SAMBAQUI: CHANGES IN MONUMENTAL ARCHITECTURE ALONG THE BRAZILIAN COAST IN RESPONSE TO DISRUPTIONS IN CLIMATE PATTERNS

By

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To Mikie Davidson
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The effects of El Niño upon monumental architecture have been well documented in Peru, however, this phenomenon has not been considered in relation to the shell mounds lining the southern coastline of Brazil. The objective of this paper is to demonstrate the presence of El Niño (EN) in Brazilian shell mounds, which are known as sambaquis, by analyzing the composition of mollusk species within the sambaqui layers. The decline of temperature sensitive mollusks as a construction material is associated with EN events. Furthermore, beach ridge data, soil core and charcoal analyses are used to support the presence of EN during the construction phases of the sambaqui called Jaboticabiera II, or Jab II, in the state of Santa Catarina, Brazil. These data are presented to demonstrate the dialogue between humans and their environment and the landscape which is a result of this interchange.
Although a popular topic gaining cultural and political significance, climate change is a misnomer since the Holocene has been in a constant state of flux (Fagan, 2004). Like evolution, the developments of shifts in climate are not progressive, nor inherently good or evil; but they are important because modern humans are dependent upon stable and predictable climate conditions. Fortunately, as we learn more about climate, patterns emerge.

The Southern Oscillation is composed of two phases, El Niño (EN) and La Niña (LN). While El Niño is often characterized as an abnormal state it is, in fact, “a complimentary phase for which the term La Niña is apposite (Philander, 1990, 11).” The most widely recognized of climatic phenomena, the phases of El Niño and La Niña present us with intense and often catastrophic changes in Southern Oscillation patterns. The response of human civilizations to these changes has been well documented by archaeologists in Peru (Sandweiss, 2003; Richardson, 1998; Moseley et al., 1992). However, little archaeological work has considered how EN and LN would affect societies along the Atlantic coast. This paper seeks to examine the long history of archaeological research of the Brazilian shell mounds, or sambaquis, within the context of fluctuations in climate, particularly El Niño and La Niña events, and how these recurring phases affected the construction of sambaquis in Brazil. A brief history of theory in Brazilian archaeology will be presented since it is impossible to neglect the social and political powers which have shaped the study of these monuments. The

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1 It is possible to present “normal” conditions statistically, but the Pacific is rarely in what could be considered a “normal” state (Philander, 1990, 11).
sambaquis are especially important since they offer insight into not only the mortuary practices of the people that built them, but also the climatic phenomena that influenced the choices of those same people.

**Research Questions**

Climate shifts have a profound effect on the subsistence patterns of maritime societies. The demise of mangrove and the species these areas support may alter the food procurement choices of the people who rely on such specialized ecosystems for food. Moreover, some species become central to the ideology of a people and the loss of these species due to climate change may alter or destroy belief systems. The cultural consequences of EN and LN, albeit more catastrophic, have been well documented along the coast of Peru (Moseley, 1982; Moseley et al., 1992; Sandweiss, 2003). The research developed in Peruvian archaeology on the relationship between environment and cultural changes provides a model for climate research in Brazil. Therefore, this paper will investigate the following research questions:

- What changes took place in construction techniques and/or building materials in response to cyclical climate shifts?
- What interpretations can be made concerning the interaction between humans and fluctuations in climate?

**Research Approach**

Historical ecology focuses on the cultural and historical production of landscapes which shape cultural experience by retaining the material manifestations of human action (Stahl 2008: 7).

Historical ecology is a term whose definition has been disputed since it not so much a theory as a “toolbox,” or the combination of “conceptual and practical tools (Crumley, 2006, 390-391)”. Very simply put, ecology is the interaction among or between any living organism and the physical environment. Therefore, historical
ecology is the history, or sum, of human interactions with their dynamic environment over a given period of time (Winterhaulder, 1994). Winterhalder (1994) claims “a complete explanation of ecological structure and function must involve reference to the actual sequence and the timing of the causal events that produced them. Time, or history, is an important component of historical ecology. The combination of culture, history, and environment leads to what humans understand as landscape. The sambaquis present us with a human produced landscape, the result of thousands of years of cultural and environmental interaction. In response to climatic shifts, and the consequences of intense El Niño and La Niña events, humans altered their behavior (i.e. substituted dark earth and fish bone for shell), and, in the case of the sambaquis, modified the environment leading to the formation of a landscape which continues to influence the way humans attribute meaning to their surroundings (Balée, 1998).

Materials and Methods

Jaboticabeira II (Jab II) represents the most thoroughly studied sambaqui site in Brazil (Figure 1-2). The site is 6 m high, 400 m long, and 250 m wide (Villagran, 2009). Using the work of both Daniela Klökler (2000) and Cintia Bendazzoli (2007), I have been able to analyze changes in composition of mollusk species and fish bone through time in Jab II. I must admit that the layers of Jab II do not follow in chronological order, and one finds sambaquis within sambaquis making it difficult to distinguish layers. The layers are defined based on color, texture, and composition. Furthermore, within layers features that are related to a specific event, such as a fire pit, burial, or post mold, are referred to as structures (Klökler, 2000, 84). I have chosen to utilize the layers as they

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2 The environment is not to be understood as a sterile container which holds human action or an external stimulus which goes about forcing adaptation, as is the case with environmental determinism.
are defined by Klökler (2000). Composition data from three profiles of Locus 1—1.15, 1.25, 1.40—and their corresponding layers were graphed in order to demonstrate anomalies and general patterns. The graphs are based on the frequency of species in samples taken by Klökler (2000). Weight has not been included since issues with weight between species as well as levels of preservation make interpretation difficult. For example, A. brasiliana weighs considerably more than B. solisatus. Thus, judging the composition of a layer based on the weights of these two species would be misleading (Klökler, 2000). Therefore, the frequency of a species, as defined by Klökler (2000) is based on MNI (Minimum Number of Individuals). Furthermore, species have been separated into two categories: Primary and Secondary species, and a third category, Inorganic, has been defined for stone and sediments. The species which pertain to this analysis and have been defined by Klökler as primary species are as follows: Anomalocardia brasiliana, Brachidontes solisatus, Lucina pectinatus, Cyrtopleura sp., Ostrea sp., and Thais haemastoma, while fish bone, burned bone, charcoal, otoliths, mammal bone, crab, and barnacles are defined as secondary (Klökler, 2000,81). Although the mollusks that make up the primary category respond differently to changes in temperature and salinity one would expect that as Primary materials became harder to procure the sambaqui people would come to rely more heavily on Secondary and/ or Inorganic materials, or those materials consisting of species more tolerant of changes in salinity and temperature, for their construction needs.
The purpose of this paper is to present nearly fifty years of sambaqui research within the context of climate shifts, e.g. EN and LN, and to investigate the dialogue that takes place between a maritime people and their dynamic environment.

Data pertaining to the species of mollusk, the presence or absence of mangrove in Cabo Frio, RJ, sediment core analysis, and beach ridge formations found along the southern coastline of Brazil will be presented to support the argument that climate shifts affected the construction of sambaquis along the southern coastline of Brazil (Fig. 1-1).
El Niño Research in Peru

The biggest debate in Peruvian archaeology has been the development of civilization, complete with monumental architecture, before the advent of ceramic technology and, seemingly, without the cultivation of plants that served as foodstaples. However, it is now accepted that people were cultivating “industrial cultigens,” such as cotton, which was used to make the nets for fishing (Moseley, 1975; Richardson, 1998).

