X	Y	X2	Y2	XY
6	1	6	1	36	6
	2	5	4	25	10
	3	1	9	1	3
	4	4	16	16	16
	5	3	25	9	15
	6	2	36	4	12
SIGMA	21	21	91	91	62
SIGMA X/Y2	441	441			
Pearson	-0.6571429				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
6	1	116.29	1	13523.36	116.29
	2	113.82	4	12954.99	227.64
	3	106.97	9	11442.58	320.91
	4	112.72	16	12705.80	450.88
	5	112.5	25	12656.25	562.50
	6	112.31	36	12613.54	673.86
SIGMA	21	674.61	91	75896.52	2352.08
SIGMA X/Y2	441	455098.6521			
Pearson	-0.3165881				

RANK w/ Substitution *Fissurella latimarginata*

N	X	Y	X2	Y2	XY
4	1	4	1	16	4
	2	1	4	1	2
	3	3	9	9	9
	4	2	16	4	8
SIGMA	10	10	30	30	23
SIGMA X/Y2	100	100			
Pearson	-0.4				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	70	1	4900.00	70.00
	2	58.8	4	3457.44	117.60
	3	62.29	9	3880.04	186.87
	4	60.77	16	3692.99	243.08
SIGMA	10	251.86	30	15930.48	617.55
SIGMA X/Y2	100	63433.4596			
Pearson	-0.6372301				

RANK w/ Substitution *Fissurella crassa*

N	X	Y	X2	Y2	XY
4	1	1	1	1	1
	2	3.5	4	12.25	7
	3	2	9	4	6
	4	3.5	16	12.25	14
SIGMA	10	10	30	29.5	28
SIGMA X/Y2	100	100			
Pearson	0.6324555				

RANK w/ Index

N	X	Index	X2	Index	XINDEX
4	1	48.81	1	2382.42	48.81
	2	56.47	4	3188.86	112.94
	3	54.54	9	2974.61	163.62
	4	56.47		3188.86	225.88
SIGMA	10	216.29	14	11734.75	551.25
SIGMA X/Y2	100	46781.3641			
Pearson	0.7497946				

Quiani 10 Shell Inventory

SPECIES	STR/LVL	QUANTITY	WEIGHT*	LXW (LARGEST)**	LXW (SMALLEST
Acanthina sp	3	1f	17.32	-	
Aulacomya ater	3	1v; 16 f	8.44	64.5x34.5	
Aulacomya ater	3	1v 1f	11.31	74.5x40.0	-
Choromytilus chorus	3	1v; 16 f	163.58	120.5x56.5	
Choromytilus chorus	3	1f	2.26	-	
Choromytilus chorus	3	17f	73.43	-	-
Choromytilus chorus	3	14f	119.62	76.0x41.5	-
Choromytilus chorus	3	1f	5.85		
Choromytilus chorus	5	8f	14.95	-	-
Concholepas concholepas	3	5v	143.22	65.5x73.0	21.0x22.5
Concholepas concholepas	3	10v, 3f	297.51	64.5x66.5	36.0x30.0
Concholepas concholepas	3	12v, 1f	189.38	65.5x72.5	32.5x37.5
Concholepas concholepas	5	4f	53.11	-	-
Concolepas concholepas	3	9v; 4f	199.6		
Crepidula dilatata	3	1 f	6.31	-	
Crepidula dilatata	3	3	8.94	39.5x27.5	21.5x17.0
Crepidula dilatata	3	2v	12.88	41.0x31.0	22.0x17.5
Fissurella crassa	3	1	8.27	-	
Fissurella crassa	3	3	10.45	48.5x27.5	33.5x16.5
Fissurella crassa	3	1v	8.8	57.0x32.5	
Fissurella latimarginata	3	2	9.48	-	-
Fissurella maxima	3	2f	13.3	-	
Fissurella maxima	3	1	18.19	-	
Fisurella latimarginata	3	1v	6.94	-	-
Fisurella maxima	3	1f	14.52		
Perumytilus purpuratus	3	16 v	36.48	37.0x16.5	
Perumytilus purpuratus	3	11v	24.87	25.0x19.5	19.5x13.5
Perumytilus purpuratus	5	61v, 1f	139.02	40.5x20.0	26.0x12.0
Protothaca thaca	3	1v; 1 f	24.38	42.0x50.0	
Protothaca thaca	3	1v	15.12	45.0x52.0	
Protothaca thaca	3	2v	24.77	41.5x55.5	44.5x42.5
Protothaca thaca	5	1v, 1f	16.41	45.5x55.5	-
Tegula atra	3	1	0.47	10.5x10.0	
Tegula atra	3	1f	2.55	-	-
Tegula atra	5	4f	21.68	-	-
Thais chocolata	3	1f	15.62	-	
Thais chocolata	3	1f	11.4	-	-
Thais chocolata	5	6f	34.12	-	-
Unknown univalve	5	2f	9.2	-	-

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VITA

Graduate College
University of Nevada, Las Vegas

Sally Llull Billings

Home Address:
910 Quicksand Lane
North Las Vegas, Nevada 89032

Degrees:
Bachelor of Arts, Anthropology, 1994
University of Nevada, Las Vegas

Publications:

1994 *Southern Paiute at Yama 4: A Pilot Study.* UNLV Journal of Anthropology, 5:11-28.

1999 Molycorp, Inc. Mountain Pass, California Groundwater Monitoring Wells Access Route Cultural Resources Investigations, Class III Report.

Thesis Title:
Sedentism Among the Archaic Fisher-Folk of Northern Chile: A Malacological Perspective.

Thesis Committee:
Chairperson, Dr. Bernardo Arriaza, Ph.D.
Committee Member, Dr. Margaret Lyneis, Ph.D.
Committee Member, Dr. Alan Simmons, Ph.D.
Committee Member, Dr. Claude Warren, Ph.D.
Graduate Faculty Representative, Dr. Stephen Rowland