Spatial Analysis of Archaeological Assemblages from the Late Ceramic Age (AD 400-1400) Site of Grand Bay, Carriacou, West Indies

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Spatial Analysis of Archaeological Assemblages from the Late Ceramic Age (AD 400-1400)

Site of Grand Bay, Carriacou, West Indies

by

Kara I. Casto

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts with a concentration in Cultural Resources Management

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Keywords: Caribbean, coastal erosion, GIS, site formation, spatial distribution, island archaeology

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Dedication

For my grandmother, Betty Jane Nethken
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First, I would like to extend my eternal gratitude to Scott Fitzpatrick, Michiel Kappers, and Quetta Kaye for their guidance throughout my time spent as a member of the Carriacou Archaeological Field Project. Thank you for having faith in my abilities and research proposals. Scott, I would like to thank you for your willingness and promptness to address all of my questions and concerns about my research, taking time out of a busy schedule to read this thesis, and especially for introducing me to the real world of archaeology which has allowed me to pursue a career that I enjoy immensely. Michiel, you are my “metadata” hero and without your gracious sharing of the Carriacou data, this thesis would not exist. I also want to thank you for having a contagious fun-loving spirit, providing comedic relief during long days in the field and lab, and answering all of my database and GIS questions.

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Abstract

The present study utilizes a geographic information system (GIS) to examine the spatial relationships between the assemblages of major artifact and ecofact categories at the Late Ceramic Age (AD 400-1400) site of Grand Bay, Carriacou. In addition, the study examines how these assemblages formed through various cultural and natural formation processes and have been affected by recent episodes of coastal erosion. Previous archaeological research for this region of the Caribbean is lacking, but with the determined efforts of the Carriacou Archaeological Field Project, Grand Bay’s role has been brought to the forefront of current investigations answering questions about pre-Columbian migration and colonization of the Lesser Antilles, inter-island exchange systems, maritime adaptations, and subsistence economies. With the rapid destruction of Grand Bay’s archaeological resources through coastal erosion exacerbated by illegal sand mining, the site also has the potential to provide information on site management and preservation practices of coastal and island archaeological and historical sites that has created open and continuous discourse between archaeologists, lawmakers, landowners, and other key stakeholders. As Grand Bay is one of the most intensively occupied sites in the southern Lesser Antilles, its value to Caribbean archaeology is undeniable. Thus, its immediate study and preservation are imperative before what information can be gleaned from the site is lost forever.

Using data gathered from four field seasons at Grand Bay and spatial autocorrelation and cluster analysis, the present study aims to identify spatial patterns within the distributions of
major archaeological materials categories. These two forms of spatial analysis focus on identifying clusters and individual outliers within the assemblages that are then used to examine site formation processes, identify potential activity areas, and interpret the overall spatial organization and distribution of archaeological materials at Grand Bay.

Analysis of Grand Bay’s archaeological assemblage shows that three main material categories – ceramics, vertebrate remains, and shell – are, in general, spatially correlated and form the majority of the midden deposits at Grand Bay. Clustering of these materials shows that different areas of the site were used more intensively over time resulting in patterns of higher artifact concentration in these areas. The possible clustering of coral artifacts can likely be explained by the storage of this resource for use in tool manufacture. Areas of clustering and outliers among shell and vertebrate assemblages can be explained by differing excavation techniques and the effectiveness of wet-screening to recover smaller constituents vital to understanding Grand Bay’s subsistence economies.

Within the assemblages recovered in the habitation area at Grand Bay, clustering of the three main material categories may indicate the primary deposition of refuse or the spread of the midden deposits into this space. Further analysis of diagnostic ceramics is required to fully understand this clustering pattern. The separate cluster of stone artifacts may represent a lapidary and or tool manufacture activity area.

Although some inconsistencies were revealed in the data, and a lack of data for deeper midden deposits did not allow for further analysis, overall this study provides evidence to support basic inferences about the formation of the midden deposits at Grand Bay through cultural processes and the effect coastal erosion has on these interpretations. A final purpose of the study is to demonstrate how spatial analysis of the data supports and/or refutes these
interpretations. Results from the analyses in this study should not be viewed as definitive, but as a stepping stone for future research at Grand Bay.
Chapter 1:
Introduction

Artifacts are the physical representation of human cultural behaviors and as such can be used to make numerous interpretations about prehistoric societies. Numerous causative processes including erosion, social organization, resource procurement, length of occupation, and activity loci affect the formation of an archaeological site and its material assemblages. Cultural formation processes can provide clues about anthropogenic modification of the landscape, discard of artifacts, site abandonment and reuse while natural formation processes interact with cultural processes to transform site locations further and inform investigators about post depositional effects on artifact distributions (Rossignol 1992:6).

The purpose of this thesis is to examine spatial distributions and temporal changes within the archaeological assemblages of the Late Ceramic Age (ca. AD 400-1400) site of Grand Bay on the island of Carriacou. Archaeological investigation of Grand Bay has been the primary goal of the Carriacou Archaeological Field Project (CAFP) since 2004 and has resulted in a plentiful artifactual assemblage. Spatiotemporal analysis of this assemblage will provide a gateway to understanding site formation processes, both natural and cultural, which serve as systematic links between archaeological remains and past cultural systems (Schiffer 1976:12). Natural processes are of special concern at Grand Bay as the site’s location on the eastern shores of the island has had a significant impact on recent changes in its extent. These processes have made their mark on the site over the last 10 years through the destruction caused by hurricanes and tropical
storms, both rare occurrences in this part of the Caribbean. Sadly, the rates of erosion have been intensified due to modern human activity in the form of sand mining along the shoreline for construction purposes (Fitzpatrick et al. 2006).

I envision that this study will reinforce the importance of graphic illustration and spatial analysis of artifact assemblages. Viewing artifact clusters is instrumental in determining global and local spatial patterns, which can then be related to site formation processes, artifact deposition, and resource acquisition. Through this study, I expect that these patterns will offer further insight into how Grand Bay and its local resources were used during the site’s occupation.

To my knowledge and after exhaustive research efforts, my analysis in this thesis is likely one of a limited number of studies to utilize ArcGIS and its spatial analysis tools to examine intrasite artifact distributions in the Caribbean. While using pen and paper to map artifact distributions is adequate, newer technologies, such as ArcGIS, allow for quicker manipulation and analysis of extensive archaeological databases. Therefore, this study could have a great impact on the use of GIS for artifact distribution analysis within Caribbean archaeological research and provide a stepping stone for further investigation into the dynamics of site formation processes within this region.

Despite the lack of similar studies within the Caribbean, it is evident from the available sources that intrasite spatial analysis can provide insight into the general research questions spatial analysis attempts to answer or at least provide some avenues for interpretation of the archaeological record. The questions I hope to address with my analysis are: What can these distributions tell us about the spatial organization of archaeological sites? Are there distinctions between activity areas within sites? What do artifact distributions tell us about post-depositional processes and their effects on the archaeological record? Do these distributions reflect changes in
resource acquisition, intensification, and/or depletion? Do variations in the distributions relate to cultural changes or adaptations? These are only a few questions that can be answered through spatial analysis to further the understanding of the archaeological record and provide direction for the conservation and management of cultural heritage at Grand Bay and throughout the world.

Finally, I hope to highlight areas for future excavation. The amount of cultural material being lost at Grand Bay is significant. Because Grand Bay is one of the most intensively occupied sites in the southern Caribbean, its investigation has potential to provide information about inter-island exchange, settlement patterns within the Lesser Antilles and the Caribbean as a whole, marine resource exploitation, and adaptations to local environments (Fitzpatrick et al. 2006). The incorporation of public archaeology and heritage management as part the CAFP has also helped to bring awareness to this site and its destruction. If areas of high potential can be identified, we can more confidently interpret the natural and cultural processes that helped shape the site we see today and provide more substantiated proof for the protection of Carriacou’s invaluable archaeological history.

**Organization of the Thesis**

This thesis is organized into eight chapters. The case study of Grand Bay is presented in Chapter 2. This case study examines the use of spatial analysis for interpretation of the effects natural and cultural processes have on artifact assemblages and what measures can be taken to mitigate these effects. The environmental context and cultural chronology for the site is discussed as well as previous archaeological work. Summaries of the investigations at Grand Bay by the CAFP are also provided in this chapter.
Chapter 3 reviews relevant literature that pertains to site formation processes and intrasite spatial analysis. First, I provide a theoretical framework for the study of formation processes. I then provide summaries of relevant studies for various methods of analysis used to determine these processes and how they persist in the archaeological record. In the final section of this chapter, I discuss the study of site formation processes from a Caribbean perspective citing several works that have performed intrasite spatial analysis on Caribbean artifact assemblages and archaeological sites.

In Chapter 4, I discuss coastal erosion and its impacts on coastal and island archaeological resources. A variety of global studies are cited that address these impacts and provide recommendations for the preservation and management of these fast-disappearing resources. I then examine the role of archaeology, cultural resource management, heritage management and heritage tourism within the Caribbean as a means of protecting coastal sites. The efforts of the CAFP to develop collaborative discourse among key stakeholders in Carriacou’s archaeological resources are also discussed within this chapter.

Chapter 5 summarizes the various methods used to collect and analyze data in the field and laboratory employed by the CAFP as well as the methods by which spatial data were obtained and transformed for use within ArcGIS. The last section of this chapter contains the methods of spatial analysis I utilized to understand these artifact distributions better, as well as relevant case studies to provide context for these types of analysis.

In Chapter 6, I provide a preliminary analysis of the artifact assemblages through the use of distribution maps of each major material category analyzed in this study – ceramics, vertebrate remains, shell, stone, and coral. This is done as a natural first step in understanding the spatial organization of Grand Bay’s assemblage.
Chapter 7 presents the results of the first method of spatial analysis utilized – the Global Moran’s I index for spatial autocorrelation. I examine the results of these analyses for each of the five major materials categories recovered at Grand Bay to determine if the artifacts within the midden and habitation components of the site are randomly distributed or form distinct clusters within each level of excavation. The final section provides a discussion of the results, their implications for various formation processes, such as localized activity areas, and how these patterns change or persist throughout the formation of the archaeological deposits.

The results of local cluster analysis are presented in Chapter 8. This type of analysis, Anselin’s Local Moran’s I, was used to determine if there were any spatial outliers in the artifact distributions and what these outliers may suggest about the cultural and natural formation processes at Grand Bay. This analysis further substantiates the results of the Global Moran’s test by identifying statistically significant “hot” and “cold” spots within the distributions. The final section discusses what these outliers and clusters imply about refuse deposition at Grand Bay, natural processes that may have formed these clusters, and the impacts of coastal erosion on the clustering or spatial separation of archaeological materials within the deposits.

I present my conclusions in Chapter 9 along with recommendations regarding the future archaeological investigation, site management and protection of Grand Bay. In addition, I provide conclusions about the utility of the spatial analysis techniques for interpretation of intrasite artifact distributions and the formation processes that created these distributions at Grand Bay.
As a case study of how site formation processes can be inferred using spatial analysis, I will use the case of a Ceramic Age (ca. AD 400-1400) site, Grand Bay, located on the eastern shoreline of Carriacou. First, I present the general location of the study area followed by a description of the environmental setting of the area. A brief description of previous archaeological research concerning the prehistory of the region is followed by the cultural chronologies of the Lesser Antilles providing context for Grand Bay’s cultural associations. Last, a summary of the history of the CAFP between 2003 and 2008 are provided.

Project Location and Environmental Setting

The island of Carriacou is located in the southern Lesser Antilles in the West Indies, approximately 250 km north of Venezuela and 30 km north of Grenada and is the largest island in the Grenadines, with a surface area of roughly 32 sq km (Figure 2.1; Fitzpatrick et al. 2004). Carriacou is one of three islands that belong politically to Grenada, Petit Martinique being the third and northernmost of the three.

Geologically, the island is moderately complex with a mixture of volcanic rocks overlain by Miocene fossiliferous limestone, with Grand Bay located within the Grand Bay formation that is primarily comprised of such Miocene-age turbiditic, volcanioclastic, fossiliferous sandstones (Donovan et al. 2002; Donovan et al. 2003; Jackson et al. 2008; Pickerill et al. 2002). The region
Figure 2.1: Map of Caribbean with location of Carriacou (from Fitzpatrick et al. 2009:248)
is tectonically and volcanically active, the creation of the Lesser Antilles being primarily through the subduction of the North American plate under the Caribbean plate. Carriacou sits on the southern Lesser Antilles platform in immediate proximity of three active volcanoes – the submarine Kick’em Jenny (last eruption 2001) about 20 km south of Carriacou, Mount Saint Catherine on Grenada (last eruption ca. 1000 years ago), and Soufrière on Saint Vincent (last eruption 1979) (Heath et al. 1998).

As shown in Figure 2.2, the project area is located on the eastern (windward) shore of the island of Carriacou. Higher elevations are depicted as darker areas in Figure 2.2, with the highest points on the island reaching heights of approximately 290 m (Fitzpatrick et al. 2004). Figure 2.3a-d shows that most of the site is low grassland which is grazed by cows, donkeys, and goats. Many parts of the site are overgrown with thorny scrub, cactus, and Manchineel (Hippomane mancinella) – a tree that produces poisonous apple-like fruits and a milky white sap that will cause blistering of the skin with even limited exposure and was reportedly used by Caribs to poison their arrows (Jones 2007).

As with other islands in the Lesser Antilles, Carriacou experiences summer wet and winter dry seasons. Despite its lack of permanent streams, a number of springs and rainwater collect in natural basins across the island during the wettest months (Bullen and Bullen 1972; Sutty 1991). Although rare in this part of the Caribbean, recent hurricanes have had a profound impact on the coastal profile at Grand Bay, with an estimated 1 m of cultural material being lost each year; this damage has been exacerbated by unsanctioned sand mining for local development (Figure 2.4; Fitzpatrick et al. 2006).

The Grand Bay site covers an area of approximately 6000 sq m and stretches for about 130 m along the coast (Figures 2.5a and 2.6). Stratified layers of densely packed midden
Figure 2.2: Map of Carriacou showing topography and site locations. Darker areas of the map correspond to higher elevations, with the highest peaks reaching 290 m. (courtesy of Michiel Kappers)
Figure 2.3: Vegetation and terrestrial fauna at Grand Bay. a) Free roaming cow grazing among prickly pear (*Opuntia* sp.) and shrubs; b) Goats roaming along the coastal profile; c) Iguana (*Iguana iguana*); and d) Windswept shrubs, prickly pear, and Manchineel (pictured on far right). Note the pile of queen conch in the center left of the photograph recovered during excavations and culturally deposited specimens protruding from walls in excavation trenches. This concentration of conch shell is possible evidence of stockpiling (photographs by Kara I. Casto).

deposits, up to 1.5 m deep, along with posthole/pit features and human burials, can be seen in the coastal profiles (Figure 2.6b-d). Rainwater gullies also inter-cut the site, revealing the depth of the humic topsoil and exposing an orange/yellow subsoil into which posthole/pit and hearth features, indicative of domestic activities, were cut (see Figures 2.5 and 2.7).

A coral reef lies approximately 1.5 km offshore providing some protection to the shoreline and a plethora of diverse marine resources for prehistoric site occupants as evidenced
by the abundance of coral and shell tools, *Eustrombus (Lobatus) gigas* (formerly *Strombus gigas*, [Giovas 2013:37]), numerous bony fish and mollusk species, and sea turtles as identified through extensive zooarchaeological analyses of midden deposits (Fitzpatrick et al. 2009; Giovas 2009, 2013; LeFebvre 2007). The island is also home to a variety of terrestrial fauna that were exploited by prehistoric inhabitants, including iguanas, lizards, birds, and mammals such as opossums, the now-extinct rice rat, and agoutis (LeFebvre 2007).

**Archaeological Background**

Until the 2000s, with the initiation of the CAFP, there was a paucity of archaeological research on Carriacou as compared with other islands in the Lesser Antilles. Because of this lack in research, little was known about the first occupation of the island, extent of sites, or connections between population groups within the region. Jesse Fewkes was the first known scholar to visit the island in 1904. His research focused on the analysis of ceramics to document early occupation (Fewkes 1914, 1970[1907]; Fitzpatrick et al. 2006; Fitzpatrick et al. 2008).
Fewkes described the artifacts he collected as “among the finest West Indian ware that has yet come to the Smithsonian Institution” (Fewkes 1970:189-190 [1907]).

Bullen and Bullen (1972) were the next to visit the island, where they spent two days in 1969 examining three sites – Sabazan, Grand Bay, and Dover – on the south and east coasts (see Figure 2.2). Ceramic artifacts recovered were identified as belonging to a wide range of cultural affiliations ranging from Insular Saladoid to late Suazoid. The only excavation carried out by the Bullens was a single, foot thick “slice” of the profile at the east end of the Sabazan site from which charcoal samples were collected, dated and published as “940 ± 100 years B.P. or about AD 1010” (Bullen and Bullen 1972:17). The Bullens went on to suggest that the date would apply to the end of the Modified Saladoid period or the introduction of Caliviny ceramics.

Figure 2.5: Coastal profile at Grand Bay. a) View of coast at Grand Bay facing south; b) Posthole, left, and human burial, right, in the coastal profile; c and d) CAFP bioarchaeologist Dr. Scott Burnett and undergraduate student Amanda Novotny excavating a human burial in the coastal profile (photographs by Scott M. Fitzpatrick)
Figure 2.6: Plan view of the Grand Bay site with superimposed grid system. Excavated trenches are marked with diagonal hatching.
Figure 2.7: Plan view of cultural features and probable habitation area at Grand Bay
Leslie Sutty (1990) surveyed sites on Carriacou and recorded surface finds at Sabazan, Grand Bay, and several other prehistoric sites. However, she did not perform any excavations, only providing a preliminary compilation of Carriacou’s prehistory. Grand Bay was noted as perhaps the most important site based on the diverse array of ceramic styles and its extent, which Sutty said extended “some 10 to 12 acres” (Sutty 1990:246). These observations led future archaeologists towards a similar conclusion about the importance of the Grand Bay site and the necessity for intensive excavations to understand settlement and migratory patterns in the Caribbean better. They have also helped the CAFP begin to establish the role that “Carriacou played in various socio-religious and exchange economies, the direct connections that people on the island had with South America […] and the size and intensity of occupations over a thousand year period” (Fitzpatrick et al. 2009:249).