The development of civilization before the development of subsistence agriculture was not thought possible before archaeologists in Peru argued that a civilization could be supported by the exploitation of marine resources. This research led to the theory, first proposed by Michael E. Moseley in 1975, that Peru’s earliest civilization was founded primarily on a maritime subsistence strategy. While working to prove the possibility of a maritime civilization, archaeologists also found a curious inconsistency in the archaeological record. At the Amotape campsite, Richardson discovered a species of mollusk, Anadara tuberculosa, which are “mangrove species that require both warmer and wetter conditions than now exist in that area of northern Peru (Sandweiss, 2003, 26).” Moreover, the site situated above the Talara Tar Seeps contains the remains of now extinct mammals, birds, and insects. The very presence of some species indicates that the area would have had more water and vegetation to support such an ecosystem. For example, the species of insect present include those that must have standing water in order to survive (Sandweiss, 2003, 27). Furthermore, the Siches site (5,200–5,900 BP) also contained the same warm water mollusks in the basal level of the area excavated as those found at the Amotape campsites. However, archaeologists found

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3 Although civilization is a problematic term, it is used here to distinguish the sambaqui people as a discrete and cooperative cultural group.
an intermingling of warm and cool water mollusks in the upper and more recent levels of the Siches site (Sandweiss, 2003, 31). The presence of these warm and cool water mollusks is important, because the Siches site is the only site to span the climate shift which took place around 5800 BP. Archaeologists were prompted to consider the paleoclimate, and what they found was astounding. The Terminal Pleistocene (13,000–11,000 BP) through the Mid-Holocene (9,000–5,800 BP) are characterized by warmer sea surface temperatures and a far less arid environment (Sandweiss, 2003). Interestingly, around 5,800 BP the frequency and intensity of El Niño changed dramatically; resulting in the much cooler sea surface temperatures and arid conditions found in Peru today. Peruvian archaeologists have used the appearance or absence of temperature sensitive mollusks to indicate climate change (Richardson, 1995) and the same could be done for research along the Brazilian coast. Furthermore, it is during this time (~ 5800 BP) that we see the construction of monumental architecture in Peru, and this may represent a cultural response to the sudden shift in the environment (Sandweiss, 2003; Moseley, 1982).

**Geomorphology of Peru and Brazil**

**Peru**

The western and eastern coasts of South America are very different, and it is important to note these differences when comparing the civilizations that developed along either coast. The northern coast of Peru is a region of tremendous seismic activity, which has brought about tectonic uplift. Although the degree of this continental uplift is still a source of disagreement among archaeologists, uplift has had an impact on the height of the coast Peru and, therefore has influenced the effects of sea level fluctuations in the region (Richardson, 1998, 43). The same seismic activity has
produced earthquakes that, along with the torrential rains of EN, have moved huge amounts of sediment that have brought about the formation of beach ridges along the coast of Peru. The formation of these beach ridges also gave rise to dune fields, which can have catastrophic cultural consequences; excavations have shown that ancient cities became entombed within encroaching dunes (Moseley et al., 1992).

**Southeastern Brazil**

Southeastern Brazil, including Rio de Janeiro and Santa Catarina states, is characterized as a high relief area, or high-grade rocky coast (Dominguez, 2009). The coast rests on crystalline massifs forming the Serra do Mar Coastal range; the range stretches from the state of Espírito Santo (~20° S) to the north of Santa Catarina state (~26° S) (Hesp et al., 2009, 93). The region experienced a major uplift by the end of the Cretaceous (89–65 mya) and was followed by a gravitational collapse during the Cenozoic (58–20 mya) and, as a result, the rivers of this region flow towards the interior (Dominguez, 2009, 29). Although a transference fault zone exists along the Florianópolis shelf, there is no evidence of tectonic activity after the Cenozoic period (Hesp et al., 2009, 97). The region of interest to the south of the Serra do Mar Mountains, Jaguaruna, is described as “a relatively straight coastal segment” which exhibits “all major coastal landform/barrier types (e.g., chenier plains, beach ridge plains, foredune plains) (Hesp et al., 2009).” Understanding the geomorphology of the region is particularly important when dealing with the reconstruction of paleoclimate.

**Shell Mounds**

Shell mounds, composed largely of mollusk shell and fish bone, were traditionally seen by archaeologists as little more than trash heaps or even the result of ancient geological phenomena (De Blasis, 1998). However, these archaeological sites are now...
being studied as locations of great importance for feasting and mortuary ritual (Gaspar, 2008; Russo, 2004; Klökler 2001; Villagrán, 2009) and time-capsules of environmental change (Suguio et al., 1992; Scheel-Ybert et al., 2003). Shell mounds offer a great deal to paleoenvironmental studies since they are found on virtually every continent. In their various shapes and sizes, they are located in Japan, Peru, South Africa, the United States, Brazil, and elsewhere (Akazawa, 1988; Habu 2004; Uhle, 1907; Sassaman, 2006; Carstens et al., 1996; Singer et al., 1982; Reitz, 2001; Sandweiss, 2003). The Klasies River Mouth site, located in the Eastern Cape Province of the Republic of South Africa, boasts evidence of the earliest recorded shell mound. The site is a series of cave chambers that were inhabited continuously from 122,000 to 42,000 BP and is of special importance because it is linked with the earliest anatomically modern humans (Singer et al., 1982). Thus, from our earliest beginnings we find the construction of shell mounds in relation to the exploitation of marine resources. South Africa may hold the oldest shell mounds, but the largest shell mounds in the world are found in Brazil in great clusters, or complexes, along its southern coastline (De Blasis et al., 1998). The era of Brazilian shell mound construction dates between 6,000 and 1,000 BP, however, they were continuously inhabited up until European contact in the 16th century. As mentioned above, due to the material used to construct sambaquis they provide great insight into the climate conditions throughout the period of their construction and, in some cases, this represents over one thousand years. Archaeologists are able to use the mollusk shell, sediment, fish bone, and burned plant remains of the sambaquis as proxies for reconstructing the paleoenvironment, paleoclimate, and sea level fluctuation of this region (Suguio et al., 1992; Scheel-Ybert, 2000).
The effects of the Southern Oscillation are felt from Japan, throughout North and South America, as well as the coast of West Africa. However, it has not been considered how it would have affected a maritime society living along the southern coastline of Brazil. The Southern Oscillation is not an isolated event—this phenomenon has been well documented in Peru, Central America, and North America (Salwen, 1962; Scuddfer, 2003; Shackelton, 1988; Moore, 1991; McKillop, 1995). Such immense changes would have been experienced throughout South America, including Brazil.

Moreover, the time in which the sambaquis were built (6000–1000 BP, although the golden age of sambaqui construction occurs between 4000 BP and 2000 BP), coincides with the occurrence of El Niño in greater frequency and intensity (~ 5800 BP), and it is at this time that we see the rise of monumentality in Peru (Gaspar et al., 2008; Sandweiss, 2003). However, it is around 2000 BP that there is drastic reduction in the use of shell, and sambaqui people begin to substitute dark earth, or soil rich in organic material, for shell, and, by 1600 BP individuals are no longer interred in monumental shell mounds (Gaspar et al., 2008, 327). Instead, low earthen mounds are found clustered in cemetery like sites. Interestingly, data from beach ridge and sediment core analyses indicate an increase in EN conditions from 2200 ± 200 yr BP to present. Furthermore, archaeological evidence in Brazil presents evidence that the expansion of agricultural societies took place about 2000 yr BP and resulted in marked cultural change (Gaspar et al., 2008, 328).