Cultural Chronology

A series of 21 radiocarbon dates collected from several sites throughout the island of Carriacou (19 collected by CAFP, one collected by members of the Carriacou Historical Society [CHS], and one reported in Bullen and Bullen 1972) suggests an occupation range at the Grand Bay site from approximately AD 400-1400, commonly referred to as the Ceramic Age. These dates, listed in Table 2.1, correspond with the end of the Early Ceramic, or Saladoid, (ca. 500 BC-AD 600) and Late Ceramic (ca. AD 600-1492) time periods (Hofman et al. 2007; Keegan 2000). Most of the dates fall within the Troumassan Troumassoid (ca. AD 500-1000) and a few within the Suazan Troumassoid (ca. AD 1000-1400) ceramic subseries. Macroscopic examination of nearly 35,000 ceramic sherds, approximately 25 percent of the ceramics collected from Grand Bay, has also been carried out to establish Carriacou’s chronological position within
Caribbean prehistory (Fitzpatrick et al. 2009; Kaye et al. 2011). It has been determined from this type of analysis that examples of zone incised cross-hatch (ZIC) are present in younger strata along with sherds of white-on-red (WOR) painting. These decorative elements are consistent with wares associated with the Saladoid period, ca. 500 BC-AD 600 (Allaire 1997; Keegan 2000; Righter 1997). In addition, rare, or uncommon, finds from this time period include adornos (stylized anthropomorphic and zoomorphic appliqués attached to vessel rims), a sherd representative of the “Huecoid” period (see Figure 14, Kaye et al. 2011), and pieces of ceramic griddles used for cooking cassava. These tangible examples of a Saladoid occupation at Grand Bay further support the earliest radiocarbon date obtained.

Ceramic artifacts examined are of primarily Troumassian Troumassoid and Suazan Troumassoid types and correspond with the radiocarbon dates listed in Table 2.1. Diagnostic elements of Troumassian ceramics are red, black, and white painting, painted and unpainted curvilinear incision, a lack of zoomorphic adornos, and overall cruder and plainer wares (Allaire 1997; Keegan 2000). After AD 1000, Troumassoid ceramics transitioned into the Suazoid series, named after the type site of Savanne Suazey on Grenada (Bullen 1964). Ceramic artifacts from this period are characterized by simple and bulky plain vessels, finger-indented rims, flat anthropomorphic adornos with flaring, pierced ears, and occasional fine red-painted or incised vessels (Allaire 1997; Keegan 2000). Macroscopic examination of Grand Bay’s ceramic assemblage also supports the interpretation of a decline in manufacturing quality and production of bulkier wares between the Saladoid and Troumassoid time periods. Many sherds recovered in Saladoid contexts had an average thickness of 2-3 mm (Kaye et al. 2011), while those in Troumassoid contexts had thicknesses of 7-12 mm (Fitzpatrick et al. 2009). Thus, a continual post-Saladoid occupation has been established at Grand Bay.
Table 2.1: Radiocarbon Dates from Grand Bay

<table>
<thead>
<tr>
<th>Lab no.</th>
<th>Type</th>
<th>Species</th>
<th>Unit</th>
<th>Stratum</th>
<th>cmbs</th>
<th>$^{13}$C/$^{12}$C ratio</th>
<th>Measured $^{14}$C age BP</th>
<th>Cal. BC/AD (2σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA-62278</td>
<td>Shell</td>
<td><em>C. pica</em></td>
<td>447</td>
<td>L007</td>
<td>145</td>
<td>2.53</td>
<td>1917±37</td>
<td>AD 390-590</td>
</tr>
<tr>
<td>AA-62279</td>
<td>Charcoal</td>
<td>---</td>
<td>447</td>
<td>L006</td>
<td>110</td>
<td>-25.13</td>
<td>1243±36</td>
<td>AD 680-880</td>
</tr>
<tr>
<td>AA-62280</td>
<td>Shell</td>
<td><em>Venus</em> sp.</td>
<td>447</td>
<td>L006</td>
<td>127</td>
<td>3.39</td>
<td>1789±38</td>
<td>AD 530-690</td>
</tr>
<tr>
<td>AA-62280</td>
<td>Shell</td>
<td><em>Venus</em> sp.</td>
<td>447</td>
<td>L006</td>
<td>127</td>
<td>3.36</td>
<td>1822±41</td>
<td>AD 470-670</td>
</tr>
<tr>
<td>AA-62281</td>
<td>Charcoal</td>
<td>---</td>
<td>447</td>
<td>L006</td>
<td>93</td>
<td>-23.96</td>
<td>1339±36</td>
<td>AD 640-770</td>
</tr>
<tr>
<td>AA-62282</td>
<td>Charcoal</td>
<td>---</td>
<td>F016</td>
<td>(posthole)</td>
<td>---</td>
<td>-25.97</td>
<td>1227±36</td>
<td>AD 690-890</td>
</tr>
<tr>
<td>AA-62283</td>
<td>Bone</td>
<td>Human</td>
<td>F006</td>
<td>---</td>
<td>---</td>
<td>-14.21</td>
<td>1062±44</td>
<td>AD 1050-1250</td>
</tr>
<tr>
<td>Beta-206685</td>
<td>Shell</td>
<td><em>E. gigas</em> (juvenile)</td>
<td>N. profile</td>
<td>---</td>
<td>108</td>
<td>2.1</td>
<td>1870±70</td>
<td>AD 380-670</td>
</tr>
<tr>
<td>Beta-233647</td>
<td>Shell</td>
<td><em>C. pica</em></td>
<td>415</td>
<td>L002</td>
<td>---</td>
<td>1.8</td>
<td>1310±40</td>
<td>AD 1020-1190</td>
</tr>
<tr>
<td>Beta-257793</td>
<td>Bone</td>
<td>Human</td>
<td>563; F0164</td>
<td>---</td>
<td>---</td>
<td>-12.4</td>
<td>870±40</td>
<td>AD 1040-1260</td>
</tr>
<tr>
<td>UCIAMS-94044</td>
<td>Bone</td>
<td><em>Tayassu/Pecari</em> mandible</td>
<td>415 Sq. 23</td>
<td>L002</td>
<td>---</td>
<td>-22.2</td>
<td>990±20</td>
<td>AD 990-1150</td>
</tr>
<tr>
<td>UCIAMS-94045</td>
<td>Bone</td>
<td><em>Cavia</em> maxilla</td>
<td>446 Sq. 9</td>
<td>L002</td>
<td>---</td>
<td>-13.5</td>
<td>1020±20</td>
<td>AD 990-1030</td>
</tr>
<tr>
<td>UCIAMS-111934</td>
<td>Bone</td>
<td>Human</td>
<td>F177</td>
<td>---</td>
<td>---</td>
<td>-10.27</td>
<td>69±15</td>
<td>AD 1410-1450</td>
</tr>
<tr>
<td>UCIAMS-111935</td>
<td>Bone</td>
<td>Human</td>
<td>F180</td>
<td>---</td>
<td>---</td>
<td>-13.57</td>
<td>1565±15</td>
<td>AD 620-680</td>
</tr>
</tbody>
</table>
Figures 2.8 and 2.9 are illustrations of the cultural layers within Trenches 415 and 446. I created these illustrations based on the cultural stratum associated with each 1-x-1 m excavation unit found in the Grand Bay database. Occupation periods at Grand Bay are defined based on stratigraphy with associated radiocarbon dates, diagnostic ceramics, and archaeological contexts. These periods are defined in Giovas (2013) as Initial (ca. AD 400-650), Early (ca. AD 650-850/900), Middle (ca. 850-1000), Late (ca. AD 1000-1250), and “Final” (ca. AD 1250-1450). According to Giovas (2013:117), the radiocarbon date associated with this occupation period from a burial feature “may represent intermittent use of the site for special activities following site abandonment since dated midden layers signifying occupation appear to terminate around AD 1250.” Stratum L001 is the topsoil layer. Diagnostic ceramics from Stratum L002 are characterized as Suazan Troumassoid, placing the approximate date of the midden deposits associated with cultural layer L002 between AD 1100-1300 (LeFebvre 2007). Five radiocarbon dates, two from burial features and three from archaeological contexts, provide an approximate date range for stratum L002 of ca. AD 1000-1250. There are no radiocarbon dates from strata L003, L003A, and L005, but these strata are assigned an approximate date range of ca. AD 850-1000 based on interpolation between dated Late and Early periods. Stratum L006 is associated with both the Initial and Early periods of site occupation. Four radiocarbon dates from the upper portion of this stratum are associated with the Early period while two dates from the lower portion are associated with the Initial period. Two final dates, AA-62278 and Beta-206685, are also assigned to the Initial period. These occupation periods and assigned dates and strata are given in Table 5.2.
Figure 2.8: Cultural stratigraphy of Trench 415: a) facing northeast and b) facing southwest

Carriacou Archaeological Field Project

Groundwork for the CAFP began in 1999 after participants in the 18th Congress of the International Association for Caribbean Archaeology (IACA) visited the island. During this trip, participants encountered concentrations of archaeological material at two sites and the “evident lack of protection” (Kaye 2003:129) at both sites. It was decided at this time that a more in-depth study of the archaeology of the island was needed to increase awareness for protective
legislation. Methodological details of survey and excavation techniques utilized by CAFP will be discussed in Chapter 4.

Figure 2.9: Cultural stratigraphy of Trench 446: a) facing northeast and b) facing southwest. Voids are areas of the trench that were eroded.
<table>
<thead>
<tr>
<th>Period</th>
<th>Date Range</th>
<th>Assigned $^{14}$C Dates and Lab No.</th>
<th>Assigned Strata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final</td>
<td>ca. AD 1250-1450</td>
<td>AD 1410-1450 (UCIAMS-11934)</td>
<td>N/A; F177</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 1040-1260 (Beta-257793)</td>
<td>N/A; F0164</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 1040-1250 (AA-62283)</td>
<td>N/A; F006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 1020-1190 (Beta-233647)</td>
<td>L002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 990-1150 (UCIAMS-94044)</td>
<td>L002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 990-1030 (UCIAMS-94045)</td>
<td>L002</td>
</tr>
<tr>
<td>Late</td>
<td>ca. AD 1000-1250</td>
<td>Interpolation between Early and Late dates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>L003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>L005</td>
</tr>
<tr>
<td>Middle</td>
<td>ca. AD 850-1000</td>
<td>AD 690-890 (AA-62282)</td>
<td>L006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 680-880 (AA-62279)</td>
<td>L006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 640-770 (AA-62281)</td>
<td>L006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 620-680 (UCIAMS-111935)</td>
<td>N/A; F180</td>
</tr>
<tr>
<td>Early</td>
<td>ca. AD 650-850/900</td>
<td>AD 530-690 (AA-62280)</td>
<td>L006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 470-670 (AA-62280)</td>
<td>L006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 380-670 (Beta-206685)</td>
<td>N. Profile, 108 cmbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 390-590 (AA-62278)</td>
<td>L007 (subsoil transition)</td>
</tr>
</tbody>
</table>

Table 2.2: Grand Bay Occupation Periods (modified from Giovas 2013:193)
2003 Survey

In March 2003, an international team of archaeologists consisting of Scott Fitzpatrick (then at NCSU, now at the University of Oregon), Michiel Kappers (QLC BV, Ltd, The Netherlands), and Quetta Kaye (Secretary, IACA) conducted the first comprehensive archaeological survey of Carriacou. Their objectives were to relocate, identify, and map site locations, determine which sites had the highest potential for subsurface cultural remains, and assess the threat of destruction to sites from erosion and development.

The field season focused solely on a series of pedestrian surveys of the entire coastline, as well as interior areas that were relatively flat or easily accessible, and surface collection (Kaye 2003). The results of this comprehensive survey indicated that there were 12 separate locations of prehistoric use, six of which had significant finds, and all of which were coastal (see Figure 2.2). Of these areas, two had extensive stratified coastal profiles and abundant artifacts, faunal remains, and archaeological features that were deemed most at risk from coastal erosion - Grand Bay and Sabazan (Fitzpatrick 2006; Kaye 2003).

Through preliminary analysis, sites were found to span the early to late ceramic periods (ca. 500 BC-AD 1450), corroborated by the radiocarbon date in Bullen and Bullen (1972) and dates from new samples taken from the Sabazan site during this survey (Fitzpatrick et al. 2004). In collaboration with the local tourist boards, local heritage managers, and the CHS Museum, plans for further research were set in place to increase community awareness about Carriacou’s past through public archaeology programs, to determine the extent of prehistoric settlement through excavation, and to promote future legislation to protect these important sites (Kaye 2003).
2004 Excavations

The 2004 CAFP, like the 2003 survey, was a multi-national endeavor. The team was comprised of undergraduate and graduate students drawn from the University College London (UCL) Institute of Archaeology and various United States universities. Project staff members included two professional archaeologists from The Netherlands, a geologist, a ceramics analyst, a postgraduate faunal analyst, and a postgraduate specialist in human remains. Taking their direction from the results of the 2003 survey, the co-directors began excavations at Grand Bay because of the extensive surface and profile evidence for prehistoric occupation and the imminent threat of site destruction by erosion, development, and looting as indicated through site measurements confirming that erosion was occurring at an alarming rate of approximately 1 m per year (Fitzpatrick et al. 2006; Kaye et al. 2004).

Between June 28 and July 31 the team recorded the site’s profile in detail and began excavation in four designated 5-x-5 m trenches – 446, 561, 563, and 592 (see Figure 2.3). Excavation progressed to the 20 cm level in all trenches except Trench 446, the most threatened by profile erosion, to which a depth of 30 cm was reached. Material was also recovered from a handful of 1-x-1 m units in Trench 447 as it would likely not survive another rainy season based on the recent rates of erosion along the coast. Table 2.3 provides a summary of recovered material from the site including surface finds, excavated midden deposits, features, and recovery from the coastal profile (totals were calculated by the author from the Grand Bay database and may not reflect totals provided in other publications).

Queen conch dominated the excavated shell material, with a total of 615 recovered (Fitzpatrick et al. 2009). Due to limitations for transporting and curating the large, bulky shells, queen conch specimens were quantified in the field using a Minimum Number of Individuals
(MNI) count described in Fitzpatrick et al. (2009) and Giovas (2013). Because of this limitation, the weight of recovered shell in Table 2.3, and subsequent tables in this chapter, does not include the weight of mature conch shells. Thus, the resulting weights of shell recovered at Grand Bay are comprised of mainly shell ecofacts, but also shell artifacts, such as adzes and beads.

**Table 2.3: Summary of Material Recovered at Grand Bay, 2004**

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kilograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>699.1</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>13.1</td>
</tr>
<tr>
<td>Shell (excl. mature <em>E. gigas</em>)</td>
<td>58.9</td>
</tr>
<tr>
<td>Stone</td>
<td>1.3</td>
</tr>
<tr>
<td>Coral</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Considerable quantities of faunal material were present in midden deposits and suggest focused exploitation of marine taxa, as would be expected given Grand Bay’s close proximity to multiple marine habitats. An unexpected amount of turtle bone was recovered, indicating capture of these larger marine animals as a food source, as well as tool manufacture and use, suggested by pieces shaped as burnishing tools and a pointed awl 4.0 cm in length (Kaye et al. 2004).

**2005 Excavations**

A second season of archaeological investigations at Grand Bay was conducted between May 23 and July 22. The first month of excavations were conducted primarily by American students again participating through the NCSU study abroad program while the second month’s team consisted of a group of students from UCL Institute of Archaeology. Staff members included Mary Hill Harris, a ceramics analyst, Michelle LeFebvre – a PhD student from the University of Florida who worked with the project in 2004 as a faunal analyst, and Christina
Giovas – a PhD student from the University of Washington. This season was the first in which I was personally involved in excavations at Grand Bay.

Once again measurements of the site’s coastal profile were taken to study the rate of erosion at the site over time. Erosion at Grand Bay between the 2004 and 2005 field seasons was exacerbated by an intense rainy season and two hurricanes, further proving the necessity of intensive excavation at the site and legislative protection for Carriacou’s archaeological sites (Kaye et al. 2005). Figure 2.10 shows the outline of the coast at Grand Bay between 2004 and 2010, demonstrating the adverse effects natural erosion and sand mining have had on the site over this time period.

Despite an unusually rainy season and a direct hit from Hurricane Emily in July, excavations continued in Trenches 446 and 561, opened during the 2004 field season, and a new trench, 415, was opened (see Figure 2.3). Considerable amounts of archaeological material were again recovered and processed by the team as summarized in Table 2.4. Trench 415 was excavated to a depth of 35 cm, Trench 446 was excavated a further 35 cm to a combined depth of 65 cm, and Trench 561 was excavated to the subsoil at a depth of 40 cm. A number of features were also excavated in Trench 561 including several large features that have since been interpreted as posthole remnants of a possible longhouse (Fitzpatrick et al. 2009; see Figure 2.7).

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kilograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>1013.7</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>61.7</td>
</tr>
<tr>
<td>Shell (excl. mature <em>E. gigas</em>)</td>
<td>120.9</td>
</tr>
<tr>
<td>Stone</td>
<td>5.5</td>
</tr>
<tr>
<td>Coral</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 2.4: Summary of Material Recovered at Grand Bay, 2005
Figure 2.10: Map of the Grand Bay site showing features, burials, excavated trenches, and coastal erosion (courtesy of Michiel Kappers)
2007 Excavations

Excavations at Grand Bay continued between July 2 and August 3. As in previous years, the team consisted of undergraduate students from the NCSU study abroad program and the UCL Institute of Archaeology, myself included. Staff members during the 2007 field season included Mary Hill Harris, Michelle LeFebvre, and Christina Giovas. New additions to the team were illustrator John Swogger and bioarchaeologist Scott Burnett. The main objective, as in previous years, was to continue excavations at Grand Bay. A new suite of seven AMS radiocarbon dates, suggesting that Grand Bay was contemporaneously occupied along with the Sabazan site (Fitzpatrick et al. 2006), led to the inclusion of this second site in the 2007 excavations (see Figure 2.2). This expansion of the study has provided a much needed comparison and examination of the foraging variability between the two sites (Giovas 2013).