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4 When referring to monumentality, I am discussing those structures which require planning, i.e. the organization of labor, and show evidence of symbolic importance, e.g. burials, iconography, etc.
Maritime Society

The Brazilian shell mounds are referred to as sambaquis, which is a term derived from the Tupi language with *tamba* translating as shellfish and *ki* as a piling up of objects (Gaspar et al., 1998, 592). The sheer size of these structures is impressive, the Sambaqui de Garopaba (Fig. 1-3) stands nearly 400 meters long and 30 meters high after having been partially destroyed by shell mining, but what is more incredible is the number of burials found in sambaquis. Jaboticabeira II, located in the extensive sambaqui complex of Camacho, Santa Catarina, is estimated to have had nearly 43,000 individuals interred within it layers over a period of 800 years (Fig. 1-2) (Gaspar et al., 2008, 327).

Figure 1-2. The upper layers of Jaboticabeira II.

5 Please note that two spellings exist for this site including Jaboticabeira II and Jabuticabeira II.
Sambaquis are normally found in bay or lagoon areas; areas of brackish water which support the growth of mangroves — areas of rich floral and faunal diversity that were important in the diet of the sambaqui peoples (Gaspar et al., 2008, 319). Mangroves are particularly sensitive to water temperature, and will not grow if sea surface temperatures are cooler than 24° C (UNEP Regional Seas Report, 1994). It seems that during cold phases along the Brazilian coast the salt marshes moved northward and replaced the mangroves, and during the humid, warm phases the mangroves, in turn, moved southward, replacing the salt marshes (Hurt, 1974, 6).

Thus, one would expect mollusks associated with either system would become dominant in the archaeological record, and would be indicative of climatic conditions during the construction of the sambaquis in which the shells are found. Sambaquis are difficult to define. They vary in size anywhere from a collection of shell two meters high

Figure 1-3. Dr. Paulo De Blasis and Danilo Assunção pictured as we walk towards Sambaqui de Garopaba. It is impossible to capture the incredible size of the site in a photo.
to, as mentioned above, imposing structures thirty meters high (De Blasis et al., 1998, 77). Moreover, there is no evidence of a sambaqui “recipe” and the “proportions of soil, sand, shell, and the kinds of cultural inclusions and features in sambaquis also are variable (Gaspar et al., 2008, 319).”

Furthermore, the larger sambaquis differ from the smaller in terms of their stratigraphic sequencing.

Larger shell mounds typically have horizontally and vertically complex stratigraphy, including alternating sequences of shell deposits, narrow and darker layers of charcoal and burned bone that mark occupation surfaces, and clusters of burials, hearths, and postholes descending from these surfaces (Gaspar, 2008, 319).

Despite the differences found among sambaquis a pattern does exist. The larger sambaquis are surrounding by smaller sambaquis lacking burials. Thus, we begin to see a clustering of sambaquis with the largest acting as a central mark (Figure 1-4). The smaller sambaquis that lack the complexity of the larger, more central sambaquis may have served campsites or processing stations, or satellite locations to serve the needs of people in the outer reaches of the region (Gaspar, 2008, 320). Andreas Kneip created a typology of Brazilian sambaquis based on the geomorphology of the Camacho region (Kneip, 2004). Indeed, the clustering of sambaquis and the duration of their occupancy dispel any notion of the sambaqui community as a primitive nomadic people and, instead, indicate a sedentary and incredibly cooperative population (De Blasis pers. comm., June 2009). Moreover, paleopathological analysis found signs of endemic disease, which is linked to a dense and sedentary population, meanwhile there are very few indications of social inequality within the population - individual burials are the exception rather than the rule (Gaspar et al., 2008). It is believed that the mollusk shells along with fish bones forming the sambaquis represent a diet that relied heavily
on maritime exploitation, and it is clear the sambaqui people were highly skilled fishers and gatherers. The shell fish species gathered in order to construct the sambaquis are no longer recognized as representing a main food source, and the economy of the sambaqui people is interpreted as that of intensive fishers rather than collectors of low calorie shell fish.

Moreover, it is now argued that the mollusk species have symbolic value (Gaspar, 2008, 322). The symbolic role of the ocean is clearly important; many of the zooliths that have been recovered have been carved in the likenesses of species found in the
ocean (whale, shark, turtle, etc.) although bird and sometimes human effigies are also found (Gaspar et al., 2008, 329). These zooliths are similar in style and ideology and are found from Cananéia/Iguape down to Uruguay—a distance of 2000 km (Gaspar et al., 2008, 329). Therefore, these carved effigies act as further evidence of a “pan-regional network,” or a complex system of interaction between people of a common linguistic and religious background (Gaspar et al., 2008, 329). The lagoons and estuaries that were manipulated and managed by the sambaqui people were the basis of a specialized livelihood. Within the sambaquis themselves there is no indication that deposits of terrestrial mammal or bird are included in the layers of shell and fish bone, although these species do appear as effigies (Gaspar et al., 2008). The lack of these species in a ritual context could be attributed to the fact that features associated with human dwellings have not been found in relation to sambaqui sites, however, one must consider issues of preservation in a tropical climate. Furthermore, research to date has not considered areas immediately adjacent to the sambaquis themselves. Further research and excavation is needed “off the sambaqui.” Of course, it is clear that sambaquis are in no way representative of normal human habitation sites, although they do represent a planned and developed landscape (Gaspar et al., 2008, 320). Many ideas have been postulated as to what the sambaquis meant, or why they were built—from acting as a form of communication tower to a means of escaping tropical insects on the ground—but what is certain is these structures are an enduring form of landscape modification. Of course, in order to better understand this practice we must first reconstruct the environment upon which the sambaqui people so heavily relied.

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6 Gaspar has argued that sites in Rio de Janeiro have evidence of habitation floors on the sambaqui, but archaeologists disagree about this interpretation.
CHAPTER 2
HISTORY OF SAMBAQUI RESEARCH

In order to understand the current paradigms circulating through Brazilian archaeology one must recognize past influences and how cultural identity and politics have formed research questions and the methods employed in archaeology in general and in Brazilian archaeology in particular. Therefore, this chapter will present the history of sambaqui research, its influences, and the outlook for the future.

Paulo Duarte

Brazil has long considered itself a European culture (Funari, 1995). Therefore, the early efforts of the Museu Nacional were directed towards what was considered “civilized” cultures of foreign origin using European methods (Funari, 1995, 238). Furthermore, the work of museums was not structured as a scholarly endeavor. Indeed, archaeology by the museums was linked more with patron support sponsored by museum directors than with scholarly work (Funari, 1995, 238). This form of elitist archaeology began to change with Paulo Duarte, whose humanist approach and effort to protect the cultural heritage of Brazil earned him few friends. In fact, his 1946 book arguing against the dictatorship in Brazil led to his exile and “signaled the onset of the ethical commitment of Brazilian intellectuals in support of freedom, and against arbitrary rule by those in authority (Funari, 1995, 239).” Duarte’s ethical stance led him to propose the development of academic archaeological institutions and heritage protection (Funari, 1995, 239). However, his humanist and anti-positivist approach were interpreted as romantic and antithetical to the hierarchical nature of Brazilian society (Funari, 1995).
French School

In 1954, Joseph Emperaire, a geographer of Musee de l'Homme, and his wife, Annette Laming were brought to Brazil by Paul Rivet, who was the director of Musee de l'Homme and a visiting professor in Brazil at the time (Barreto, 1998). The team joined Paulo Duarte in the first systematic excavations of shell mounds in Brazil. Emperaire and Laming introduced the refined French excavation methods for that time:

Excavations were aimed at recording stratigraphic sequences, reconstructing occupational floors, and their internal structures...Analysis of artefacts, mainly lithics, was aimed at reaching formal typologies, following Francois Bordes' methods (Barreto, 1998, 575).

The couple was extremely influential, and their extensive training of local archaeologists is considered one of their most positive contributions to Brazilian archaeology (Barreto, 1998, 575). However, applying French methods to Brazil at that time became problematic. In Brazil, archaeologists had not established chronological and geographical distribution. Thus, by ignoring how the sites related to a larger context, the single-site approach rendered site reports useless (Barreto, 1998). Then, without paying attention to site formation or developing a taphonomy of deposits in tropical environments the reconstructions of living floors were greatly limited (Barreto, 1998, 576). Finally, the French method of classification, mainly concerned with lithics, led to confusion. Archaeologists attempted to place the rough tools found in their excavations within the Paleolithic categories developed by the French and overlooked the “technological and functional characteristics of tools that have proved more functional (Barreto, 1998, 576).” Therefore, a frustration developed in relation to the French style of archaeology, and this frustration led many Brazilian archaeologists to look elsewhere for their theories and methods – namely, to the Americans.
American Influence

The work of Clifford Evans and Betty Meggers, both of the Smithsonian Institute, has defined the American presence in Brazil since the early 1950’s, however, their work had little impact until 1960’s. Their work began with Amazonian cultures rather than the sambaquis, however they argued for a broader regional approach which was missing in Brazilian archaeology during that time (Barreto, 1998). In 1964, Evans and Meggers hosted a series of seminars aimed at archaeological theory, methodology, ceramic classification and interpretation (Barreto, 1998; Funari, 1995). However, the team imported a brand of archaeology which was the exact opposite of Duarte’s humanism. Their empirical approach divorced Brazilian archeology from historical concerns, but this “anti-historical empiricism” from America was introduced into a society in which empiricism was interpreted very differently from that of the United States:

There is a clear imbalance between the capitalist, individualistic principles behind positivism in the United States and the same approach when applied within the social fabric based on non-egalitarian, patronal values (Funari, 1995, 240).

“Theoretical Vacuum”

Unlike Archaeology in the United States, Brazilian archaeology did not develop as a sub-discipline of Anthropology. In fact, Archaeology was not recognized as a professional discipline until nearly twenty years after Anthropology and other related social sciences had been established in Brazil (Barreto, 1981, 574). As a result, Brazilian archaeology languished is a perpetual “classificatory – descriptive” approach for some time (Barreto, 1981). In her discussion of the development of Brazilian archaeology, Cristiana Barreto (1981) is explicit as to the circumstances which led to
the stunted growth of the discipline and she explains,

A wide gap between archaeology and anthropological theory coupled with a certain cultural colonialism are important causes responsible for this particular state in the discipline in Brazil. Ironically, the strong influence of foreign schools (both French and North American), while producing many advances, has also left Brazilian archaeology in a theoretical vacuum and a methodological straitjacket (574).

The result of Evans and Meggers seminars were pupils who hindered the development of new perspectives by persecuting and ostracizing those who challenged their empiricist ecological determinism (Funari, 1995). The “irmãos”, or “brothers”, as the group of determinists came to call themselves, would obstruct the publication of any data they felt to be incongruous with their own findings (Funari, 1995). Although the dominant discourse was ineffective, the aim of the “irmãos” was to maintain the accepted standard. Funari (1995) argues that empiricism and ecological determinism did not lead to a strong positivist science in Brazil because of the authoritarian regime that used empiricism to justify their rule which allowed the “irmãos” to “reinstate patron/client practices with arbitrary power (242).” Despite the historical suppression of a theoretical archaeology in Brazil the future of Brazilian archaeology is bright. New generations of archaeologists are increasingly aware of the theoretical vacuum surrounding them and, as is clear from the literature cited, they are questioning and challenging the rigid discourse of their predecessors.

**Current Approaches**

**Interdisciplinary Research**

As a discipline, Archaeology has begun to embrace the need for cooperation beyond our field alone, and sambaqui research is no exception to this movement. The most exciting and informative work is being done by archaeologists working with
geographers, geologists, climatologists, and soil scientists. Furthermore, interdisciplinary research recognizes the complexities inherent in the study of prehistoric civilizations and allows for otherwise overlooked variables to be teased out from the chaos of the past. Theoretical approaches come and go, but cooperative scholarship should be maintained in order that Archaeology remains relevant. This paper is intended to exemplify the possibilities of interdisciplinary research.

**Geological Studies**

Geographic Information Systems (GIS) have been used to map the sambaquis in relation to sea level fluctuations and the geomorphology of the region in which the sambaquis are found (Kneip, 2004). In her analysis, Kneip (2004) found that the sambaquis formed separate clusters with large mortuary sambaquis being surrounded by smaller, sterile (or those without burials) sambaquis. Moreover, these clusters corresponded to sea level fluctuations when the patterns of preferred ecological zones for sambaqui construction, mangrove and salt marsh, shifted. However, many problems surround interpretations made based on sea level fluctuations including the fact that no agreement has been reached on a sea level curve for Brazil during the Holocene. These issues are discussed in greater detail below.

Ximena S. Villagran of the University of São Paulo has integrated methods developed by geologists and soil scientists into the analysis of sambaqui construction, particularly the presence of a *terra preta* layer covering Jaboticabeira II as well as many other sambaquis after 2000 BP. Using facies, or “a sedimentary unit characterized by a group of diagnostic depositional attributes identified in the field” Villagran identifies the depositional processes, both natural and anthropic, which led to the development of this particular cultural landscape (Villagran et al., 2009, 313). In an archaeological context...
the facies are referred to as archaeofacies. Using scanning electron microscopy (SEM), Multi-elemental chemical characterization, and micromorphology Villagran et al. (2008) analyzed soil samples collected from Trench 10 and Trench 11 in Jaboticabeira II in order to identify “recurrent anthropic processes of deposition.” Her work has expanded beyond Jaboticabeira II and she is now applying these same methods to other sambaquis in the Jaguaruna region.

Building a Ritual Landscape

The work of Maria Dulce Gaspar and Paulo De Blasis has been discussed briefly above. Both archaeologists argue that the sambaquis are the remnants of a ritual landscape; the lack of clearly defined habitation sites on the sambaquis and the overwhelming number of burials in the larger of these monuments has led to the interpretation that the main function of the sambaquis was as ritual centers for elaborate burial customs. Gaspar et al. (2008) interpret these funerary areas as having been specific to certain groups based on kinship, territorial affiliation, or other social category. These individual kinship mounds eventually joined to form one large mound. However, there have been no studies, at present, to verify that those buried within close proximity of one another are, in fact, related.

Individual burials are rare, with most burials being comprised of an adult and child, and secondary burials were the rule; thus, Gaspar et al. (2008) argue that burials may have taken place at a prescribed time in which all those who died within a certain time frame were brought to a central location for a community-wide burial event. Furthermore, there is evidence of later ceremonies, interpreted by Gaspar et al. (2008) as mortuary feasts, where communities would gather and light fires and consume large amounts of fish. These fires, or hearths, correspond to the location of burials below the
shell surface and these activities are believed to have led to the development of the dark organic layers within the sambaquis.