New measurements were taken along the coastal profile to continue monitoring erosion at the site. Excavation was primarily focused on Trenches 415 and 446 with additional emphasis on Trench 446 as nearly 1/3 of the trench had been destroyed since the 2005 field season (Figure 2.11). Progress was made in both trenches with depths of approximately 70 cm and 1 m being reached in 415 and 446, respectively. Table 2.5 summarizes all archaeological material recovered during the 2007 field season. Ceramics were again the most abundant artifacts recovered, over 600 kg, followed by shell and vertebrate remains.

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kilograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>618.2</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>36.9</td>
</tr>
<tr>
<td>Shell (excl. mature E. gigas)</td>
<td>59.2</td>
</tr>
<tr>
<td>Stone</td>
<td>4.2</td>
</tr>
<tr>
<td>Coral</td>
<td>0.2</td>
</tr>
</tbody>
</table>
2008 Excavations

Archaeological fieldwork resumed at Grand Bay and Sabazan between July 7 and August 9 with a total of thirty-seven staff and students from various US universities and UCL. Staff members included Christina Giovas, John Swogger, Mary Hill Harris, Scott Burnett, and myself.

One of the primary goals during this season was to complete excavation in Trenches 415 and 446 and to investigate further the habitation area by opening Trench 562 to connect previously excavated trenches to examine the arrangement of habitation structures and other associated features (Kaye et al. 2009). It was paramount to complete excavation in Trench 446 as
less than half of the 5-x-5 m trench remained (Figure 2.12). Unfortunately, heavy rains inhibited
the team’s best efforts to completely finish this trench or Trench 415, but the earliest layers of
occupation were reached and ceramics recovered from these layers were stylistically dated to the
Terminal Saladoid period (ca. AD 400-600). Table 2.6 summarizes the archaeological material
recovered at Grand Bay in 2008.

One noteworthy and unexpected find encountered during the excavation of a circular
feature (F0164) in Trench 563 was an isolated human skull found to be resting above a crouched,
nearly complete skeleton (Figure 2.13). Subsequent investigation of the fill between the isolated
skull and the skeleton produced several disarticulated bones from a late-term fetus. Therefore,
this burial feature contained the remains of three individuals, a unique type of inhumation at
Grand Bay. As of 2014, preliminary analysis of this inhumation has found that the skeleton is
that of an adult male radiocarbon dated to AD 1040–1260 (Osborne 2013:53,73). Future
analysis, including an in progress radiocarbon date for a portion of the isolated skull and possible
DNA analysis, may reveal that these remains are of related individuals, and perhaps an example
of ancestor veneration.

Table 2.6: Summary of Material Recovered at Grand Bay, 2008

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kilograms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>255.6</td>
</tr>
<tr>
<td>Vertebrate remains</td>
<td>5.7</td>
</tr>
<tr>
<td>Shell (excl. mature E. gigas)</td>
<td>44.8</td>
</tr>
<tr>
<td>Stone</td>
<td>8.9</td>
</tr>
<tr>
<td>Coral</td>
<td>1.9</td>
</tr>
</tbody>
</table>
Figure 2.12: Extent of Trench 446 in 2008, facing northeast. Superimposed lines show the effects erosion has caused in this area of the Grand Bay site. Ten 1 x 1 m units could be excavated during the 2008 field season (photograph by Kara I. Casto).

Figure 2.13: Excavation of F0164 (photographs by Kara I. Casto)
Excavations at Grand Bay continued in summer 2011, but a summary of findings is not provided here as they are not used in the current analysis. Of importance to this study though is the enforcement of a law against sand mining. The meeting with new government officials in 2008 led to the outlawing of sand mining which Kaye et al. (2011) state had a positive impact on rates of erosion at Grand Bay and that erosion had diminished at Grand Bay with enforcement of this new law.

One goal of the current study is to show that erosion along the coastal profile at Grand Bay has had a significant impact on the study of this extensive Ceramic Age site. Since intensive excavations began at Grand Bay in the early 2000s, an estimated “280-300 cubic metres of soils (150+ anthropogenic), 13,000 kg of cultural remains, and dozens of features such as burials and habitational remnants” (Fitzpatrick 2012:180) have been lost each year due to erosion. Therefore, the finding that erosion had diminished between 2010 and 2011 is an encouraging step for this and future investigations at Grand Bay.
Chapter 3:
Archaeological Site Formation Processes and Intrasite Spatial Analysis

In order to understand the intrasite spatial and temporal analysis of artifact distributions presented in this thesis, one must have an understanding of the context in which this research exists. Contained within this chapter is an overview of the theoretical framework of site formation processes, their importance in interpreting prehistory, and examples of intrasite spatial analyses that take into consideration site formation processes.

Site Formation Processes: Theoretical Considerations

The study of site formation processes defines a sub-discipline within the field of archaeology that “deals with cultural and natural transformations of materials between the systemic and archaeological contexts” (Shahack-Gross 2007:74). One of the earliest reports to mention the effect of formation processes on an archaeological assemblage, albeit briefly, is found in Knowles (1893:141). Site formation research has come a long way since then and can truly trace its origins to the settlement and processual studies of the 1950s and 1960s (Schiffer 1983). These studies led to the study of patterns within the archaeological record (e.g., Binford 2009; Hodder 1972; Rouse 1977; South 1978), but were deemed simplistic and eventually developed into the formation processes research heralded in the works of Michael Schiffer (1972, 1975, 1976, 1983, 1987). According to Preucel and Hodder (1996:8), the study of site
formation processes is one of the most important developments in low level theories defined as “empirical generalizations about the archaeological record.”

Site formation processes include those of natural and cultural agents and occur before and at the time of deposition and post-deposition (Clarke 1973; Schiffer 1987). Schiffer (1987:7) defines cultural formation processes as “the processes of human behavior that affect or transform artifacts after their initial period of use in a given activity” and natural formation processes as “any and all events and processes of the natural environment that impinge upon artifacts and archaeological deposits.” In other words, cultural processes can be deliberate or accidental acts that positively or negatively affect the archaeological record while natural processes affect the persistence of the archaeological record (Okumura and Eggers 2008). Therefore, in order to reconstruct human behavior from archaeological material, it is imperative to understand these processes at a site level through both time and space.

**Site Formation Processes: Archaeological Interpretations**

Many archaeological research problems such as subsistence and settlement reconstruction or spatial organization and distribution of activity areas must incorporate formation processes in order to provide adequate and more accurate interpretations of the archaeological record. Archaeologists often use what Schiffer (1983) calls traces of formation processes, or depositional properties, which have the potential to indicate formation processes. Through intrasite spatial analysis, this thesis takes into consideration refuse deposition, artifact density of deposits, and the horizontal and vertical distribution of artifacts, after Schiffer’s (1983:685-686) definitions of these properties, to attain two goals of this analysis: a) determine the effects of erosion on the destruction of Grand Bay’s archaeological deposits and b) understand the accumulation
processes and discard patterns which formed the midden deposits at Grand Bay. Relevant studies of these depositional properties are discussed below.

Refuse Deposition and Accumulations Studies

Through ethnographic and ethnoarchaeological research, archaeologists have been able to study the patterns of discard behavior as one type of formation process that may then be applied to the archaeological record to infer prehistoric cultural behaviors.

In their use of vacant lots as a teaching tool for understanding formation processes, Wilk and Schiffer (1979:531) postulate that the “rate of refuse production and the nature of the refuse affect the means and place of disposal.” Evidence of this can be seen in the vast amount of ceramics excavated at Grand Bay, which consist primarily of broken and discarded vessels that have reached the end of their lifespan. These attributes suggest the vessels likely did not carry any ideological significance and were being discarded along with the everyday garbage. The authors also define storage as another type of “refuse” (Wilk and Schiffer 1979:532) that consists of usable materials deposited on site for future use. Manifestation of this observation in the archaeological record at Grand Bay is evident in the abundance of queen conch shells. In addition to being a main dietary resource in the Caribbean, large quantities of shell have been suggested as possible storage caches for use in tool manufacture (O’Day and Keegan 2001).

Murray (1980:490-491) states that “material elements come to rest where they are found at an archaeological habitation site basically as the result of two purposeful human behaviors (besides burial behavior)—discard behavior and abandonment behavior.” In her examination of 79 cultural groups, she confirmed her hypothesis that discard behavior at sites with evidence for permanent occupation or occupation periods of at least one season would result in discard
locations away from enclosed living spaces (Murray 1980:497). With regard to Grand Bay, a permanent structure is indicated by evidence of numerous postholes uncovered on site. These postholes are located approximately 15 m from excavation units 415 and 446 within the midden deposits (see Figures 2.52.7) suggesting that this type of discard behavior can be inferred at Grand Bay.

Artifact Densities of Deposits

Comparison of artifact densities within a deposit can help archaeologists understand cultural processes such as changes in site occupation and natural processes that affect the post-depositional distribution of artifacts (e.g., Wood and Johnson 1978).

Sullivan (1995) analyzed surface artifact distributions and variations in the densities of debitage and ceramic assemblages and found nine activity areas that varied with respect to “occupation duration and the intensity of lithic reduction” (Sullivan 1995:58).

Hardy-Smith and Edwards (2004:253) examined refuse disposal and the volumetric and areal densities of artifact distributions and found that primary refuse contained within domestication areas or dwellings, discrete activity areas dispersed across the interior spaces of these structures, and differences in the range and attributes of artifacts found in interior and exterior deposits are representative of short-term occupations. In contrast, sedentary groups tend to dispose of refuse outside of the occupation areas of a site, in the form of secondary refuse, in an effort to keep the living spaces clean and free of various types of refuse.

The density of ceramic remains within middens also has been shown to be the result of changes in ceramic production rather than an increase in population, overall ceramic use, breakage or consumption rates (Rosenswig 2009:16, 25). Further examination of artifact
densities between two types of middens revealed that they would be much higher in pit middens as compared to open-air middens. These higher densities suggest that artifacts deposited in pits were less susceptible to post-depositional processes such as trampling or erosion. Artifact densities can thus be used to more accurately reconstruct cultural behaviors by “exploring variability in artifact patterns resulting from systemic ways in which archaeological deposits form and the artifacts within them preserve” (Rosenswig 2009:27).

*Horizontal Spatial Distribution*

Studies related to the horizontal distribution of artifacts often refer to surface assemblages or clusters of artifacts within activity areas. Binford (1962) deliberated the function of artifacts within cultural systems. His ethnoarchaeological studies have shown that the distribution of artifacts can yield information about the social organization of a population and can be used to infer similar patterns within the archaeological record (Binford 1962:218). Socio-cultural changes within the cultural environment are often suggested by changes in the temporal-spatial distribution of style types and these changes in artifact assemblages are another example of how archaeologists can begin to interpret the cultural formation of sites, artifact assemblages, and midden deposits (Binford 1962:220).

One of the earliest well-read studies that utilized spatial analysis to interpret horizontal distributions of artifacts was undertaken by Whallon (1973) on seasonal hunter-gatherer camps at the preceramic cave site of Guila Naquitz. The results of his analysis revealed areas of prehistoric human activities within one occupation level which he interprets as having occurred at “different times and places and possibly by somewhat different work groups” (Whallon 1973:275). In one instance he finds that chipped stone waste flakes are associated with
butchering game and only some types of plant processing as they are strongly correlated only with two groupings of plant remains but have low correlations with other identified groupings of plant remains (Whallon 1973:277). He also found that all animal remains were grouped together, a pattern indicative of a butchering or processing area. He further explains this grouping as a possible indication of a gender specific activity. The last grouping he discusses is that of the prickly pear which is negatively correlated with all other items in this assemblage. Because of the economic importance of this fruit, this negative correlation is interpreted as an indication of its importance and the possibility that it may have been gathered and processed in large quantities after trips solely dedicated to its procurement (Whallon 1973:277).

**Vertical Spatial Distribution**

Traditional stratigraphic studies, which Schiffer (1983:685) cites “have long made use of vertical patterns to discern various formation processes,” typically examine the formation of sites based on chronological sequences, not behavioral or natural processes that affect cultural deposits. However, the vertical distribution of artifacts is a readily observable result of both cultural and natural formation processes at archaeological sites and hence, can be analyzed for adaptation to changing environments, identification of palimpsests, and spatial organization of activities to establish changes in site use and function.

Anderson and Burke (2008:2277) found that vertical separation of artifact clusters was the cause of natural erosion and chemical weathering of the limestone walls that resulted in carbonate cementation in lower levels that crosscut stratigraphic levels and hindered excavation of lower cultural levels (Anderson and Burke 2008:2277). Vertical spatial distributions and densities of lithics and faunal remains also have been shown to reveal differences in occupation
length and size (Hoguin et al. 2012). Deposits with larger artifact densities and extents tend to reflect a more intensive occupation. Whereas, deposits with smaller densities and extents often suggest that the space was utilized for specialized tasks and shorter periods of time.

Summary

To summarize, midden deposits reflect the cultural behaviors that created them. Differences in midden density and composition can reflect subsistence behaviors, occupation span of sites, household activities, economic and cultural significance of specific artifact types, and different types of refuse. Ethnographic and ethnoarchaeological data have proven beneficial in the analysis of archaeological midden deposits. It is important to realize that not all cultural behaviors are represented in the archaeological record, and archaeologists must take care when making inferences about a prehistoric population, even with numerous ethnographic examples in the literature. Density of midden materials recovered from Grand Bay are analyzed in the hope of finding evidence for cultural formation processes that reflect changes in the reliance on marine resources, changes in ceramic technology and production, and changes within these densities that may be the result of erosional episodes.

At Grand Bay, horizontal distributions of the archaeological assemblages are examined for potential activity areas within the midden deposits and changes in these distributions that may be indicators for changing subsistence economies, as well as for social and economic complexity. Vertical distribution of artifacts also can reflect both natural and cultural formation processes and changes within the vertical distributions at Grand Bay are examined for evidence of these processes. While researching many articles related to the study of artifact distributions, I found that these studies typically rely on point data, which is lacking in the Grand Bay dataset.
However, vertical and horizontal changes in the weight of materials recovered from Grand Bay can still be examined for similar formation processes and cultural behaviors as seen in the examples above.

**Intrasite Spatial Analysis and Site Formation Processes: A Caribbean Perspective**

Much of intrasite spatial analysis focuses on locating activity areas using spatial distribution of archaeological materials, refitting of artifacts within a surface collection, or understanding spatial organization of sites and chronological evolution of this organization. As mentioned, this thesis examines the spatial distribution of midden deposits at the site of Grand Bay in the hope of determining how the midden formed through cultural and natural processes during deposition and the post-depositional effects of erosion on the distributions. My analysis also examines Grand Bay’s archaeological assemblage for potential activity areas and evidence to support prior interpretations of spatial use and organization.

While various types of spatial analysis have been used throughout the field of archaeology since the 1960s, their use and that of newer technologies, such as ArcGIS, in the Caribbean has been rather limited until the last two decades. Instead of focusing on appropriate local or small geographic scales to address specific research questions, the majority of projects in the latter half of the twentieth century focused on the theories and uses of space related to larger geographic and cultural scales developed by Irving Rouse (Altes 2013:297; Rouse 1964, 1977, 1992). Altes [2013:307] notes that, although progress has been made towards implementing GIS analysis within Caribbean archaeology, there has been a “concentration on building databases for future analysis and management [which] reflects the nascent stage of archaeological GIS in the Caribbean [and] much of this [work] remains focused on integration of datasets and probability
models, rather than addressing how human beings spatially organize life.” Regional studies that have utilized intrasite spatial analysis to address how the distribution of archaeological assemblages reflects past cultural behaviors and natural processes are reviewed below.

Tromans (1986) examines artifact distributions within and between two prehistoric sites, used seasonally for salt collection, on Middle Caicos, British West Indies. In terms of intrasite analysis, a multi-response permutation procedure was utilized to “delineate any activity modifications within the site caused by social stratification as well as any specialized production locations” (Tromans 1986:63). He found that, at both sites, there was no evidence of clustering between artifacts based on average distance between them or ceramic typology. These findings suggested that there were no well-defined activity areas at the sites leading Tromans to conclude that their occupation was seasonal and occupants had no need to develop ceramic production areas or create a stratified society.

Twenty artifact groups were analyzed by Williams (1986) to identify associations between cultural materials, activity areas, and to distinguish domestic and non-domestic areas at the site of Puerto Real, Haiti. Williams utilized factor analysis to determine that there were distinct associations between the various artifact groups at Puerto Real, which created defined areas for both domestic and specialized activities in the archaeological record. He also utilized a form of cluster analysis to identify clusters of artifact patterning indicative of activity loci. These clusters reflected both domestic and non-domestic areas as well as special-use areas and Williams hypothesized that the variability among the clusters, and materials associated with them, may reflect differences in economic status. Last, he performed component factor analysis of materials associated with structural remains and interpreted the findings as a reflection of three occupation types at the site: 1) European domestic occupation; 2) non-domestic European
functions; and 3) households with limited access to European goods (Williams 1986:296). Williams’ analyses merely provided baseline information on spatial distributions at Puerto Real, but are significant nonetheless in their understanding of spatial organization within early Hispanic sites in the Caribbean.