Considerably more work (i.e., excavation) is needed in the areas adjacent to sambaquis in order to understand how the sites related to one another and their purpose or purposes. Unfortunately, archaeologists still do not fully understand the rules governing mortuary ritual at these monuments since the sampling number is far too small to make generalization in regards to the sequence and timing of the proposed community burial events. For example, treatments of the bodies (e.g., covering bodies with red pigment, removal of bones, the inclusion of bones from other individuals) are inconsistent (Gaspar et al., 2008). However, greater sampling from burial sites, such as Jaboticabeira II, and sambaquis in other regions will allow archaeologists to delineate regional variations as well as fundamental mortuary behaviors throughout Brazil.
In order to understand El Niño (EN) and La Niña (LN), one must first consider the Southern Oscillation (SO). The Southern Oscillation is the term given to pressure fluctuations located in two centers; one is located over the western tropical Pacific and eastern Indian Ocean, while the other is found over the southeastern tropical Pacific (Philander, 1990, 9). These two regions are separated by thousands of kilometers, however, pressure readings at either location demonstrate that the areas are “remarkably coherent and out of phase (Philander, 1990, 9).” In the early 20th century, Sir Gilbert Walker named this phenomenon the Southern Oscillation, and much later, in the 1960’s, Jacob Bjerknes of the University of California- Los Angeles would recognize that an important relationship exists between the SO and sea surface temperatures (SST). SO is caused by variations in the interannual SST, but Philander (1990) points out that if one were to examine the phenomenon from the position of an oceanographer, the SST changes are brought about by fluctuations in the wind patterns associated with the SO. Thus, the line of reasoning becomes cyclical and complex. However, put simply, it is the interactions between the ocean (SST) and the atmosphere (wind patterns of the SO) that are the basis for fluctuations in the SO (Philander, 1990, 5). SO has become a blanket term for the immense changes in patterns of rainfall and wind fields, and its effects are found well beyond the Pacific and Indian Oceans (Philander, 1990; Allen et al., 1996).

EN and LN are phases of the SO. EN is the term for SO conditions in which the trade winds are weak and pressure is low over the eastern Pacific while pressures are high over the western tropical Pacific (Philander, 1990, 4). The term El Niño, which
translates as “the Christ child,” was originally associated with a counter-current flowing from north to south along the Peruvian coast which was said to appear after Christmas (Philander, 1990, 1). The term has been claimed by popular culture and has become both something to fear and to blame for all manner of environmental and economic disasters (Philander, 1990). However, EN and LN events vary considerably, and it is best that these be understood as a general terms.¹ EN episodes are followed by LN. LN is the phase of the SO when SST in the central and eastern tropical Pacific are unusually low and trade winds are intense (Philander, 1990, 4).

These phases translate into fluctuations in temperature and rainfall throughout South America and the westward movement of the convection zone (Martin et al., 1993). In Brazil, the disruption of precipitation patterns brought on by EN led to “strong and consistent positive anomalies in the spring of El Niño all over southern Brazil, but also in the winter of the following years in some areas” and “even stronger and more consistent negative anomalies” during the spring of LN years (Grimm, 2000, 36). However, the precipitation anomalies associated with EN and LN are particular to regions. For example, in Cabo Frio, RJ EN strengthens the normally weak trade winds leading to arid conditions. These conditions occur because the polar frontal systems are blocked due to an increase in low level jet. As a result, southern Brazil experiences “high rainfall in the blocking zone and drought in the regions located northward (Martin et al., 1993, 338).” Thus, EN and LN have a strong effect on sea surface temperatures, precipitation, as well as salinity levels. The combination of these effects influence the

¹ EN events are categorized as strong, moderate, weak, and very weak, but considerable variability exists even within these defined levels (Philander 1990: 11).
environments of the mollusk and gastropod species found in the sambaquis. As mentioned, these effects are regional, and will be discussed in greater detail below.

**Mangrove and Salt Marsh**

Mangrove represents 1,376,255 hectares of Brazilian land (de Lacerda, 2002, 8). Moreover, these rich ecosystems are key indicators of fluctuations in temperature and precipitation. Although mangroves are able to withstand temporary shifts in climate patterns they are most successful “where the coolest winter temperature is above 20°C and temperatures are constant throughout the year…and the salinity ranges between 5 and 30 ppt (de Lacerda, 2002).” Furthermore, the upper limit of mangrove temperature tolerance seems to be SST that are not warmer than 24°C throughout the year (Saenger, 2002, 3). Thus, the temperature range for the successful growth of mangrove is a very narrow 20–24°C. To be certain, temperature is the primary factor in the distribution of mangroves, and along the coast of Brazil, SST are generally above 20°C, except in Cabo Frio, RJ (de Lacerda, 2002, 40). However, the availability of fresh water is also crucial in order to reduce the build-up of salt deposits left by tidal flooding of the mangrove wetland. Rainfall is particularly important for “leaching the residual salts from the mangrove soils and reducing salinity (de Lacerda, 2002, 40).”

Cabo Frio is affected by El Niño quite differently than the more southern sites in Santa Catarina state due to local upwelling. The Cabo Frio upwelling occurs during the dry season, therefore, EN compounds the already arid conditions (Sylvestre et al., 2005). EN strengthens the normally weak trade winds leading to greater aridity, which, along with reduction of rainfall leads to an increase in evaporation and higher levels of salinity in the lagoons. However, EN is characterized in Santa Catarina by heavy
rainfall and flooding; thus, these two regions represent the two extremes in EN events (Grimm et al., 2000).

Therefore, the increased aridity and reduction in rainfall associated with EN events coupled with the cold water upwelling of Cabo Frio, RJ serve to greatly reduce and even destroy the presence of mangrove in this area. Scheel-Ybert (2000) found significant fluctuations in the presence and absence of mangrove vegetation in her charcoal analysis of six sambaquis, four of which were located in the Cabo Frio region (Sambaqui do Forte, Sambaqui Salinas Peroano, Sambaqui Boca da Barra, and Sambaqui do Meio). Her analysis demonstrated differences in the development of mangrove on either side of channel; on the western side (associated with the Sambaqui do Forte) she found an abrupt reduction of mangrove vegetation after 4900 $^{14}$C yr BP. The lack of mangrove vegetation continues until 2300 $^{14}$C yr BP when the mangrove begins to re-establish itself in the region. However, between 2000 and 1400 $^{14}$C yr BP, the charcoal analysis indicates the absence of mangrove related to an increase in aridity and a subsequent increase in salinity. On the eastern side of the channel (Sambaqui Salinas Peroano and Boca da Barra) mangrove is very well represented until 4300/4500 $^{14}$C yr BP and is never re-established (Scheel-Ybert, 2000, 116).

In Santa Catarina, the disappearance of mangrove vegetation seems to have commenced around 2000 BP. Villagran et al argue that this process was due to the desalinization which resulted from the progressive reduction of paleolagoons (Villagran et al., 2009, 313). Furthermore, this desalinization led to a decrease in A. brasiliana, a species that does not respond well to rapid desalinization, as well as some species of oyster (Villagran et al., 2009, 313). Heavy rainfall also leads to rapid desalinization, and
this region of Brazil generally receives much higher levels of rainfall during EN events and is very dry during LN events. Upon visiting Jaguaruna, Brazil I entered a snack shop for a quick bite to eat. Along one wall of the store were framed photographs of the city in 1972 when a flash flood had barreled through the small city. The streets and buildings were buried in layers of mud and debris was caught in every corner and crevice. I sat staring until the shopkeeper turned to me and began explaining that the flood had been the worst in living memory. As he continued to detail the horrors, Dr. De Blasis explained that the flood was during an EN event. I, of course, was intrigued and I found that this region of Brazil had experienced an increase in rainfall greater than 45% that year (Allan et al., 1996, 135). Therefore, flooding associated with EN conditions could have a tremendous effect upon salinity and the presence of mangrove if the events were intense and frequent.