Curet (1992) provides evidence for the use of horizontal distribution of post molds in defining house structures, possible trends in house change, and how those changes might have been related to other cultural, social, political and economic transitions in prehistoric Puerto Rico. Analysis of three sites led Curet (1992:169) to hypothesize that house structures in the Late Saladoid/Early Ostionoid period tended to be oblong, communal houses, in the early and late Ostionoid-Elenoid period they were still oblong, but smaller in size and probably housed nuclear families, and by the Chicoid period they were small, circular structures. Changes in Precolumbian Caribbean house structure can then be seen as possible representations of the shifts in social and economic conditions towards the development of complex chiefdoms which have been well documented in this region and are exhibited in changes in ceramic production and design, dietary resources, agricultural intensification, increasing population, and the appearance of ball courts (Curet 1992:170-171). Curet’s analysis is not a traditional study of horizontal artifact distributions, but highlights the variability in the interpretation of the archaeological record through spatial distributions.

Armstrong and Hauser (2004) examine cultural diversity among laborers during the post-emancipation era in Jamaica through intrasite spatial analysis. They found that a house occupied by East Indian laborers was spatially separated from its African Jamaican counterparts and that the subsets of household artifact assemblages in each context revealed distinct differences between the two cultural groups. Artifacts considered personal items in the East Indian house
consisted of items used to enhance and fasten clothing and likely reflected preferences based on heritage rather than economic differences (Armstrong and Hauser 2004:15). The East Indian house also contained far fewer manufactured artifacts (toothbrushes, combs, etc.) related to health and hygiene than those found in the African and European households. This small distribution indicates that the East Indian household relied more on indigenous medical systems such as Ayurveda. Armstrong and Hauser also found that the construction and layout of the East Indian house showed a clear cultural distinction between laborer households at the site. The layout of the house contained many elements that are mirrored in the architectural practices of South Asia and conformed to many aspects of the Vāstu system that defines how space is organized and employed in residences.

Linville (2005) provides preliminary analysis of the spatial distribution of non-tool shell artifacts on the island of Aruba. With a limited dataset, she suggests that distributions show the variation in how prehistoric Aruban peoples used marine shell in the production of non-tool items. Only one site is subjected to an intrasite analysis, Tanki Flip. Linville (2005:258) suggests that because of the variations in the shell artifacts at this site, it is possible it represents not one site, but a series of sites. There are no formal spatial analyses in Linville’s study, just broad analyses that bring about more questions and generalizations of what the data in question may represent in terms of spatial and temporal variations in function and meaning of these non-tool shell artifacts.

Geoarchaeological investigations of Los Buchillones, Cuba were used to provide insights into the environmental setting of a Taino village (Peros et al. 2006). The stratigraphy at the site showed that relative sea level gradually rose over a period of several thousand years, suggesting that excavated archaeological material was associated with shallow-water conditions which
affected the types of shelters built and their locations. Changes in sea level likely forced the Taino “to adapt their settlement patterns to the ever-changing coastal environment” (Peros et al. 2006:422). Evidence of pile dwellings at Los Buchillones would represent what Peros et al. (2006:423) call a “unique adaptation among Taino settlements” as other Taino sites are generally associated with sand beaches.

Van den Bel and Romon (2010) provide insight into burial practices through a simple analysis of spatial distribution of burials at a Precolombian site on Guadeloupe. Of 16 exhumed burials, they found that 13 of these formed three distinct spatial clusters. These clusters were found to be associated with three separate house locations identified by posthole patterns. Results from radiocarbon dating of the burials and two of the house locations suggested that there was a time gap between the occupation of the house and the burials. The authors conclude that these observations suggest reuse of abandoned areas of the site or perhaps an abandoned ancestral village for burials and that the spatial clusters of the burials could suggest kinship among the deceased and familial ties to the burial locations.

At the site of Long Bay, Bahamas, Bate (2011) employs spatial analysis to identify activity areas, evidence for long-distance trade, and areas of higher-status activities within ceramic distributions. Absolute artifact counts were used to illustrate ceramic distributions at Long Bay in ArcGIS. The spatial analysis of these distributions is rudimentary with only visual observation of distributions being analyzed. Her analysis confirmed previous observations of the distribution patterns at the site, which showed that the density of artifacts increased in the southern and eastern portions of the site. These patterns were suggested to be the result of specific discard behaviors, natural formation processes, or that the excavated area of the site was not representative of the site’s entire extent. She admits that the results obtained from the spatial
analysis were “less successful than expected” (Bate 2011:338) because of the limited spatial data available and that further research is required to truly understand the distributions and how they reflect cultural behaviors at Long Bay.

Wesler (2013) examines spatial distributions of artifacts at a nineteenth-century household site in Jamaica. The patterns within the distributions were evidence that the rear yard was an activity area from the time the house was built. The compositions of artifact distributions were representative of the upper-class occupants with the inclusion of few artifacts representative of lower-class servants. He notes though that, unfortunately, areas of intensive activity were missed in the present study and further work is needed to “get a fairer representation of all of the deposits” (Wesler 2013:20) and to understand better the spatial organization of this household site.

Of this small sample of studies only one, Bate (2011), mentions the use of ArcGIS to illustrate spatial distributions of artifacts, but she did not utilize the spatial analysis tools in the program and simply used it to map the ceramic distributions at the Long Bay site. Van den Bel and Romon (2010) and Wesler (2013) do not explicitly state the methods used to create spatial distribution maps, but, most likely, the authors used ArcGIS or a similar program. As stated in Chapter 1, the present analysis is one of the few to address the spatiality of a Caribbean site and its archaeological assemblages using GIS and spatial analysis.

The following chapter examines the effects of a specific site formation process, erosion of coastal and island archaeological sites, and provides summaries of global and Caribbean case studies related to this process as well as a detailed examination of coastal erosion at Grand Bay.
Chapter 4:

Erosion and Site Preservation in Coastal and Island Archaeology

While global surveys of formation processes affecting archaeological sites similar to those provided by Wood and Johnson (1978) and Schiffer (1983, 1987) helped pave the way for in-depth research of these important processes, Rick et al. (2006:568) suggest that researchers provide taphonomic reviews for specific geographic regions to supplement these global syntheses. These regional studies can allow for more directed research into the formation and destruction of coastal sites without the inclusion of unnecessary processes that do not affect the region and sites being investigated. The “variability of disturbance processes affecting a single site underscores the importance of understanding formation processes on a variety of scales (site, region, etc.)” (Rick et al. 2006:585). Without adequate descriptions of site-specific and regional processes, archaeological interpretations are significantly weakened and subject to misinterpretation.

One of the biggest threats to coastal sites is marine erosion, which is “particularly devastating because little can be done to stop it [and it] is both natural and inevitable; therefore, relatively little systematic attention has been paid to mitigating its effects, except in isolated cases” [Rick et al. 2006:572]. This observation does not take into account the fact that coastal erosion has been exacerbated by human activity and sea level rise induced by climate change. The dynamic nature of coastal regions makes them highly susceptible to erosion caused by natural and human-induced processes that, over the course of time, threatens to completely
destroy the archaeological record within these regions. The midden deposits and coastal profile at Grand Bay are not exempt from this imminent destruction, and since 1999 have undergone drastic changes which resulted in the recession of the coastline by approximately 1 m annually (see Figure 2.8). This chapter aims to provide a synopsis of the effects erosion has on coastal archaeological sites, why their conservation is of utmost importance, and how archaeological investigations can benefit coastal conservation and management efforts.

**Site Management and Preservation of Coastal Cultural Heritage**

In their contribution to the inaugural issue of the *Journal of Island and Coastal Archaeology*, Erlandson and Fitzpatrick (2006) discuss current issues facing island and coastal archaeology and offer compelling arguments for intensive research in these habitats. Much of archaeological and other anthropological research has been weakened by the assumption that inland archaeological sites are “fully representative of past human behavior—and that a global sea-level rise of 125 meters since the last glacial era has not biased our understanding of human history, especially the evolution of island, coastal, and maritime adaptations” (Erlandson and Fitzpatrick 2006:6). Coastal sites therefore have been given more precedence in recent years. Their study can provide invaluable information in understanding human migration, evolution of seafaring and other maritime technologies, effects of colonialism and globalization, history of human impacts on coastal ecosystems, adaptations to environmental changes, and many other research topics broached by Erlandson and Fitzpatrick (2006:21-24). Thus, this section includes a small sample of global and Caribbean case studies that have addressed the impacts coastal erosion has on the archaeological record and provided some recommendations for the preservation and management of these fast disappearing resources.
According to Rowland’s (1999) discussion on the effects of accelerated climate change on Australia’s coastal archaeological sites, these types of sites have the potential to provide researchers with information pertaining to paleoclimate, changes in sea level, biological systems, past erosional episodes, and ecotourism. He suggests that the conservation of coastal cultural heritage should “form part of the environmental policies of both government and non-government operations” (Rowland 199:110). If archaeologists fail to consider how climate change can be the cause of increased storm activity, storm surges, sea level rise and the resulting erosion of coastal sites, these sites will soon be lost forever. As he mentions, these direct impacts to coastal sites then have indirect impacts on inland sites from population pressures and new development (Rowland 1999:112). An unexpected “advantage” of coastal erosion is the revelation of new sites and, in some cases, the expansion of the archaeological record within a region. Taking this knowledge into account, a strategy for conservation of coastal sites is suggested in which a “rational, tempered response incorporating potential greenhouse effects along with other potential long-term environmental changes…places heritage issues among overall scientific, government and public response strategies on local, regional, national, and international scale” (Rowland 1999:114). He then lists the criteria of this response strategy: 1) assessment of short and long-term impacts on sites; 2) increased effort to record coastal sites; 3) monitoring of previously recorded sites to determine nature of ongoing and potential impacts; 4) assessment of the extent and quality of resources available for salvage excavations; 5) creating discourse between indigenous groups and other stakeholders about the potential impacts; and 6) involvement of archaeologists in multi-disciplinary ventures dealing with climate change (Rowland 1999:114-115).
Constantinidis (2009) provides a framework for the development of a GIS database model to monitor archaeological sites; the model can incorporate potential negative impacts by natural and anthropogenic forces. This is especially beneficial for coastal sites that are constantly changing under the influence of any combination of these forces. Site-specific GIS databases are not only for the benefit of archaeologists, but also for developers, local governments, stakeholders, and other concerned parties. These databases can be quickly updated and manipulated to incorporate new excavation areas and finds, impacts of mass erosional and depositional episodes, potential impacts of urban or tourism development, and, theoretically, to “determine when actions should be taken to prevent [a site’s] damage” [Constantinidis 2009:118]. This step has been taken at Grand Bay with the development of a site-specific GIS database and the data contained within this database are the basis for this thesis.

Robinson et al. (2010) investigate Georgia’s coastal archaeological resources through systematic field survey and recommend that archaeologists focus on prioritizing the investigation of sites that are in danger of, or are currently, being lost to erosion based on a measure of site-specific rate of shoreline change. They state that the “study of site loss and vulnerability to physical processes provides important information regarding spatial distribution of archaeological sites relative to dynamic shorelines” (Robinson et al. 2010:315), and these studies may influence the interpretation of settlement patterns and responses to environmental changes. Prioritization of sites that are at risk of complete destruction can be beneficial for financially distraught governments and organizations seeking to protect local cultural heritage. Instead of funneling monies into projects at sites that have a lower risk of immediate destruction, they can focus efforts on those that are most at risk while continuing to monitor other sites. As Robinson et al. [2010:322] comment, “even if the projected life [of a site] is long, the impetus to document
actively eroding sites is not diminished.” By creating a list of prioritized sites, plans can then be made to develop formal intensive investigation of these coastal sites. The work of the CAFP is a direct example of these recommendations. After the initial survey of Carriacou, CAFP directors selected Grand Bay for further investigation due to its extent and rate of erosion.

The *Journal of Coastal Conservation* published a special issue in June 2012 dedicated to coastal archaeology with the primary goal of emphasizing the efficacy of archaeology as a component of larger coastal conservation and management efforts (Rick and Fitzpatrick 2012:136). Publication of these papers indicates the increased interest in the role coastal and island archaeological sites has in the broad and general understanding of human history. Most of the papers also recommend that a public discourse be created, sooner rather than later, between all key stakeholders to identify the potential threats to coastal sites and prioritize the study of sites that are most threatened. In their contribution, Reeder et al. (2012) use an environmental vulnerability analysis, similar to the approach used by Fitzpatrick et al. (2006) and Robinson et al. (2010), to quantify the threats to coastal sites and allow for the prioritization of future research. Due to the high costs and time needed for archaeological fieldwork, Reeder et al. (2012:195) suggest the collection of small column or bulk samples as an appropriate alternative strategy to “ensure that some basic information is gathered from threatened sites before they are lost.” The decision to conduct limited collection versus extensive excavation should be a collective one made between a variety of interested parties including local archaeologists, agencies, indigenous groups, and land owners. Many of the variables used in their analysis such as wave height, coastal slope, and historical erosion rates are being monitored on most of the world’s coasts and are freely available to researchers. Therefore, there is no reason why coastal
archaeologists should not be involved in developing locally-appropriate studies and responses to local conditions in order to protect the world’s coastal cultural heritage.

Caribbean Studies

Protection of the Caribbean’s coastal archaeological and historical sites has typically fallen into the laps of national trusts set up to safeguard an individual island’s natural and cultural heritage. Few examples exist within the region of proper, and successful, cultural resource management initiatives that seek to curb destruction of these coastal resources by erosion and anthropogenic activities. Many of the most recent advances in cultural heritage management within the Caribbean have focused on the promotion of heritage tourism as a means for protecting cultural resources while generating revenue and fostering pride in a nation’s cultural history. Beginning with a discussion of the United Nations Educational, Scientific, and Cultural Organization’s (UNESCO) influence on cultural heritage management, this section aims to highlight the varied history and future of cultural heritage management within the Caribbean that includes heritage tourism, development of effective cultural resource management initiatives, continued archaeological investigations, and collaboration between Caribbean archaeologists, other coastal scientists, key stakeholders, indigenous groups, lawmakers, and island governments.

A lack of funding, expertise, and legislation in many small island nations often does not allow for the development of cultural resource management strategies similar to those outlined in Section 106 of the United States’ National Historic Preservation Act (1966). Only in the last 20 years has UNESCO made recommendations for the development of such initiatives and
continues to advocate for the preservation of the Caribbean region’s natural and cultural heritage after deeming the region under-represented on the World Heritage List (van Oers 2005:8).

The UNESCO World Heritage Centre organized an international seminar in September 2004 during which participants directly discussed the identification of Caribbean archaeological and historical sites that may meet the criteria for nomination to the World Heritage List and suggested recommendations for regional management of these resources (Sanz 2005). Recommendations made during this meeting involve the creation of a central data management repository, seeking funding opportunities, fostering regional and global networking, creating public awareness about Caribbean archaeology, stimulating more specific pre-Columbian research, stimulating government involvement in protection and education related to Caribbean archaeology, and many others (Sanz 2005:110-111). However, according to Honychurch (2005:32),

“Many of these sites may not qualify for World Heritage status because of their small size or because they lack unique and outstanding features worthy of designation. But this does not rule them out from being recognized as important national heritage sites within their island or state. Neither does it negate the role that such sites play along with others in the regional context.”

He also suggests the use of the World Heritage Convention’s Operational Guidelines by archaeologists and cultural heritage managers to help in identification, documentation, and proposition of management strategies of these sites.

In researching many of the case studies provided in the UNESCO World Heritage Centre’s (van Oers and Haraguchi 2005) report on the proceedings of a thematic expert meeting on wooden urban heritage within the Caribbean, there was little evidence for the successful
implementation of cultural resource management initiatives although many of the participants gave sound suggestions for their implementation in the future. Again, this lack of execution and application is likely due to a combination of factors including the dearth of funding, trained archaeologists, and effective legislation in these small island nations.

According to Jordan and Duval (2009:194), legislation to protect cultural heritage in the Caribbean is “uneven…resulting in some countries having strict laws designed to protect their built heritage, while others have few, if any, regulatory frameworks.” In their broad overview of heritage management and tourism within the Caribbean region, the authors highlight legislative initiatives taken in the several Caribbean island nations including St. Lucia and Trinidad and Tobago. The St. Lucia National Trust was created in 1975 that mandates the conservation of natural and cultural heritage of the nation and has since received full government support and as such, Section 33 of the Physical Planning Act No. 29 of 2001 specifically addresses the preservation of the nation’s sites and built environment (Jordan and Duval 2009:194; Marquis 2005:73). Contrast the long standing national trust to preserve St. Lucia’s cultural heritage with that of Trinidad and Tobago where it took over a decade to draft, pass, and set up the National Trust of Trinidad and Tobago Act during which time significant examples of the nation’s heritage were lost (Jordan and Duval 2009:195; Lewis 2005:77). With the appointment of its first council in 2000, the Trust gained the power to prevent large-scale destruction of Trinidad and Tobago’s cultural heritage, but there remains the necessity of identification and acquisition of financial resources and trained specialists to successfully carry out conservation projects, a recurring problem among many of the Caribbean’s nations (Lewis 2005:78).

In the Dominican Republic, progress has been made by the Program in Maritime Studies at East Carolina University and Indiana University to promote public awareness about the
island’s underwater archaeology resources, to support sustainable eco- and heritage tourism, and to establish underwater maritime heritage museums, particularly ones that showcase sites in situ or are considered “living” (Harris 2014:104). Multidisciplinary research on the island incorporates the assignment of Peace Corps volunteers to the project, underwater archaeology technical workshops for the island’s heritage professionals, active promotion of the *Quedagh Merchant* shipwreck site as a sustainable tourism destination by the Consorcio Dominicano de Competitividad Turistica, and enhancement of accessible SCUBA diving tourism (Harris 2014:104).

From an archaeological standpoint, measures implemented by local governments to control the impacts of erosion, particularly human-induced erosion, have been “largely inadequate” (Erlandson and Fitzpatrick 2006:21). As previously stated, cultural resource management (CRM) initiatives are seemingly few and far between in the Caribbean. Scudder-Temple (2009) delivers brief histories of CRM in the Bahamas, Turks and Caicos, and Nevis with the ultimate goal of creating a framework for the development and implementation of CRM initiatives in small island nations.