Coastal salt marshes are very similar to mangrove environments; however, changes in SST and salinity result in different types of vegetation. Therefore, salt marsh are areas along saline bodies of water that are vegetated by herbs, grasses and/or low shrubs and, unlike mangrove, are not dominated by trees (Adam, 1990, 1). The importance of salt marsh lies in the fact that as temperatures decrease and salinity levels become unfavorable for the growth of mangrove species, areas once dominated by mangrove are gradually claimed by salt marsh. Once again, temperature is the most important factor for the development of mangrove or salt marsh. Although scientists may distinguish these areas based on the types of vegetation present in each, both environments represent an interface between land and sea. These are areas where terrestrial biota interacts with marine biota, and vice-versa (Adam, 1990). Moreover, the
sensitivity of these ecosystems to shifts in temperature and precipitation allow mangrove and salt marsh to act as gauges for climatic fluctuations.

**Mollusks**

Sambaquis are constructed with shell, fishbone, and sediment. Shell, of course, makes the greater percentage of these materials and the species that is represented most is *Anomalocardia brasiliana*. In Brazil, this species is called berbigão and is found burrowing at shallow depths of 0.5 to 1.5 m in the muddy sand along mangrove borders (Mouëza et al., 1999, 73). However, experiments have found this mollusk to be able to withstand a large range of salinities (Leonel et al., 1983). *A. brasiliana* experiences high mortality rates during heavy rains which quickly and drastically reduce salinity levels (Mouëza et al., 1999, 73). Although the species is small, 45 mm maximum shell length, it is used extensively for food today just as it was in the past (Figure 4-1).

![Figure 4-1. *Anomalocardia brasiliana* or berbigão.](image)

The venerid clam is distributed from the West Indies to as far south as Uruguay (Mouëza et al., 1999, 73). As mentioned, the species can survive an incredible range of
salinities; from 17% to 42.5% although at salinities higher than this the clam closes tightly and respiration slows as a natural defense against desiccation (Leonel et al., 1983). The species can only maintain this defense for so long, however, and experiments demonstrated that the animals will die within 492 hours at salinity levels higher than 42.5%. *A. brasiliana* is considered to be a euryhaline organism due to its tolerance of a wide range of salinities (Kinne, 1964, 284; Leonel et al., 1983). Perhaps the ability of this species to survive such extreme changes in salinity contributes to its almost continuous presence throughout the period of intensive sambaqui construction along the coast of Brazil (6000–1600 BP). Unlike other mollusk species, the availability and/or the human desire to collect *A. brasiliana* does not seem to have diminished through time or space until around 2000 BP (Gaspar et al., 2008, 327). For example, the clam is found, generally in great abundance, in every layer containing shell in Jaboticabeira II (Bendazzoli, 2007), and the construction of this mound began in 2500 BP and terminated around 1700 BP (Gaspar et al., 2008, 327). Furthermore, the clam is found in both the cold upwelling environment of Cabo Frio, RJ and the sites of Camacho, SC much farther to the south. Thus, the use of this species to construct sambaquis spans across space and time and indicates a surprising level of cultural continuity and tradition.

Another prominent, though not as ubiquitous as *A. brasiliana*, species is *Brachidontes solisianus*. The Brazilian term for this species is mariscos. In experiments carried out by Zuim and Mendes (1980), *B. solisianus* tolerated salinities between 14.1% and 35.2% during a period of ten days. Furthermore, the authors argued that the species would be greatly affected by heavy rainfall since they prefer to
inhabit the rocky shores found at higher elevations. *P. perna*, a species that also attaches itself to the rocky shore although at lower elevations, survived salinities between 21.1 % and 35.2 % during a period of ten days (Zuim et al., 1980). *P. perna* is known as mexilhão in Brazil.² *Donax* sp. is found mixed with *A. brasiliana* in the more southern sites (Prous, 1991, 210). Table 4-1 presents temperature and salinity ranges within which mollusk species found at Jaboticabeira II will survive.

**Beach Ridge Formation**

Beach ridges are the accumulation of sediment and sand, or the result of longshore transport, running parallel to the shoreline and are the result of wave action. In Rio de Janeiro, beach ridge plains are found in the northeastern part of the state. The Paraíba do Sul River meets the coast, resulting in a large delta complex (Dias et al., 2009, 232). These beach ridges are “storm wave-built ridges” and consist of “quartzose medium sand in areas not dominated by wave action (Dias et al., 2009, 233).” The beach ridges of Paraíba do Sul are mainly formed in a south to north direction due to high energy storm waves from the southeast (Dias et al., 2009, 235). However, changes in longshore sand transport lasting much longer than a few months are recorded in the fossil beach ridges along the Brazilian coast (Martin et al., 1993). As mentioned earlier, EN events (or conditions similar to EN) block the polar frontal systems and increase subtropical jet. As a result, the swells that are normally generated from the south do not reach the central shoreline of Brazil, and the stronger northern swells transport sand from north to south (Martin et al., 1993, 340). Longshore

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² It should be noted that the survival rates of species differ between life stages. For instance, *P. perna* embryos had very little resistance to different temperature and salinity combinations, however, veligers, or individuals in the larval stage, demonstrated high levels of resistance. I have chosen not to include this variable since the mollusks found in the sambaquis represent individuals that have matured beyond the veliger state (Romero et al., 1990).
transport reversed southward at least three times between 2500 yr BP and the present (2200 ± 200 yr BP, 1300± 200 yr BP, and a recent, though undefined time). During these periods, the southeastern swells did not reach the central shoreline of Brazil and are indicative of EN events or EN like conditions (Martin et al., 1993). Furthermore, the authors believe these events to have lasted several decades (Martin et al., 1993, 345). A sediment core collected in the hypersaline lagoon of Brejo do Espinho in Cabo Frio supports the dates obtained from the beach ridge study. Cabo Frio experiences hyperaridity during EN events, and the core demonstrated a drastic increase in arid conditions at 2200 yr BP (Sylvestre et al., 2004). After this time, trade winds dominated and the authors argue these conditions indicate an increase in EN activity (Sylvestre et al., 2004). Therefore, both beach ridge and core analyses suggest an increase in the frequency and intensity of the effects of EN events around 2200 yr BP.

**Sea Level Fluctuation along the Brazilian Coast**

Coastal barriers, such as dune fields, are related to rising sea levels; however, beach ridges are the result of coastal progradation, which is related to falling sea levels (Dias et al., 2009, 230). Sea level variability has been hotly debated for decades, but recent work by Angulo et al. (2006) has found that present relative sea levels were reached as early as 7,550 yr BP or as late as 6,500 yr BP, and, then, sea levels began to rise 3 to 4 meters until a high stand was reached between 5195 ± 110 yr BP and 5410 ± 80 yr BP along the coast of Brazil. Maximum Holocene sea levels reached about 2.1 m along Santa Catarina, while, to the north, sea levels did not exceed 4 meters (Angulo et al., 2006, 500). Then, relative sea level fell slowly, with minor oscillations, until reaching today’s average sea level.
The nature of sea-level oscillations (whether high energy or low energy) along with the lack of precise paleo-sea-level indicators have made it difficult to define a paleo-sea level curve upon which all can agree (See Angulo et al., 2006). For example, the positions of the sambaquis were used by Suguio et al. (1992) to establish periods of sea transgressions and regressions. They concluded that the coastline had oscillated considerably in the past 7000 years; however, Angulo et al. (2006) argue that the paleo-sea-level indicators, such as shell and wood fragments, used to construct the paleo-sea-level curve in the past have been problematic due to the factors surrounding the deposition of these indicators. In the case of the wood fragments, they had been transported through muddy sediment, and Angulo et al. (2006) points out that “it is possible the muddy sediments from where the samples were collected were indeed a paleo-estuarine deposit, but of sub-tidal elevation (492).” Thus, the dates from these wood fragments would indicate a period of low relative sea level rather than a period of transgression. Regardless of the sea level curve used, sea levels were in a state of decline from 2500 BP to present (See Angulo, 2006). Therefore, during the period in which EN and LN conditions are recorded the sea level along the coast of Brazil was in a state of regression.

**Jaboticabeira II - Santa Catarina, Brazil**

I have chosen to utilize the layers as they are defined by Klökler (2000). Composition data from three profiles of Locus 1–1.15, 1.25, and 1.40 – and their corresponding layers were graphed in order to demonstrate anomalies and general patterns. The graphs are based on the frequency of species in samples taken by Klökler (2000). Weight has not been included since issues with weight between species as well as levels of preservation make interpretation difficult. The species which pertain
to this analysis and have been defined by Klökler as primary species are as follows: *Anomalocardia brasiliana*, *Brachidontes solisanus*, *Lucina pectinatus*, *Cyrtopleura* sp., *Ostrea* sp., and *Thais haemastoma*, while fish bone, burned bone, charcoal, otoliths, mammal bone, crab, and barnacles are defined as secondary (Klökler, 2000, 81).

Although the mollusks that make up the primary category respond differently to changes in temperature and salinity (Table 4-1) one would expect that as Primary materials became harder to procure the sambaqui people would come to rely more heavily on Secondary and/or Inorganic materials, or those materials consisting of species more tolerant of changes in salinity and temperature, for their construction needs.

A general pattern, which is that of an “L” shape, is found when reviewing the relationships among the three categories. Certainly, the topmost layer which is a form of *terra preta* tends to be an anomaly among the other layers. However, even within the same sambaqui this layer does not consist of the same composition pattern throughout the different profiles. The structures also tend to stand out. As previously mentioned, structures are features within a layer that represent a specific moment in time in which the sambaqui people were actively engaged with the layer that encompasses the structure. However, within Profile 1.40, one will notice that although a structure is present it follows the same “L” pattern of the other layers (Figure 4-4). It is important to note that the structures most closely resemble the layer they are within, and in the case of 1.25-1.25.2 Structure the feature actually overlaps into the above layer of 1.25.1 (Figure 4-3) (Bendazzoli, 2007). Thus, due to the event-like nature of the structures and their relationship with the surrounding layers they will not be considered separately from the greater layers. In other words, the structures will be
analyzed as an event which took place during the construction of the layer, and not representative of the layer as a whole.

![Figure 4-2. Primary, Secondary, and Inorganic components for layers of Profile 1.15.](image)

Figure 4-2. Primary, Secondary, and Inorganic components for layers of Profile 1.15.

The different profiles exhibit a correlation between the amount of primary components and secondary/inorganic components. For example, Layer 1.25.35 has a large reduction in the quantity of primary components and, as expected, secondary and inorganic components make up a larger percentage of that layer (Figure 4-3). Furthermore, the date of the 1.25.3 layer corresponds to the timeframe in which EN conditions are documented in the reversal of long shore transport in beach ridges along the Brazilian coast (2170 ± 45 yr BP and 2200 ± 200 yr BP, respectively).
Figure 4-3. Primary, Secondary, and Inorganic components for layers of Profile 1.25.

The individual primary species graphs presented were also developed using MNI data from Klökler (2000). In my analysis, I identified five species of interest (A. brasiliana, B. solisanus, L. pectinatus, Thais sp., Ostrea sp.) which are defined as primary species and fish bone, and the relative numbers of individuals are given in Figures 4-6 through 4-8. In this analysis, I was interested to see how individual species that made up the primary category interacted with one another during EN events. Generally, it seems that as A. brasiliana is reduced B. solisanus is used as a supplementary material.
Figure 4-4. Primary, Secondary, and Inorganic components for layers of Profile 1.40.

For example, if one consider Figure 4-7 and layer 1.25.21 a drastic reduction in 
*A. brasiliana* corresponds to a large increase in *B. solisanus*. Moreover, the same 
pattern is found in profile 1.40 (Figure 4-8). In this case, layer 1.40.36 is dated as 
having been constructed at 2210 ± 60 yr BP, or within the time period in which evidence 
of EN (reversal of long-shore drift, hyperaridity in Cabo Frio) is found along the coast of 
Brazil.

In layers 1.25.21 (Figure 4-6) and 1.40.36 (Figure 4-7) as *A. brasiliana* decreases 
as a prime component *B. solisanus* increases. *B. solisanus* is capable of withstanding 
lower salinity levels, which would result from the rapid desalinization of lagoons during 
flooding events, than *A. brasiliana*, but not by much (Table 4-1). Unfortunately, only 
layer 1.40.36 has been dated (2210 ± 60 yr BP) (Klöker, 2000), and without a date for 
1.25.21 it is impossible to argue these layers represent the same event. However, the 
data does seem to support the argument that as a primary species decreases in 
frequency within a layer, species better equipped to withstand changes in salinity and
temperature increase. Then, as mangrove and paleolagoons continued to disappear around 2000 BP along with the mollusk species associated with these ecosystems, it seems very likely that sediment and fish bone were used in lieu of shell building material.

![Figure 4-5. Frequency of individual species and fish bone within layers of Profile 1.15.](image)

**Discussion**

Therefore, with the supporting evidence from beach ridges, the sediment core from Brejo do Espinho, and the presence and absence of mangrove in Cabo Frio, the construction of Jaboticabeira II was affected by EN events. Preferred materials were supplemented with sediment and fish bone during the construction of layers corresponding to EN events. Outside of these EN events, construction materials occur in the 'normal' percentages demonstrated in the graphs (i.e., the “L” shape).
However, once the preferred primary materials, mollusk shell, the sambaqui people were presented with dilemma of what material should be used in their monument construction and it is this choice that archaeologists bear witness to the dialogue between humans and their environment over time. When a group must negotiate their terms, as in changes in monumental construction brought on by lack of preferred materials, archaeologists must analyze what the group deemed negotiable and non-negotiable. Non-negotiables are fundamental to cultural identity, whether it is construction materials or burial customs, and these non-negotiables are only slowly and grudgingly altered. Within this process a group demonstrates the value they place on different cultural markers through time.
Figure 4-7. Frequency of individual species and fish bone within the layers of Profile 1.40.