For many years the Bahamas Archaeological Team oversaw the nation’s CRM activities. While professional archaeologists conducted some of the excavations and surveys, many were not, and subsequently, most of the information obtained was only shared between and amongst the organization’s members with limited publications available for current reference (Scudder-Temple 2009:56). With the establishment of the Antiquities, Monuments and Museum Corporation in 1999, management of Bahamian cultural resources became the responsibility of the government, and in 2004 mandates were adopted to govern archaeological investigations, mitigate impacts to sites from development, and ensure inclusion of all stakeholders in all CRM
initiatives (Scudder-Temple 2009:57). She notes that, although these procedures were adopted, without an on-site archaeologist they have often been overlooked or given limited attention (Scudder-Temple 2009:57).

As seen with other Caribbean nations, the Turks and Caicos established a non-profit, non-governmental National Trust to oversee the preservation of the cultural, historic, and natural heritage of the islands. Regrettably, the Trust’s website was inaccessible while I was completing this thesis and further information about its mission and any current preservation initiatives could not be gathered. From the examples given by Scudder-Temple (2009:59-60), it appears that governance of CRM activities on these islands has been “virtually non-existent” with excavations not being monitored by the National Trust or any other agency and only one known salvage project approved for government funding. Archaeological excavations on the islands began in the late 1970s, primarily under the supervision of American archaeologists, Shaun Sullivan and William Keegan, and helped in the establishment of the National Museum of Turks and Caicos. Cameron and Gatewood (2008:64-65) make a special note of a locally produced magazine, Times of the Islands, for its blend of promotional material about area resorts alongside cultural and historical articles. In every issue of the magazine, there is a feature on archaeological projects, Talking Taino, and the National Museum’s newsletter, The Astrolabe, which often includes articles on the islands’ prehistory and colonial history. The efforts of the agencies taxed with creating and promoting national heritage are to be lauded, but they are in the incipient stages, again hampered by insufficient funding and government support. With continued interest in archaeological investigation of the islands’ prehistory, the creation of a heritage program by the National Trust should place these efforts in a prominent position, but as of yet, no site reconstruction efforts are underway (Cameron and Gatewood 2008:66).
On the island of Nevis, the Nevis Historical and Conservation Society (NHCS) was founded in 1980, but not until 2007 did the organization have any formal or informal governance over archaeological activities on the island (Scudder-Temple 2009:62). On their website, they state that their mission is to “promote the effective management of historical, cultural, and natural resources” (NHCS 2014). The website lists a number of historical heritage sites complete with succinct descriptions and photos, information on biodiversity and oral history projects, and a brief synopsis of the society’s participation in coastal erosion monitoring. Although no reports or publications on this erosion monitoring were available on the website, it is promising to know that the NHCS is proactive in monitoring its impact. Archaeologists can in turn use this information in their pursuit of coastal site preservation.

Archaeological research that will result in further discussion of the impacts of erosion on Nevis’ coastal archaeological resources was begun in 2010 by the directors of the CAFP, Scott Fitzpatrick, Quetta Kaye, and Michiel Kappers, together with Victor Thompson. As with the extensive excavations conducted by CAFP, the project’s objectives included detailed investigation of pre-Columbian site, raising public awareness about the island’s archaeology, and collaborating with the NHCS to organize a public exhibition of archaeological finds (Kaye et al. 2010).

The island of Montserrat is a prime example of how natural and human activities can threaten the archaeological record. Continuous volcanic eruptions since 1995 have had a catastrophic effect on many of the island’s southern archaeological sites and forcing the island’s inhabitants either to relocate abroad or move to new settlements in the north (Cherry et al. 2012; Fitzpatrick 2012). These new settlements have thus created threats to previously undisturbed archaeological sites through increased development projects. Because the island has no trained
archaeologists, no archaeological agency, and no effective protective legislature, the Survey and Landscape Archaeology on Montserrat (SLAM) was established in 2009 to address the impact current and future development may have on the island’s archaeological resources (Cherry et al. 2012:283). The project’s objectives incorporate locating and documenting archaeological sites and features, assessing risks posed by environmental and cultural threats, and examining long term effects of cultural development and human-environment interactions (Cherry et al. 2012:283). All located sites and features are identified, photographed, recorded using GPS units, and imported into a GIS database for integration with remotely-sensed satellite imagery, aerial imagery, and data relating to land-use and hydrology to be used for further research and educational purposes, risk assessments, and eventually comparison to other examples from the Caribbean (Cherry et al. 2012:289-290).

One promising step for the preservation of Montserrat’s archaeological and historical resources was the awarding of an Archaeological Institute of America Site Preservation Grant to the Carr Plantation Archaeology and Heritage Project in 2012. The grant monies were earmarked for protection of the site from urban development, creation of an archaeology-focused program at local secondary schools, interpretive signage at the site, development of a guided walking tour of the site, and erection of protective fencing around the site (Archaeology 2012:65-66).

Summary

As evidenced by these examples, the role of cultural resource and heritage management in protecting the Caribbean’s coastal cultural heritage is an ongoing struggle for many of the region’s nations. From the above examples, it appears that there is no lack of national plans, agencies, or discussion to create and promote heritage management or conservation programs
throughout the region, but the majority of Caribbean nations are often remiss in formulating and successfully implementing conservation policies and programs. Is this where archaeologists become the voices of the past and assist in creating effective conservation programs? I believe it is and that we should not idly sit by as vast amounts of tangible and intangible cultural resources are washed away by the same seas that played a pivotal role in their creation.

Coastal Erosion, Site Management, and Future Implications: Grand Bay Case Study

In the previous section I discussed the various directions taken throughout the Caribbean to protect cultural heritage. The destruction of Grand Bay’s archaeological resources has been thoroughly documented through the steadfast efforts of the CAFP. Impacts to Grand Bay’s coastal profile come from both natural and present-day cultural processes including hurricanes and tropical storms, climate change, sea level rise, sand mining and looting (Fitzpatrick 2012). There has been little effort to calculate how sand mining or storms are adversely affecting the integrity of the Caribbean’s archaeological sites that resulted in the first systematic survey of Carriacou and laid the groundwork for CAFP (Fitzpatrick 2012:179).

The rate of erosion at Grand Bay has been calculated at approximately 1 m per annum and is the direct result of sand mining and storm activity (Fitzpatrick 2012:179-180; Fitzpatrick et al. 2006:256-257). Based on detailed recording of the site’s coastal profile and materials recovered during excavation, Fitzpatrick (2012:180) estimates that over 13,000 kg of cultural remains are being lost each year along with burials and occupational features (e.g., postholes and hearths). Case studies examined in the previous section suggest that efforts to document erosion and its impact to Caribbean archaeology are becoming more advanced and multidisciplinary in
nature including the use of various geoinformatic techniques (see Cherry et al. 2012; Kaye et al. 2010; Reid 2008).

Advancements in how sites are documented and managed through the use of GIS techniques are evident in the creation of an archaeological information systems database for Grand Bay. Using MapInfo, drawings of visible features were digitized by Michiel Kappers, thus creating a feature plan of the site. Kappers also obtained, georeferenced, and digitized three-dimensional coordinates and digital photographs of burials within the GIS, and input thousands of measurements taken along the coastal profile over the course of nearly a decade to determine rates of erosion at the site. The use of these varied documentation and recording techniques has assisted the project’s directors in reconstruction of the site’s original size and estimation of its long-term destruction (Kappers et al. 2007:84).

In addition to these on-site efforts, the directors of CAFP have arduously sought to develop and maintain collaborative relationships with the CHS Museum, landowners, local agencies, heritage managers, and government officials. Since 2003, Fitzpatrick, Kaye, and Kappers have worked closely with the Grenada and Carriacou Tourist Boards to identify ways to preserve and promote Carriacou’s rich archaeological history to boost and supplement the island’s tourism sector (Kaye 2003:133). Every excavation season, local and national dignitaries, school groups, tourists, and local community members are formally invited, and encouraged, to visit the site for guided tours and to assist with excavations as well as to observe finds processing operations and exhibits at the CHS Museum. The directors also utilize local media outlets including television, radio, and newspapers to increase public interest in the archaeological work that is being conducted on the island and protecting these valuable, quickly diminishing resources.
During the 2004 field season a site and laboratory tour organized for local VIPs, a public archaeology day inviting locals to visit the CHS Museum for a brief lecture and exhibition, and presentations to two school groups supported these goals. Kaye et al. (2004) noted that although two school groups were spoken to about the project, many of the planned activities with them were unfulfilled and that support from the educational institutions was clearly lacking.

In 2005, the CAFP co-directors continued their mission to promote heritage management, archaeology awareness, and education through previously well received avenues as well as several new ventures. A group of public officials from Grenada and Carriacou were again invited to visit the site, observe finds processing, and attend a presentation highlighting the benefits of public archaeology and archaeological awareness on the island. Another public archaeology day was held at the CHS Museum and was again well-attended by locals and several tourists. In the museum itself an updated “Recent Finds” display (Figure 4.1a-d) was installed as well as laminated posters discussing the interpretation of stratigraphic sequences at archaeological sites, the ongoing collaboration between the CAFP and the CHS Museum, and a display explaining the significance of skeletal and subsistence remains (Kaye et al. 2005).

The CAFP co-directors also worked closely with local television (Grenada Broadcasting Network) to broadcast a series of news clips about fieldwork at Grand Bay, gave interviews to local radio and newspapers, and visited two local secondary schools. Site visits and participation in fieldwork were actively encouraged and numerous locals and several tourists joined the team on site and were given guided tours by one or more of the co-directors. During one visit by a local school group, while I was personally showing one participant proper excavation methods, we recovered a well preserved Suazan Troumassoid anthropomorphic adorno, Figure 4.2. This
was an exciting find for all the children and an opportunity to explain what role this specific type of artifact may have had for inhabitants.

Collaboration between local government and the project continued in 2007 with additional site visits by local school children, participation in excavation by local residents, as well as new relationships with the Minister for Tourism in Grenada and the Grenada and Carriacou Tourist Boards (Kaye et al. 2007) and a feature article on the work of the CAFP between 2004 and 2007 in the Discover Grenada magazine (Kaye et al. 2008).

In 2008, a positive step was made that directly affects Grand Bay – the removal of sand from Carriacou’s beaches was made illegal after newly elected government officials witnessed firsthand the destruction it was causing to the site (Kaye et al. 2009:97). Unfortunately, it has been brought to the attention of Fitzpatrick (2012:183) that this activity has continued unabated and locals are now using the cover of darkness to destroy the site’s shoreline further and perpetuate the destruction of Carriacou’s archaeological resources. Because Grand Bay is the only extensively excavated site on Carriacou, it is imperative that future research takes into account the current rates of erosion and involves the continued collaboration between CAFP, the CHS Museum, landowners, Carriacou’s schools, community members, and government officials. Progress towards this end has been made, however, there is no doubt that continuous collaboration is needed to maintain the ongoing work to protect this small island’s rich archaeological history.
Figure 4.1: Artifacts recovered at Grand Bay on display in the “Recent Finds” case at the Carriacou Historical Museum: a) Recent finds including several ceramic body stamps in the upper left corner; b) Bodily adornments including shell beads and Olivia shell pendants; c) Shell and stone tools, pestles, and turtle bone pendants; d) Various examples of anthropomorphic and zoomorphic adornos found at Grand Bay (photographs by Scott M. Fitzpatrick)
Figure 4.2: Suazan Troumassoid adorno recovered in May 2005 (photograph by Kara I. Casto)
Chapter 5:

Methods

In order to evaluate the spatial distributions of artifacts at Grand Bay, as well as depositional and post-depositional formation processes, two primary methods of data collection were employed. First, during the four field seasons of the CAFP discussed in this study, intensive excavations were conducted at Grand Bay with the goals of determining the site’s extent, obtaining precise measurements of the coastal profile to document ongoing erosion, and recording of Carriacou’s extensive and significant, but quickly disappearing, prehistoric archaeological sites. Second, the data collected in the field were compiled into a site-specific archaeological information system, ArcheoLINK, for use in future analyses and site management. Data analyses presented in this thesis have allowed me to evaluate the spatial and temporal distributions of artifacts recovered at Grand Bay and identify how certain post-depositional processes, namely erosion and sand mining, have impacted these distributions. Thus, results from these analyses have provided the following: 1) preliminary evidence for potential activity areas that have not been previously identified through excavation; 2) reconstructions of depositional behaviors; 3) a basis for proposing areas of high potential, those most at risk of being destroyed, for future excavation; and 4) supplemental evidence for the necessity to continue established heritage awareness programs.

The first section of this chapter discusses the various field and laboratory methods used to collect data at Grand Bay. The second section describes the spatial nature of the collected data as
well as the artifact categories and their attributes used in this thesis. The final section offers summaries of the types of spatial analysis utilized in this thesis, spatial autocorrelation and cluster analysis, and examples of their application within the field of archaeology.

Field and Laboratory Methods

Under the supervision of the CAFP directors, Scott Fitzpatrick, Michiel Kappers, and Quetta Kaye, dozens of undergraduate and graduate students have participated in the survey and excavation of Carriacou’s prehistory. The methods discussed below are specific to the Grand Bay excavations.

Pedestrian Survey

Kaye (2003) describes methods used during a comprehensive pedestrian survey of Carriacou to locate archaeological sites around the island. Site locations were recorded using a handheld Global Positioning System (GPS) unit. A total station was also employed at Grand Bay, and several other sites, to more accurately define their boundaries, important landscape features, and artifact scatters. This information has since been incorporated into Grand Bay’s ArcheoLINK database to generate site maps and manage surface collections and excavated materials.

During this survey, Grand Bay’s coastal profile was photographed and drawn to determine the rate of erosion between this and any return visits to the site. Over 220 kg of multi-period ceramics were collected from a 120 m stretch at Grand Bay and included rims, bases, zoomorphic and anthropomorphic adornos, griddles, stamps as well as shell, coral and stone tools, food remains (small mammal, fish, and shellfish bones), and evidence of human burials
(Kaye 2003:132). These finds are not included in the present analyses as the data were not provided in the database files received from Kappers.

*Excavation Methods*

Formal excavation began at Grand Bay in June 2004. Initial auguring of the perimeter of the site was used to create a grid system of 5-x-5 m excavation units whose numerical arrangement allows for extension of the site in all directions, if necessary (see Figure 2.7). The grid system was generated using a baseline between two datum points using a total station and were then measured by GPS to align the grid with the local Grenada coordinate system. According to Kappers et al. (2007:83), to avoid accelerating erosion at the site the concept of large east-west excavation trenches was abandoned in favor of alternating excavation within a selection of these 5-x-5 m units. This method has the added benefit of creating an extended stratigraphic profile for the site without the necessity of excavating a long continuous trench (Kappers et al. 2007:83).

These excavation units were then subdivided into 25 1-x-1 m squares each delineated by survey pins and numbered sequentially, beginning in the southwest corner, from 1 to 25 (Figure 5.1a). After the removal of 5 cm of topsoil, excavation progressed in arbitrary 10 cm levels primarily using hand trowels, but also mattocks and shovels as needed. Four central squares (7, 9, 17, and 19) were selected for recovery of smaller artifacts (Figure 5.1). In an effort to glean more precise information about prehistoric diet at the site, fill removed from a 50-x-50 cm column taken from the southwest corner in each of these four units was wet-screened through a 6 mm (1/4 in) mesh screening box placed atop a 1.5 mm (1/16 in) mesh screening box to recover
both larger and smaller constituents. The remainder of the fill removed from these units was wet-screened through 6 mm screens only.

Accurate recording of all materials and their provenience is possible at Grand Bay because each square in every level of an excavation unit is given a unique field barcode identifier that identifies the excavation year, site, trench, square, and level once scanned into the GIS in the field (Figure 5.2). For example, in Figure 5.2 the barcode reads “05CGB001003,” identifying “05” as the excavation year, site as “CGB” or Carriacou Grand Bay, and “001003” as the unique field find number. The trench, feature, fill, planum, square, and date the barcode was created were written on the label and then entered in the GIS once the barcode was scanned, permanently linking the field find number “001003” to Trench 415, Excavation Level 2, Square 17. Also written on this example was “1/4,” indicating that this particular label was for finds that were wet-screened through 6 mm mesh. As squares are excavated, if there are multiple bags for an individual square, new barcode labels with the same field identifier are printed and “Bag _ of _” written on each label to ensure all finds associated with this square and excavation level maintain provenience between the field and processing area at the CHS Museum.

![Figure 5.1: Grand Bay excavation unit: a) Grid Plan of Excavation Units, shaded squares are designated ‘sample squares’; b) Trench 415 with 5 cm of topsoil removed with exception of the four sample squares designated for wet screening (photograph by Julie Little).](image)
As mentioned, excavation was performed in arbitrary 10 cm levels. Each of the 25 squares in a unit had the same level completely excavated before the next level was begun. For example, all squares in Trench 446 Level 1 were excavated to an approximate depth of 10 cm, or 15 cm below surface level (bsl), before any excavation began in Level 2. This was done to reduce contamination between the levels and provide standardized measurements for excavated materials when conducting post-excavation analyses such as those presented in this thesis. Before and after each level in a unit was excavated, the depth at each corner of the excavation squares was measured with the total station and transferred to the GIS. By also measuring each square’s depth, it is possible to reconstruct the shape of each square and its units more accurately
and, as I have done in this thesis, to examine any changes within the horizontal distribution patterns of midden deposits over time.

In Trenches 561, 563, and 592, the surface was cleaned and all features were recorded using the total station. Surface drawings were then created, digitized, and placed in the site’s geodatabase to create the feature plan shown in Figure 2.8. Non-burial features were then sectioned and drawn to determine their vertical dimensions, overall shape, and function (i.e., hearth, posthole). Burials were marked with four pins enclosing them in an imaginary box that was then measured before and after their excavation with the total station to obtain three-dimensional coordinates. These coordinates were then used to georeference and digitize digital photographs taken of the burials.

At the end of each field season tarpaulins were placed in each excavation unit and covered with backfill to provide a “sterile” surface for the next field season. Backfill was primarily removed and replaced manually through the use of shovels and mattocks. If necessary, heavy machinery was employed to move large amounts of backfill and reduce the time needed for this task.

*Processing and Storage of Data*

I have previously described the use of a barcode system in the field to identify finds from each excavation unit, square, and level. This section will further highlight this coding system’s utility for processing, storage, and management of archaeological materials.

The work days during each field season at Grand Bay were divided into on-site excavations and laboratory/processing duties. As squares were excavated, finds were often left in the field between excavation days in order to maintain accurate records from each square. This
reduced the confusion that might have been caused if there were multiple bags of finds from a square and different persons were conducting excavations in that particular square on separate days. Although participants were required to keep field journals, oftentimes their notes were not up-to-date or they may have forgotten which square they were excavating the previous day. Leaving finds on-site also allowed for all the material associated with each square to be processed as a whole in the laboratory.

Once a square was completely excavated to the arbitrary 10 cm depth, all finds were bagged in heavy gauge polythene finds bags and the square’s unique barcode label placed in the bag. If multiple bags were necessary for a square, new labels were produced with the associated field find number and placed in these bags as described in the previous section. Finds were then taken to the project’s laboratory housed in the upper level of the Carriacou Historical Museum.

At this point they were washed, dried in trays with appropriate labeling, usually the field tags, and sorted into the major materials categories – ceramics, vertebrate remains, shell, stone, and coral. Material for each category was placed in a new bag, or bags depending on the amount of materials, and then given to the laboratory manager for further processing.

Once the laboratory manager received the sorted material, she or he was required to check the accuracy of the processing up to this point. This step included ensuring that there were no extra trays with material still in the process of being washed and dried, and that finds were thoroughly dried as a buildup of moisture inside the bags could cause problems for long-term storage of archaeological materials.

After ensuring that all finds for a particular square had been properly dried and sorted, each category of finds was weighed and, depending on time constraints, a count of the finds, descriptions of any diagnostic pieces, and other pertinent information that may be of use to future
analyses, was also stored in the database. A digital scale connected to the system automatically recorded the weight values within the finds database. This was achieved by first scanning the barcode associated with the finds being processed, taring the scale based on the size of the finds bag used, weighing the finds, and printing a new barcode label that showed the original field find number appended by a category code and a possible sub-number or letter. A sub-number or letter was used if there were multiple bags of a finds category. The new labels were placed inside each associated bag and the original field tag was placed inside the larger bag or storage container that housed all the finds from an associated square.

As finds were weighed and processed, they were placed in boxes that also had unique barcode identifiers. The box barcodes retain information about all the finds contained within a single box. This allows for quick relocation and retrieval of finds from a particular square or finds that warrant closer inspection by specialists or researchers. If finds are removed from the museum and island for further analysis, information about the agency or individual who is responsible for their analysis and return is also stored in the data system. All finds are currently stored at the Carriacou Historical Museum.

**Digitizing the Data**

As previously mentioned, all spatial data were captured with a total station and then input into the Grand Bay geodatabase to map the site, track excavation progress, and monitor erosion along the coastal profile. Michiel Kappers provided all data used in this thesis. The data points for 2004-2008 and 2010 were stored in Microsoft Excel files, with the exception of 2006 and 2010, which were ASCII files. These files included measurements taken along the coastal profile as well as the measurements taken for each excavation level to determine unit boundaries. In
addition to these files, Kappers provided shapefiles containing the excavation grid plan, site boundary, and excavated and digitized features and burials. These were used to create several of the maps throughout this thesis.

The spatial data files contained measurements for each 10 cm excavation level in the excavation units, the coastal profile, features, and burials as well as some surface measurements for site delineation and landscape features. Each measurement was given a Point Id, Easting and Northing measurement based off the site datum, and Height. A Point Code was also provided for features, burials, and the coastal profile. From these files I created polygon shapefiles for each 10 cm excavation level as well as the six distinct cultural layers within the midden deposits and two cultural layers in the habitation area.

The artifact weights used in this thesis were contained within an Excel file exported from the Grand Bay database that contains the provenience information for all recovered material at Grand Bay. In order to use the data from the finds database, I calculated the total weight for each material category for each excavation trench, square, and level and input these into the associated attribute tables. Within these tables are the following attributes: Id – associated excavation trench and square (i.e., 41501 is Trench 415 Square 01); Ceramic_Wt; Shell_Wt; Bone_Wt; Coral_Wt; and Stone_Wt. All weights used in the analyses are given in grams.

Other attributes from the Grand Bay database relevant to the current study include the following: Barcode – the unique identifier for each processed bag of artifacts; Field_find – the original field identifier for an excavation square; Trench – the larger excavation unit; Planum – the associated 5 cm topsoil level or 10 cm excavation level given by an Arabic numeral; Feature – associated cultural stratigraphic layer or feature such as posthole, burial, or surface collection; Feature_type – associated excavation level or feature given as various codes defined in Table
5.1; Square – associated excavation square numbered 01 to 25; Category – artifact category given as codes defined in Table 5.2; Sub_No – sub-number given if multiple bags were needed to store artifacts from an excavation square; Number – number of artifacts a bag contains; Weight – weight of the artifacts given in grams; and Remark – notes about the artifacts contained with the associated bag such as decorated ceramics, shell beads, or stone tools. Table 5.3 is a copy of entries from the database file.

The data for all materials excavated from Grand Bay as of 2008 are included in this thesis. While Level 10 of Trench 415 was found to have missing data for many of the excavation squares, likely due to insufficient processing time during the 2008 field season, the available data were used in the following analyses. For the results of these analyses to be reliable, at least 30 features or attribute values are needed when using the Global Moran’s I and Anselin Local Moran’s I spatial analysis tools (Esri 2014). To satisfy this condition, I merged the shapefiles for Levels 1 through 9 of Trenches 415 and 446 and those for Levels 1 and 2 of Trenches 561, 563 and 592.

Table 5.1: Feature Type Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>Hearth Pit</td>
</tr>
<tr>
<td>IND</td>
<td>Indeterminate provenience</td>
</tr>
<tr>
<td>INH</td>
<td>Inhumation</td>
</tr>
<tr>
<td>LAY</td>
<td>Excavation Layer (associated cultural stratum for each 10 cm excavation planum)</td>
</tr>
<tr>
<td>ND</td>
<td>Natural Disturbance</td>
</tr>
<tr>
<td>POH</td>
<td>Posthole</td>
</tr>
<tr>
<td>SUB</td>
<td>Subsoil</td>
</tr>
<tr>
<td>TOP</td>
<td>Topsoil (5 cm excavation level)</td>
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<tr>
<td>XXX</td>
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Table 5.2: Material Category Codes

<table>
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<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
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<tr>
<td>BOA</td>
<td>Animal Bone (Vertebrate remains)</td>
</tr>
<tr>
<td>BOH</td>
<td>Human Bone</td>
</tr>
<tr>
<td>CER</td>
<td>Ceramics</td>
</tr>
<tr>
<td>CHA</td>
<td>Charcoal</td>
</tr>
<tr>
<td>COR</td>
<td>Coral</td>
</tr>
<tr>
<td>SAABO</td>
<td>Sample Square Animal Bone (from 6 mm wet screened fill)</td>
</tr>
<tr>
<td>SACH</td>
<td>Charcoal Sample for Radiocarbon Dating</td>
</tr>
<tr>
<td>SASOIL</td>
<td>Soil Sample for Future Analysis</td>
</tr>
<tr>
<td>SC</td>
<td>Sample Column Material (from 50-x-50 cm sample column – 6 mm and 1.5 mm wet screened fill)</td>
</tr>
<tr>
<td>SHE</td>
<td>Shell</td>
</tr>
<tr>
<td>SPEC</td>
<td>Special Finds (i.e., shell beads, stone tools, body stamps)</td>
</tr>
<tr>
<td>STN</td>
<td>Stone</td>
</tr>
</tbody>
</table>

Spatial Analysis of Artifact Distributions

The inherent spatial nature of archaeological artifacts and archaeological data makes them irrefutably suited to various spatial analyses. The two types of mathematical spatial analysis relevant to this study are summarized below with reviews of some of their archaeological applications.

Spatial Autocorrelation (Global Moran’s I)

Spatial autocorrelation can be broadly explained by Tobler’s First Law of Geography, which states that “everything is related to everything else, but near things are more related than
<table>
<thead>
<tr>
<th>Barcode</th>
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<th>Trench</th>
<th>Planum</th>
<th>Feature</th>
<th>Feature_type</th>
<th>Square</th>
<th>Category</th>
<th>Sub_no</th>
<th>Number</th>
<th>Weight</th>
<th>Remark</th>
</tr>
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<tbody>
<tr>
<td>05CGB000624SHE</td>
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<td>446</td>
<td>4</td>
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<td>05CGB000624</td>
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<td>4</td>
<td>L003</td>
<td>LAY</td>
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<td>STN</td>
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<td>BOA</td>
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<td></td>
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<td></td>
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<tr>
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<td>05CGB000625</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>BOA</td>
<td>a</td>
<td></td>
<td>53.4</td>
<td></td>
</tr>
<tr>
<td>05CGB000625CER1</td>
<td>05CGB000625</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>CER</td>
<td>1</td>
<td>0</td>
<td>259.2</td>
<td>Decorated</td>
</tr>
<tr>
<td>05CGB000625CER2</td>
<td>05CGB000625</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>CER</td>
<td>2</td>
<td></td>
<td>2683.0</td>
<td></td>
</tr>
<tr>
<td>05CGB000625CER3</td>
<td>05CGB000625</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>CER</td>
<td>3</td>
<td></td>
<td>4691.2</td>
<td></td>
</tr>
<tr>
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<td>05CGB000625</td>
<td>446</td>
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<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>CER</td>
<td>4</td>
<td></td>
<td>2303.0</td>
<td></td>
</tr>
<tr>
<td>05CGB000625STN</td>
<td>05CGB000625</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>STN</td>
<td>1</td>
<td></td>
<td>229.6</td>
<td>Rounded</td>
</tr>
<tr>
<td>05CGB000703CER1</td>
<td>05CGB000703</td>
<td>446</td>
<td>9999</td>
<td>99999</td>
<td>IND</td>
<td>15</td>
<td>CER</td>
<td>1</td>
<td>0</td>
<td>5537.6</td>
<td>Decorated ceramic cup-chipped</td>
</tr>
<tr>
<td>05CGB000703CER2</td>
<td>05CGB000703</td>
<td>446</td>
<td>9999</td>
<td>99999</td>
<td>IND</td>
<td>15</td>
<td>CER</td>
<td>2</td>
<td></td>
<td>1487.8</td>
<td>all way around base</td>
</tr>
<tr>
<td>05CGB000726SPEC</td>
<td>05CGB000726</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>25</td>
<td>SPEC</td>
<td>1</td>
<td></td>
<td>179.2</td>
<td>Adorno - human features and two sherds of same vessel</td>
</tr>
<tr>
<td>05CGB000727SPEC</td>
<td>05CGB000727</td>
<td>446</td>
<td>4</td>
<td>L003</td>
<td>LAY</td>
<td>12</td>
<td>SPEC</td>
<td>3</td>
<td></td>
<td>563.6</td>
<td>Decorated ceramic - thumb indent handle.</td>
</tr>
<tr>
<td>05CGB000736SPEC</td>
<td>05CGB000736</td>
<td>446</td>
<td>2</td>
<td>L002</td>
<td>LAY</td>
<td>09</td>
<td>SPEC</td>
<td>1</td>
<td></td>
<td>35.0</td>
<td>Spindle whorl</td>
</tr>
<tr>
<td>05CGB000738SPEC</td>
<td>05CGB000738</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>05</td>
<td>SPEC</td>
<td>1</td>
<td></td>
<td>92.2</td>
<td>Shell adze - partial</td>
</tr>
<tr>
<td>05CGB000739SPEC</td>
<td>05CGB000739</td>
<td>446</td>
<td>4</td>
<td>L002</td>
<td>LAY</td>
<td>05</td>
<td>SPEC</td>
<td>1</td>
<td></td>
<td>58.6</td>
<td></td>
</tr>
</tbody>
</table>
distant things” (Tobler 1970:236). The three basic classes of spatial autocorrelation are adapted from Wheatley and Gillings (2002:131) and are illustrated in Figure 5.3:

1. Positive autocorrelation: neighboring attribute values or spatial objects exhibit a tendency to have similar values to each other;
2. Zero autocorrelation/Random autocorrelation: neighboring attribute values or spatial objects show no apparent relationship or patterns of clustering;
3. Negative autocorrelation: neighboring attribute values or spatial objects are distributed evenly over space or tend to be different (presence of a low value at one place makes it more likely to be surrounded by high values).

The most common measure of global spatial autocorrelation is Moran’s $I$ index (Moran 1950) which measures similarities between both the location and attribute values of spatial objects simultaneously. It then evaluates the type of pattern expressed by the given set of objects and attributes. ArcGIS 10.2 Desktop help center (Esri 2014) defines Moran’s $I$ as:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j}z_i z_j}{\sum_{i=1}^{n} z_i^2}$$
where $z_i$ is the deviation of an attribute for feature $i$ from its mean ($x_i - \bar{X}$), $w_{i,j}$ is the spatial weight between feature $i$ and $j$, $n$ is equal to the total number of features, and $S_0$ is the aggregate of all the spatial weights represented by the following equation:

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j}$$

In ArcGIS 10.2, the Spatial Autocorrelation (Global Moran’s I) tool calculates the Moran’s $I$ index value, the Expected Index value, variance for the data values, and both a $z$-score (standard deviation) and $p$-value (probability) to evaluate the statistical significance of the index value. A positive index value ($0 < I < 1$) indicates that values in the dataset cluster spatially. A negative index value ($-1 < I < 0$) indicates a negative correlation between the data values and a dispersed distribution pattern. An index value that approaches zero, or equals zero, indicates a random distribution pattern of values. The null hypothesis for the global Moran’s $I$ statistic states that the attribute being analyzed is randomly distributed among the features in a study area, complete spatial randomness (CSR), and can only be rejected if the $p$-value is statistically significant. Table 5.4 summarizes interpretations of the results given by the Spatial Autocorrelation (Global Moran’s I) tool in ArcGIS 10.2.

**Table 5.4: Interpretation of Results Given by the Global Moran’s I Tool**

<table>
<thead>
<tr>
<th>Output</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The p-value is <em>not</em> statistically significant.</td>
<td>The null hypothesis <em>cannot</em> be rejected. The observed spatial pattern could be one of many possible versions of CSR.</td>
</tr>
<tr>
<td>The p-value is statistically significant and the $z$-score is positive.</td>
<td>The null hypothesis may be rejected. The spatial distribution of high values and low values is more spatially clustered than would be expected if underlying spatial processes were random (positive autocorrelation).</td>
</tr>
<tr>
<td>The p-value is statistically significant and the $z$-score is negative.</td>
<td>The null hypothesis may be rejected. The spatial distribution of high and low values is more spatially dispersed than would be expected if underlying spatial processes were random (negative autocorrelation). This dispersed spatial pattern often reflects some type of competitive process.</td>
</tr>
</tbody>
</table>
Uses of Moran’s I in Archaeology

Three early archaeological applications of Moran’s I examine the distribution of the terminal dates of Maya monuments in relation to the Classic Maya collapse, Kvamme (1990), Whitley and Clark (1985), and Williams (1993). Whitley and Clark, through the use of an area-based version of Moran’s I, found that there was no spatial autocorrelation among the data and thus did not support the hypothesis that terminal dates of monument erection followed a general northwest-to-southeast pattern (1985:388-391). Thus, from this lack of spatial autocorrelation there was no apparent geographical pattern to the cessation of monument erection, and by inference, the Classic Maya collapse (1985:378). In his rebuttal to their “seriously flawed” (Kvamme 1990:197) results, Kvamme (1990:203) used a point-pattern version of Moran’s I and found that there is positive autocorrelation between the dates, or that nearby dates tend to be similar, but the particular nature of the trend is not revealed. In the third examination of the terminal dates of Maya monument erection, Williams (1993:706) suggests that the approaches of both Kvamme (1990) and Whitley and Clark (1985) are neither “appropriate” nor “inappropriate” and if one is deemed “inappropriate”, then so must the other. In this paper, the dates are subjected to both area- and point-based methods of determining spatial autocorrelation and, in some ways, Williams clarifies how Moran’s I was used by Kvamme (1990) and Whitley and Clark (1985). His results do suggest the presence of positive spatial autocorrelation among the dates as well as geographical patterning in their distribution (1993:708). Interpretation of these three studies could indicate a relationship between the termination of monument erection and the gradual collapse of Classic Maya civilization in a seemingly northeast to southwest trend within the region examined.
Kvamme (1996) utilizes Moran’s $I$ to examine the spatial structure of chipped-stone scatters and the distributions of chipping debris from two representative flaking clusters from a larger 6-ha area located in western Colorado. He found that spatial autocorrelation analysis of three variables — minimum debitage size, proportion of debitage greater than 20 mm, and proportion of cortex pieces — revealed highly significant spatial patterns in each of the two clusters analyzed (1996:47). He then uses Moran’s $I$ to assess the spatial association between these three variables — minimum size and proportion of debitage greater than 20 mm, proportion of debitage greater than 20 mm and proportion of cortex pieces, and minimum size and proportion of cortex pieces — to reveal highly significant positive associations between the variables in each test cluster (1996:49). To better understand the nature of the spatial distribution of chipping debris, Kvamme employed a stone worker to conduct knapping experiments and subsequent spatial analysis of their debitage scatters. The results of these experimental knapping episodes showed similar patterns and associations exhibited in the archaeological scatters. He explains these patterns and associations as a result of percussion-based knapping activities, which tend to exhibit sorting by size and type of debitage that varies with distance from the knapping locus; “scatter margins will generally exhibit higher proportions of large debitage than interior sections where small-size chipping debris dominates” (Kvamme 1996:66-67). Such analyses can give insight into the study of site activity areas, multiple episodes of knapping activities, site occupation length (e.g., one-time use, seasonal, long-term), technological changes or advancements, and effects of post depositional processes on chipping debris scatters.