The graphs labeled Figures 4-2 through 4-7 demonstrate a steady trend towards higher percentages of fish bone in the layers of Jab II. Why fish bone? As a construction material, it does not offer the same level of durability found in mollusk shells. Perhaps fish are representative of both food and the ocean like mollusks; therefore the use of fish bone may have fulfilled a symbolic or ritual requirement in the construction of sambaquis. Thus, it is in recognizing the options that were present and the choices made that we move beyond construction material percentages and begin to understand the value system of a people. Furthermore, the location of sambaquis seems to be non-negotiable. As the habitats desired for sambaqui construction (e.g., mangrove, lagoons) migrated so, too, did the sambaquis associated with them. Kneip (2004) argues that stranded sambaquis, or those sambaquis that are as much as 10 km inland today, were once associated with open bays but these shell mounds were abandoned when they became disconnected from the bay. Kneip (2004) postulates
that the shrinking of bays is due to the gradual lowering of the sea level, however, as discussed above, sea level in this region remains a point of contention among geologists.

I must admit that more detailed data is needed on the fish species represented in the category of secondary species. Of course, unlike mollusks fish are extremely mobile creatures and are, therefore, able to readily respond to unfavorable conditions by moving to a different location. However, knowing the temperature and salinity requirements of the fish in the secondary category would serve to flesh out any argument for the presence of EN and its consequences.

Regardless of whether these monuments were sites of funerary ritual or simply built to get a better view of the landscape there is a rhyme and reason to their construction, and it is in these patterns that archaeologists can hope to understand a people almost completely lost to time. The descendants of the sambaqui people seem to have migrated or been absorbed by the aggressive Tupi-Guarani tribes that would later mark the surfaces of sambaquis with their ceramic technology. Thus, we have no contemporary group which can be used as an ethnographic anchor, but that method has inherent problems anyway (e.g., navigating the effects of colonialism). Rather than searching for why the sambaquis were built, I propose that we focus on how and in what context they were built, because while being a proxy for paleoclimate, they also offer cultural deep time, or the opportunity to analyze fundamental changes in culture over thousands of years and the environmental changes that may have brought on those alterations.
It is not my intent to argue that El Niño brought about the end of tradition spanning thousands of years; that notion is far too simplistic to even be considered. Rather, EN acted as a recurring force that changed the choices the sambaqui people had before them, and archaeologists can see and quantify the choices they made – we are privy to the dialogue between humans and their environment which is preserved on a cultural landscape.

**Future Research**

Sambaqui research has been restricted to studying profiles and trenches exposed due the mining of shell during the colonial period. As limited as this method is it has yielded a great deal of data. Therefore, more intensive excavation over a larger area certainly holds incredible promise. A large scale excavation of the burial areas in Jab II is planned, but funding has put this project on hold indefinitely. As mentioned above, research must move “off the sambaqui” if archaeologists are to understand how these sites relate to one another and to the communities that built them. Of course, the work of those archaeologists engaging in interdisciplinary research is addressing the complex relationship between a community and their environment and the resulting landscape. The remnants of the rich lives of the sambaqui people are currently confined to huge shell mounds that offer cryptic responses to our questions, but, perhaps we have not been asking the right questions.
CHAPTER 4
CONCLUSION

The effects of El Niño, a phase of the Southern Oscillation are felt throughout South America. Although the effects of paleoclimate fluctuations, such as El Niños, on the development of monumental architecture have been studied in great detail in Peru, archaeologists in Brazil have focused on the overwhelming need to map sambaqui sites; these monuments have systematically been destroyed since the colonial period as a result of shell mining to make lime, roads, and buildings. Recent efforts by archaeologists working with the sambaquis have been increasingly interdisciplinary in nature and the environmental context of sambaqui construction is enjoying the greatest interest. Therefore, this paper applies the Peruvian model to the sambaquis of Brazil in order answer what effects El Niño had on the construction of sambaquis and what interpretations can be made from the changes in construction techniques.

Changes in water temperature and salinity levels along the coast of Brazil occur during El Niño events, and these fluctuations affect the mollusk populations upon which the sambaqui peopleed relied for the construction of their sambaquis. Building materials, such as *A. brasiliana*, which may or may not have had symbolic value, were sought out over thousands of years for the construction of sambaquis. However, around 2000 BP this and other popular mollusk species were supplemented with “fillers” such as sediment and fish bone. Using the work of Klökler (2000), I examined changes in the proportion of primary and secondary building materials as well as the frequency of individual species within those categories within the layers of three profiles of Jaboticabeira II. Mollusk species respond differently to changes in temperature and salinity, with some species being better adapted than others to sudden fluctuations.
These changes were correlated with the reversal of long-shore transport; high salinity levels in a sediment core from Brejo do Espinho, and the decline of mangrove in Cabo Frio and offer evidence of an El Niño around 2000 BP. Therefore, El Niño events affected the construction of sambaquis by limiting or eliminating the preferred building material. Thus, interpretations can be made based on the materials used to replace the preferred mollusk species. For example, fish bone was increasingly used as a supplementary building material despite the fact that fish bone differs greatly from shell in terms of compaction and rate of degradation. Therefore, it can be argued that the building materials were not chosen based on their durability and/or ‘build-ability’.

However, more detailed data is needed on the fish species of the secondary category and their habitat requirements before strong interpretations can be made.

Once archaeologists have grasped the variables (e.g., El Niño, sea level fluctuations, in-filling of bays) surrounding the building of these monuments the next step is to establish patterns of regional variation among sites. In order to so, however, intensive and large scale excavation must take place on sambaquis and the areas adjacent to the monuments. Future work will focus on the large scale excavation of the burial areas of Jaboticabeira II.
Table 4-1. Minimum and maximum critical temperature and salinity levels for species found at Jaboticabeira II and the effects of temperature and salinity on the survival of species found at Jaboticabeira II

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bivalvia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anomalocardia brasiliana</em> (Gmelin, 1791)</td>
<td>No Data</td>
<td>17%</td>
<td>No Data</td>
<td>42.5%</td>
</tr>
<tr>
<td><em>Perna perna</em> (Linné, 1758)</td>
<td>10</td>
<td>15%</td>
<td>35</td>
<td>55%</td>
</tr>
<tr>
<td><em>Lucina pectinata</em> (Bruguiere, 1797)</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td><em>Brachidontes</em> sp. (Swainson, 1840)</td>
<td>No Data</td>
<td>14.1%</td>
<td>No Data</td>
<td>35.2%</td>
</tr>
<tr>
<td><em>Donax</em> sp. (Hanley, 1843)</td>
<td>20</td>
<td>8%</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td><em>Cyrtopleura costata</em></td>
<td>&lt; 15</td>
<td>15%</td>
<td>35</td>
<td>30%</td>
</tr>
<tr>
<td>Marine Gastropods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Thais haemastoma</em></td>
<td>15</td>
<td>15%</td>
<td>30</td>
<td>35%</td>
</tr>
<tr>
<td><em>Nassarius vibex</em></td>
<td>No Data</td>
<td>10%</td>
<td>31</td>
<td>No Data</td>
</tr>
</tbody>
</table>
LIST OF REFERENCES


Hurt, W.R. 1964. The Interrelationships Between the Natural Environment and Four Sambaquis, Coast of Santa Catarina, Brazil. Indiana University Museum, Bloomington, Indiana.


South American Climate from the Cabo Frio Lagoonal System (Brazil) During the Last 5000 Years. The Holocene, 15, (4), 625-630.


BIOGRAPHICAL SKETCH

Kiristen Bright received her B.A. in anthropology from the University of Kentucky in 2006. Upon completion of her undergraduate work she pursued a master’s degree in anthropology from the University of Florida and received her M.A. in the spring of 2010. Her work has focused primarily on the archaeology of prehistoric ritual landscapes. She plans to continue her graduate work in archaeology.