Spatial analysis of the distribution of archaeological sites and possible relationships between them using Moran’s $I$ is presented in Fletcher’s (2008) examination of Chalcolithic sites in Israel’s Negev desert. Results from this analysis led to three conclusions: 1) Chalcolithic
settlement in the Northern Negev was clustered based on access to resources; 2) at smaller scales of analysis settlement appeared to lack any detectable pattern; and 3) spatial analysis of these settlements shows a factor of distance between sites, or groups of sites, at larger scales (Fletcher 2008:2056). He interpreted these results as indicators of the lack of a dynamic regional chiefdom-level society during this time period with the data currently available (2008:2056-2057). A second study conducted by Winter-Livneh et al. (2010) reexamined Fletcher’s (2008) analyses alongside examination of the data using a different method of Moran’s I. The results of this second study indicated that there were clustered patterns in Chalcolithic period settlements attributable to the region’s topography and nature of the access to water resources (Winter-Livneh et al. 2010:293). The spatial distribution of settlements and resulting patterns may also provide insight into the social and economic organization of past societies, adaptations to environmental limiting factors, and land use patterns (e.g., Blick et al. 2011; Hodder 1972; Niknami et al. 2009; Rieth et al. 2008).

Using Moran’s I, Al-Shorman (2010) examined the spatial autocorrelation of factors such as elevation, associated archaeological site size, and topographic zone of Jordanian dolmens in the hope of better understanding their function. Results showed no significant autocorrelation, or clustering, of the dolmens based on associated archaeological site size, but clustering of them based on elevation (Al-Shorman 2010:47-48). These analyses indicate to the author that while Jordanian dolmens share common elevations, are found in statistically significant clusters on hillside terraces, they contain few associated cultural remains other than burials, and would have taken considerable time and effort to construct, their function may have been as burial sites for high-status individuals (Al-Shorman 2010:48).
Burials have also been subjected to the use of Moran’s $I$ to determine similarities between various attributes such as age, sex, orientation, preservation, and pathology in an effort to examine changes in California’s prehistoric Wappo society (Schrader 2013). In his analysis, Schrader found that there was evidence of spatial autocorrelation among certain burial attributes as well as some classes of indirectly and directly associated artifacts and the burials. Schrader (2013:168) attributes these results to variance in excavation techniques, possible activity areas at the site in question, natural phenomena, and differences in status or wealth among the site’s occupants. Because of the incomplete nature of the dataset used, the results were not definitive, but as Schrader (2013:167) states, “if the underlying dataset were reliable, then it would appear that CA-NAP-399 during the Upper Archaic could be considered evidence of a stratified, hierarchal, complex society.”

*Cluster and Outlier Analysis (Local Spatial Autocorrelation)*

While Moran’s $I$ looks at spatial autocorrelation on a global, or in the current analysis site-wide, scale, cluster analysis identifies statistically significant clusters around an individual location (hot or cold spots) and spatial outliers as defined by Anselin (1995). To achieve this, Anselin (1995:94) outlines a class of statistics that he defines as:

Local indicators of spatial association (LISA)...a statistic that satisfies the following two requirements:

a. the LISA for each observation gives an indication of the extent of significant spatial clustering of similar values around that observation;

b. the sum of LISAs for all observations is proportional to a global indicator of spatial association.
In ArcGIS 10.2 (Esri 2014), cluster analysis is performed with the Cluster and Outlier Analysis tool by calculating the Local Moran’s $I$ statistic defined as:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^n w_{i,j} (x_j - \bar{X})$$

where $x_i$ is an attribute for feature $i$, $\bar{X}$ is the mean of the corresponding attribute, $w_{i,j}$ is the spatial weight between feature $i$ and $j$, and:

$$S_i^2 = \frac{\sum_{j=1, j \neq i}^n (x_j - \bar{X})^2}{n - 1} - \bar{X}^2$$

with $n$ equating to the total number of features. In addition to the Local Moran’s $I$ value, the Cluster and Outlier Analysis tool also calculates a $z$-score, $p$-value, and a code representing statistically significant clusters and outliers for a 95 percent confidence level. The null hypothesis for this analysis is complete spatial randomness (CSR) of the values associated with each feature. Table 5.5 summarizes the output of the tool and subsequent interpretations.

**Table 5.5: Interpretation of Results Given by the Anselin Local Moran’s $I$ Tool**

<table>
<thead>
<tr>
<th>Output ($p &lt; .05$)</th>
<th>Interpretation</th>
<th>Cluster/Outlier Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The $I$ index is positive, the value of the $z$-score is $&gt;+1.96.$</td>
<td>HH: Cluster of statistically significant high values (“hot” spot).</td>
</tr>
<tr>
<td></td>
<td>The null hypothesis may be rejected and the observed pattern is likely too unusual to be the result of CSR (positive autocorrelation). The feature is surrounded by similarly high or low values forming statistically significant clusters.</td>
<td>LL: Cluster of statistically significant low values (“cold” spot).</td>
</tr>
<tr>
<td></td>
<td>The $I$ index is negative and the value of the $z$-score is $&lt;-1.96.$</td>
<td>HL: Statistically significant outlier with a high value surrounded primarily by low values.</td>
</tr>
<tr>
<td></td>
<td>The null hypothesis <em>cannot</em> be rejected because the observed pattern may be the result of CSR (negative autocorrelation). The feature is a statistically significant outlier and is surrounded by dissimilarly high or low values.</td>
<td>LH: Statistically significant outlier with a low value surrounded primarily by high values.</td>
</tr>
</tbody>
</table>
Uses of Anselin’s Local Moran’s I in Archaeology

According to Premo (2004:855), “Williams’ prediction that spatial autocorrelation statistics would assume a prominent role in quantitative archaeological analyses has yet to be realized” and his own research showed that the set of terminal Classic Maya monument dates had undergone the majority of the handful of archaeology spatial autocorrelation analyses (Kvamme 1990; Whitley and Clark 1985; Williams 1993). While these three earlier studies investigated the global spatial autocorrelation of the terminal dates, they were unable to examine and interpret the localized clusters of these dates and what they may indicate about the collapse of Classic Maya civilization. Therefore, nearly two decades after the terminal dates dataset was first subjected to spatial autocorrelation analysis, Premo provides the first examination of it by utilizing local spatial autocorrelation statistics. His results identified how local spatial autocorrelation analysis of this dataset can reveal how terminal dates at sites with dates either much earlier than or much later than those of spatially defined neighbors “fit into local socio-political spheres and immediate biophysical surroundings” and that “the activity of monument building was largely coterminous among sites within two central neighborhoods” (Premo 2004:864). The last observation may lead to interpretation of numerous possibilities such as those related to the social and economic interconnectedness of neighboring sites and the direct and indirect impacts on these neighboring sites as a result of environmental or cultural stressors (Premo 2004:864).

Ciminale et al. (2009) applied local statistical analyses to satellite QuickBird images of the Tavoliere plain in southern Italy to identify and enhance the existence of archaeological and palaeoenvironmental features. Because the output of local spatial statistics is a new image that provides a measure of autocorrelation around a given pixel in the satellite images, their results
revealed circular and semicircular enclosures surrounded by two external ditches as well as a palaeo-riverbed (Ciminale et al. 2009:147). Their study shows that local spatial statistics can be useful in the interpretation of spatial relationships between settlements and their surrounding environment, reconstruction of these settlements, identification of smaller structures, and reduction of monetary and temporal costs associated with traditional field survey and excavation in large scale archaeological landscape studies by utilizing non-invasive remote sensing techniques (Ciminale et al. 2009:152-153).

Local Moran’s I is employed by Hill et al. (2011) to investigate spatial patterning of artifacts at a Late Paleoindian camp. They found that several artifact types formed statistically significant high value clusters in one area of the excavated area while in another portion of the area contained statistically significant low value clusters of the same artifact types (Hill et al. 2011:762). They interpret these results as evidence for two different patterns of spatial use within the excavated area. In the area with high-high values, three distinct clusters were identified and interpreted as follows: 1) a drop zone for a variety of tool using and other activities; 2) a second multifunctional activity area; and 3) hearth clean-out area (Hill et al. 2011:762-764). In the portion of the excavated area that had statistically significant low-low value clusters, the interpretation was that this area may reflect some form of barrier such as a habitation structure with an interior ground cover which prevented artifacts from becoming part of the underlying sediments (Hill et al. 2011:765).

**Summary**

In this chapter I have summarized the primary methods for excavation and data collection utilized at Grand Bay. I also provided the steps taken to transform and import the data obtained
from the project into ArcGIS for analysis. In the final section I listed the two main spatial analysis tools that will be used to analyze these data as well as examples of their archaeological applications. From the examples given, global and local spatial autocorrelation statistics have many varied applications within archaeology. As recent as 2006, Conolly and Lake (2006:158) state that “there has been some optimism that measures of spatial autocorrelation may have wider application in archaeology (Williams 1993), but thus far the most successful applications have been constrained to the analysis of Mayan terminal dates (Premo 2004).”

The use of global and local spatial statistics to examine artifact distributions is beneficial in understanding the overall formation of an archaeological site. They have also been shown as effective analyses for understanding the spatial structuring of sites, identification of distinct activity areas, social structure of past societies, distribution of sites and settlement patterns in relation to resource availability and regional topography, and the reconstruction of ancient settlements. As these tools and others that evaluate spatial relationships are becoming more accessible and easier to use, their application within archaeology has certainly increased and will continue to do so. According to Reid (2008:6) the interpretation of archaeological data using GIS applications

“Enables us to generate permanent records of sites, combine and analyze diverse sources, understand how cultural heritage relates spatially to its surrounding natural and human environment, communicate knowledge and network databases, test proposed development models and conservation strategies, facilitate monitoring and management of sites, and map one's material in the course of research.”
In the current study global spatial autocorrelation analyses are conducted on the major archaeological materials categories – ceramics, shell, vertebrate remains, stone, and coral – present in Grand Bay’s midden deposits to locate any patterns within their distributions. These patterns could indicate cultural behaviors such as preferential use of certain areas for refuse disposal, activity areas, post-depositional processes, erosion, or even excavation methods. Local spatial autocorrelation is then utilized in the hope of identifying clusters of artifact categories within the midden deposits at Grand Bay that also could be indicative of depositional and post-depositional formation processes, activity areas, or present-day anthropogenic activities such as sand mining.
Chapter 6:
Distribution Mapping of Grand Bay’s Archaeological Assemblages

In this chapter I examine the spatial distribution of each major archaeological material category analyzed in this thesis. As there is an abundance of distribution maps, these are compiled in Appendix A for reference. These distributions allow for preliminary visual analysis, a natural first step when undertaking spatial analysis of a dataset, of recovered material to determine if any patterns are discernible to the naked eye.

Exploration of the Data

Distribution maps were created in ArcMap and display concentrations of each major archaeological material category using a graduated scale for the weight values based on natural breaks. The majority of the distributions were divided into five classes with the exception of distributions within Layers 003 and 003A where only four classes were used as there was insufficient data for a fifth class. Features are depicted in the habitation area, as well as two burials that were recovered within earlier strata of the midden area. I have also included the coastal profiles for the four field seasons being examined to emphasize the effects coastal erosion has had on the loss of archaeological material at Grand Bay, seen in the eventual destruction of the majority of Trench 446.
Midden Component

During the 2004 field season, excavation of Trench 446 was completed through excavation Level 3. At this time the trench was intact, but, by 2005, a small portion of the eastern excavation squares had been lost because of mass erosion due to Hurricane Ivan in September of 2004. Levels 4, 5, and 6 were excavated during the 2005 field season. When excavations at Grand Bay resumed in 2007, another 1 to 2 meters of midden deposits had been destroyed as a result of a direct hit to Carriacou by Hurricane Emily in July 2005. Levels 7, 8, and 9 were excavated during this field season. By 2008, over half of Trench 446 had been destroyed due to profile erosion; thus, archaeological materials were recovered from ten excavation squares of Levels 10, 11, and 12 only during this field season. The distributions for the midden component were created based on five cultural layers. L001, the topsoil layer, is not included in this analysis.

Ceramics

In stratum L002, there are two areas where ceramics appear to cluster – the northwest quadrant of Trench 415 and the southeast quadrant of Trench 446. The excavation squares between these two areas seem to have either been disturbed by post-depositional processes or could indicate that there were two refuse dumping areas being used during this occupation period. The appearance of two disposal areas could be indicative of refuse separation by household. Curet (1992) found that there was a shift in habitation structures at three Puerto Rican sites from communal longhouses to smaller, nuclear family roundhouses during later occupation periods. Two areas of refuse disposal, or one larger area that has been disturbed by post-depositional processes, also could indicate intensive occupation and increased population during these time periods. Stratum L002 also contains the most ceramics of all the cultural strata, over
1250 kg. Fitzpatrick et al. (2009) and Kaye et al. (2011) noted that ceramics associated with later Troumassoid cultural styles at Grand Bay were thicker than earlier ceramics from earlier Saladoid contexts. Thus, the resulting weight distribution and suggested population intensification could be biased because of these heavier sherds. Bias is also introduced because this stratum covers a large extent of the midden deposits in both excavation trenches; whereas, L003 was limited to Trench 446 and parts of Trench 446 had eroded resulting in less archaeological materials recovered from L005 and L006.

Ceramics in stratum L003 appear to form a cluster around Squares 11, 12, and 17 seen in Figure 6.2. Weights gradually decrease the farther away an excavation square is from this apparent cluster. As L003 was not continuous across both excavation trenches, I suggest the area

![Figure 6.1: Distribution of ceramics in L002](image-url)
of Trench 415 was temporarily abandoned between the formation of L002 and L005. If this was what happened at Grand Bay, the midden deposits associated with L003 likely extend into Trenches 445 and 447. As much of Trench 447 has been lost to profile erosion, excavation of Trench 445 would be required to investigate the nature of this cultural stratum further.

Stratum L003A is a hearth pit associated Squares 16, 17, and 21 in excavation Levels 7 and 8 of Trench 446. The majority of ceramics were recovered from Square 16 as shown in Figure 6.3.

Figure 6.4 is the distribution of ceramics in stratum L005. These artifacts appear to form a cluster of similar weights in the northern two-fifths of Trench 41 and the southwestern corner of Trench 446. In Trench 415, the ceramics in this area of higher concentration were excavated
from Squares 21 through 25 of Level 6 and Squares 16 through 25 of Level 7. This distribution could be related to Burial F0132. Intentional placement of non-perishable grave goods within burials at Grand Bay is a rare occurrence. Therefore, the higher weight values seen in Squares 19 and 20 do not reflect this type of treatment; however, they may represent midden deposits used to fill in and cover the burial pit.

The lower weight values associated with the eastern two-fifths of Trench 446 are a direct result of erosional episodes. Ceramics for these squares were recovered from excavation Level 6 only. What is surprising is that the weight of ceramics from this excavation level contributed the most to Squares 2, 3, 9, and 18, which have the highest weights in this trench. Could this indicate that the midden deposits that were eroded away and those in Trench 416 contained similar amounts of ceramics? As the weights decrease the further inland the midden is located, I suggest
that those squares would have contained similar weights for ceramics and that part of the midden may have been used more as it was further from the habitation area. These higher weights could also represent the effects of gravity on items being tossed on top of a refuse heap. As items are thrown on top, they are subject to rolling down the heap and collecting on its edges.

The distribution of ceramics in L006 is shown in Figure 6.5. This distribution is another direct result of profile erosion. In this cultural stratum, it appears that more ceramics were disposed of in the area of Trench 446. With the addition of excavation data from the lower levels of Trench 415, this distribution pattern may change. Based on the data available for this analysis, the distribution reflects the widespread use of this area of the site for refuse disposal with, perhaps, more emphasis on the area in Trenches 445 and 446.

Figure 6.4: Distribution of ceramics in L005
Coral artifacts were not categorized as a distinct artifact category until excavation Level 8 was reached in Trenches 415 and 446. All other occurrences were labeled as part of the stone assemblage, as special finds as described below, or may have been incorporated in the overall weight of stone artifacts processed for an excavation unit.

Coral fragments and artifacts were recovered from only four excavation units in L002 as shown in Figure 6.6. In Trench 415, a piece of worked coral with a weight of 146 g was recovered in Square 12. In Trench 446, a possible fishing weight and a red coral bead were recovered in Square 4 with a total weight of 55.6 g. A piece of coral with a weight of 32.4 g and a tool with weight of 363.8 g were recovered from Squares 6 and 14, respectively.
In L003, there were again a limited number of coral artifacts recovered. The artifact recovered in Square 12 was a piece worked into a crescent shape with a weight of 25.4 g. The largest piece of coral, a piece of rounded coral with a weight of 109.8 g, was recovered in Square 16. A piece with a weight of 26.6 g was recovered in Square 24.

The distribution of coral in L005 is shown in Figure 6.8. The amount of coral artifacts recovered in this stratum increases and is concentrated in the southern two-fifths of Trench 415. There were no comments in the finds database to indicate whether these items were worked pieces of coral or fragments that may have been stored in this area for future use. This concentration could also represent a cleaning episode of a coral tool-making area elsewhere at the site.
Figure 6.7: Distribution of coral in L003

Figure 6.8: Distribution of coral in L005
Figure 6.9: Distribution of coral in L006

The distribution of coral in L006, Figure 6.9, is even more widespread than in L005 with artifacts and fragments being recovered in both excavation trenches. As there are no descriptions for the coral found within this stratum’s deposits, these finds were likely coral fragments that may have been collected for later use. Due to the widespread distribution, these finds could also represent discarded fragments from tool and ornament making that took place in a separate area of the site.

Shell

The distribution of shell was found to be similar to that of ceramic. In general, in units where great quantities of ceramics were found, greater quantities of shell were also be recovered.
There is often a drastic difference in the weight of shell recovered from the four environmental squares within each trench as compared with other squares.

In Figure 6.10, in L002 there seems to be two areas of clustering, one in each trench. As with the ceramics distribution, more shell was recovered in the northwestern quadrant of Trench 415. This could be the result of storm run-off that has created the gully seen in the bottom right corner of the distribution map, Figure 6.10. Similar weights concentrate in the central portion of Trench 446. These areas of concentrated higher weights surrounded by lower weight values may represent the extent of the midden during this occupation period.

As Figure 6.11 shows, shell recovered in L003 had higher weights in the more western squares of Trench 446 with weights decreasing the further east a square is located. Squares 1 through 5, 10, and 15 are not associated with this cultural layer. Squares 20 and 25 contained 217.2 g and 242.8 g of shell remains, respectively. Environmental Squares 7 and 17 had much higher weights than neighboring squares, with respective weights of 4.4 kg and 4.8 kg. The other two environmental squares, 9 and 19, had much lower weight values of .9 kg and 1.2 kg, respectively. This could be a result of profile erosion.

As seen in the distribution of ceramics from L003A, Figure 6.12, the majority of shell was recovered from Square 16 of this stratum.

The distribution of shell in L005, Figure 6.13, depicts a widespread distribution across both excavation trenches with a concentration of higher weight values in the central area of Trench 446. This concentration is similar to that seen in the ceramics distribution for this stratum. Again, the environmental squares tend to have higher weight values as compared with neighboring squares. There is a marked decrease in amount of shell recovered from this stratum as compared with L002. Over 148 kg of shell remains were recovered in L002, while 42.4 kg
Figure 6.10: Distribution of shell in L002

were recovered in L005. This could be a result of less intensive exploitation of invertebrates, exploitation of smaller invertebrate taxa, smaller population size, or that the midden extended farther east or into Trench 445. The decrease could also be related to the depth of midden deposits for each of these strata.

The distribution of shell in L006, Figure 6.14, suggests less dependence on invertebrate taxa during this early occupation period, which could be reflective of a smaller population size. There does appear to be a cluster of shell in Trench 446 around Squares 12, 16, and 17 that coincides with a concentration of ceramics recovered from this area. The area around Burial F0132 had fewer shell remains and may represent a clearing of midden deposits from this area for the creation of the burial pit. The total weight of shell recovered in L006 is less than that of L005 with 36.4 kg. As these weights are much closer than those between L002 and L005, I
would suggest that invertebrate exploitation was steady during the early occupation of Grand Bay as data lost from erosion would likely make the two assemblages more equivalent.

**Figure 6.11:** Distribution of shell in L003

**Figure 6.12:** Distribution of shell in L003A
Figure 6.13: Distribution of shell in L005

Figure 6.14: Distribution of shell in L006


**Stone**

As with ceramics and shell, there is a concentration of stone recovered in the southern portion of Trench 446 in L002. Many of the stone artifacts recovered in this trench were worked and several have been identified as possible fishing weights. Thus, this concentration of artifacts may represent an area where marine resources were processed after collection with fishing nets. It could also represent an area of fishing net repair or the dumping of fishing and other tool implements removed from another area of the site. In Trench 415, there is an area of concentration in the western-most excavation squares. Artifacts recovered in this trench included several pieces of green stone, beads, tools, and other possible worked stone fragments. This area may have been the site of specialized lapidary activities after Grand Bay was abandoned ca. AD 1250.

![Figure 6.15: Distribution of stone in L002](image-url)
Stone artifacts recovered from L003 included pieces of green stone, adzes, and other worked pieces of stone. Hearth stones made up the stone assemblage for L003A.

The distribution of stone in L005 is comprised of possible tools, including a polishing stone, part of a zemi, and pieces of quartz. The presence of stone in Square 20 of Trench 415 is not likely to be associated with Burial F0132 as the stone material was recovered in excavation Level 6 and the burial was not uncovered until Level 7. However, the exact provenience of the stone in question would be needed to verify that it was not associated with the burial. Unfortunately, this information is not available.

In L006, there is an increase in recovered stone materials and artifacts. In Trench 415 these included possible hearth stones, worked sandstone, and possible lithic flakes. In Trench 446, four hearth stones were found in Square 16 of Level 10, the same area in which L003A in Levels 7 and 8 was located and identified as a hearth pit.

Figure 6.16: Distribution of stone in L003
Figure 6.17: Distribution of stone in L003A

Figure 6.18: Distribution of stone in L005
Vertebrates

Vertebrate remains in Stratum L002 are distributed across both trenches, with higher weights concentrating in the northwest quadrant of Trench 415. This concentration could be from increased use of this area for refuse dumping during this time period. The lower concentration of remains in Trench 446 may also be the result of erosional episodes. From Figure 6.20, it is also noticeable that higher concentrations of vertebral remains were recovered in the four environmental squares – Squares 7, 9, 11, and 17. This marked difference in the quantity of remains recovered within these squares can thus skew the distribution map, which in turn skews the interpretation of the artifact distributions. The distributions are striking and attest to the value of wet-screening for recovery of faunal material. In nearly every cultural layer, these four
squares contained more animal bone than most other squares. A preliminary zooarchaeological analysis of vertebrate remains found that the majority of vertebrate remains in Stratum L002 were from bony fish and comprised 95% of the sample number of individual specimens and 87% of the minimum number of individuals (LeFebvre 2007:934). These results imply emphasized exploitation of vertebrate marine resources over terrestrial fauna. Stratum L003 is associated with Trench 446 contexts only and includes the majority of excavation Levels 5 and 6 as well as a few squares in Level 4 (see Figure 2.9). The distribution of vertebrate remains in stratum L003, Figure 6.21, is concentrated around Squares 16, 17, and 21 with weights decreasing in the squares farther from this central location.

The hearth pit, denoted as stratum L003A, was excavated within Squares 16, 17, and 21 of Levels 7 and 8 in Trench 446. As there are no radiocarbon dates associated with this stratum
or those surrounding it, I suggest the hearth pit was being used for an extended period of time based on the amount of faunal remains recovered. Figure 6.22 depicts the distribution for stratum L003A.

Vertebrate remains in stratum L005 appear to concentrate in the southwestern portion of Trench 446 and the northern two-fifths of Trench 415. Based on the distribution map, Figure 6.23, there is likely a concentration of animal bone in Trench 445. I suggest the current data and resulting distributions are indicative of the midden boundaries during this time period. As with other strata, more vertebrate remains were recovered from the four environmental squares.

Figure 6.21: Distribution of vertebrate remains in L003
Figure 6.22: Distribution of vertebrate remains in L003A

Figure 6.23: Distribution of vertebrate remains in L005
Figure 6.24: Distribution of vertebrate remains in L006

The distribution for stratum L006, Figure 6.24, shows that the area around Trench 446 contains the majority of vertebrate remains for this occupation period. Weights in Trench 446 include material from four excavation levels, while those in Trench 415 include material from only two excavation levels. Data for Level 10 of Trench 415 were not used because of incomplete processing of the materials from this level. Future analysis of the assemblage from this stratum may reveal that the amount of vertebrate remains recovered from Trench 415 is similar to that of Trench 446.

Habitation Component

The assemblages contained within the habitation area at Grand Bay were associated with two stratigraphic layers, HL001 and HL002. Stratum HL001 is the topsoil, but also contained
portions of eroded midden and exposed subsoil. This stratum is associated with excavation Level 1 of Trenches 561, 563, and 592. Stratum HL002 is associated with excavation Levels 2, 3, and 4 of Trench 561 and Level 2 of Trench 592.

**Ceramics**

It appears that in HL001 the majority of ceramics were recovered from the more southern and eastern units of Trench 563. Analyzing diagnostic ceramics is beyond the scope of this thesis, but would be beneficial to understand the contemporaneity of the deposits to reconstruct the settlement history of the site. Without these data, I can only speculate that perhaps this concentration of ceramics may be indicative of primary refuse within habitation structures. The higher concentration of ceramics in this part of the habitation area may also be the result of erosion. The two burials in this area, F0006 and F0164, could have an effect on this distribution if ceramics were used to cover the burial pits. As seen in Figure 2.13, F0164 was located in the subsoil with no associated grave good. From the distribution map, Figure 6.25, it does not appear that there were large quantities of ceramics associated with postholes in this layer.

The distribution of ceramics in stratum HL002 is a likely result of the extent of available data for the current analysis. Data for Trench 592 are from the 2004 field season only. This trench was reopened in the 2011 field season, but data were not obtained for use in this thesis. The most likely interpretations of the resulting distribution are that ceramics were used as fill in posthole features or that they are examples of primary refuse. As primary refuse they could have been left where broken or used and were trampled and further broken over time. Again, further analysis of the diagnostic ceramics recovered from Grand Bay would be needed to thoroughly understand their presence in the habitation area of the site.
Figure 6.25: Distribution of ceramics in HL001
Figure 6.26: Distribution of ceramics in HL002
Shell

In the habitation area, the distribution of shell in HL001 is similar to that of ceramics. There is again a marked concentration of shell remains in the southeastern portion of Trench 563. Interestingly, the environmental squares in this layer tend to not exhibit higher weight values, with the exception of Squares 7 and 9 in Trench 563.

In HL002, there is a concentration of shell around the hearth pit in Trenches 561 and 562, as well as around two postholes in the southwest corner of Trench 561.

Stone

Concentrations of stone are visible in both HL001 and HL002. In HL001, each square that had a weight for stone contained single stone artifacts or fragments. In HL002, there is an increase in stone artifacts. One of these, found in Square 15 of Trench 561 was a worked block of stone, perhaps associated with the hearth pit. All of the stone from HL002 was constrained to Trench 561, and included fragments of green stone, red quartz, an amber colored stone, and several other worked pieces of stone. These findings may be evidence of lapidary activity but further analysis would be required to verify this explanation.

Vertebrates

The distribution of vertebrate remains in HL001 also revealed a concentration of these constituents in the southeast portion of Trench 563. The distribution of HL002 shows that the majority of vertebrate remains concentrated around the hearth pit in Trench 561. In Trench 592, most vertebrate remains were recovered from the environmental squares.
Figure 6.27: Distribution of shell in HL001
Figure 6.28: Distribution of shell in HL002
Figure 6.29: Distribution of stone in HL001
Figure 6.30: Distribution of stone in HL002
Figure 6.31: Distribution of vertebrate remains in HL001
Figure 6.32: Distribution of vertebrate remains in HL002
Summary

From these preliminary results, the effects of cultural and natural processes on the archaeological landscape at Grand Bay are intriguing. Erosion has affected the landscape greatly, but it appears that most of the destruction and loss of archaeological remains has been limited to the coastal profile. From these distributions, it does not appear that other areas of the midden deposits were adversely affected by post-depositional hydrologic processes with the exception of Trench 415, Square 5 that has been slightly disturbed by the formation of a rain gully. In general, the total weight of materials found in this unit is lower than its neighboring units.

The vast amount of ceramics recovered from the midden component of Grand Bay may be the result of the simple fact that the majority of artifacts recovered from pre-Columbian sites in the West Indies are made of clay (Keegan 2000:135) but could also be the result of a variety of cultural formation processes. As Beck (2006:42) found in the ethnoarchaeological study of Dalupa households, large quantities of ceramics found in middens are often the result of their being treated like other forms of household refuse and immediately discarded if broken. One other explanation for the differences seen in weights of ceramics recovered is that ceramics associated with the Troumassoid period were often bulky with thicker walls – 7-12 mm on average compared with 2-3 mm for those recovered in earlier Saladoid contexts (Fitzpatrick et al. 2009; Kaye et al. 2011). This could result in a skewed interpretation of their distribution by weight and, as such, future interpretations of the distribution of these artifacts should include details from the macroscopic analysis conducted by site ceramicist, Mary Hill Harris.

As mentioned previously, higher concentrations of faunal remains often occur in units where excavated material was wet-screened. Based on the distribution maps, if wet-screening had not been employed at Grand Bay, a large portion of both vertebrate and invertebrate remains
may not have been recovered which would have severely limited interpretations about procurement strategies, exploitation of specific habitats and fauna, and the overall nature of prehistoric fishing at Grand Bay. Vertebrate and invertebrate exploitation appear to increase over time at Grand Bay based on the current level of analysis and available data. Between L005 and L002, the weight of vertebrate remains recovered nearly doubles, while the weight of invertebrate remains recovered in L002 is almost four times that of L005. The portion of Grand Bay’s vertebrate assemblage that has been analyzed is associated with post-AD 1000 contexts in stratum L002 (LeFebvre 2005, 2007; Fitzpatrick et al. 2009). Analysis of Grand Bay’s collective invertebrate assemblage reflects an emphasis on marine resources with a “shift over time toward increasing exploitation of several large or easily acquired molluscan taxa, especially queen conch and nerites snails” (Giovas 2013:335). Thus the increase in weights of invertebrate remains could be a result of these foraging methods. Shallower midden deposits for earlier occupation periods also suggest a population increase occurred during the Middle period (ca. AD 850-100) and thus increased exploitation of dietary resources.

It would be beneficial to reexamine Grand Bay’s stone assemblage to see if other pieces of coral occur throughout the midden deposits but were not separated into their own category. The majority of coral artifacts that have descriptions within the finds database indicate that this raw material was collected for use in tool or ornamental manufacture. The lack of coral fragments and artifacts in L002 and L003 could be a result of excavator bias, processing and sorting judgment, possibly that coral was no longer used as much for tools or bodily adornments, or perhaps there are other areas of the site associated with these cultural strata that contain more coral materials. A shift from using coral to shell in tool manufacture could be indicative of the ease with which shell could be harvested, as well as its dual function as a protein source and raw
material. My interpretations based on the available data for this material category are: 1) the area of Trench 415 where coral appears to concentrate represents a coral tool manufacturing area as two pieces of worked coral were recovered among other coral fragments; or 2) materials were cleared from an activity area located elsewhere at the site and deposited within this area of the midden in one depositional episode.

In the habitation area, there is an apparent concentration of artifacts in the southeastern quadrant of Trench 563 in HL001. Although this concentration may be the result of primary refuse, it could also be indicative of an activity area contained within or near a habitation structure. The differences in the amount of archaeological materials recovered between the midden and habitation area is obvious by examining the overall amount of materials recovered. This is likely the manifestation of a cultural behavior in the archaeological record. As Murray (1980:497) found, discard behavior at permanent settlements typically results in the formation of middens away from enclosed living spaces. Based on radiocarbon dates, Grand Bay was occupied continuously for close to a millennium, thus lower concentrations of archaeological materials in the habitation area support this type of discard behavior.

The following chapters will utilize two spatial analysis tests to further examine Grand Bay’s artifact assemblage. The results of these analyses will be used to determine if there are true areas of clustering within the assemblage and what this may indicate about how Grand Bay’s midden was formed and how space was utilized in both the midden and habitation components of the site.
Chapter 7: 
Spatial Autocorrelation Analysis

In this chapter I examine the spatial autocorrelation of the major material categories recovered during excavation at Grand Bay. Results from these analyses are summarized for the two distinct site components, the midden deposits and the habitation area, in the first section. A discussion of these results follows and is structured to examine how the results for all artifact categories in each excavation level relate to one another and what their relationships, or lack thereof, may indicate about the formation of the midden deposits and the use of space in a habitation context.

Results

The distributions of artifacts recovered at Grand Bay were tested for global spatial autocorrelation using the Global Moran’s I tool in ArcGIS 10. Spatial autocorrelation is tested for these distributions to determine if artifacts are randomly distributed or clustered within midden and habitation deposits based on weight of artifacts excavated within each excavation unit. The null hypothesis for all spatial autocorrelation analyses in this thesis is as follows: Weight of artifacts recovered during excavation at Grand Bay is randomly distributed within the midden and habitation deposits. In these analyses the Global Moran’s I tool was run using the following specifications: zone of indifference was chosen as the spatial relationship between features where features within a specified distance of the target feature receive a spatial weight
of 1 and influence that feature, after this distance is exceeded spatial weights and the influence a
neighboring feature has on the target feature begin to diminish with distance; Euclidian distance
was chosen as the distance method and represents the closest distance between any two features;
and ROW standardization was chosen because some of the data included in the analysis might
have been biased due to sampling design or aggregation. For the majority of the analyses run for
excavation levels within the midden deposits, the Threshold Distance was set to 2 m because
artifacts within a refuse pile have greater tendency to become dispersed through various
processes. An exception was the analysis of stone and coral artifacts in which the threshold
distance was set to 1 m. This was done because these artifacts comprise a small part of the
overall artifact assemblage. When they are recovered, they are often small beads, tools, or other
worked pieces and are less likely to have large distribution patterns within the assemblage.

The results of the analyses for each material category are summarized on the following
pages. The z-score is the number of standard deviations from the mean and the p-value is the
probability value. As discussed in Chapter 5, the null hypothesis can only be rejected if the p-
value is statistically significant. A p-value less than .01 coincides with a 99% confidence level
and indicates very strong clustering within the artifact distributions while a p-value less than .05
coincides with a 95% confidence level and indicates a less strong clustered pattern. A p-value of
.10 thus coincides with a 90% confidence level and indicates an even weaker clustered
distribution and the increased likelihood that the pattern is the result of random chance.

Results are discussed based on their context within the cultural strata of the midden and
habitation components at Grand Bay. The distributions of artifacts within each stratum are
discussed in order to see how they relate to one another. Clustered or random distributions of the
different artifact types within an excavation level may be indicative of cultural and natural
formation processes, site maintenance, activity areas, and changes in resource utilization and
technologies as well as many other possible interpretations used to reconstruct Grand Bay’s
occupation.

*Midden Component*

Within the cultural strata associated with Grand Bay’s midden component, only material
categories that contained at least 30 features were analyzed. Thus, the stone assemblage was not
subjected to spatial autocorrelation analysis, nor was the coral assemblage of strata L002, L003,
and L005. Stratum L003A was also exempt from this analysis.

*Stratum L002*

Table 7.1 summarizes the results of spatial autocorrelation of archaeological materials
within this cultural stratum. The three categories analyzed – ceramics, shell, and vertebrate
remains – exhibited spatial clustering at the p<.01 level which indicates that the relationship
between the features for each category is very strong. This type of associated clustering is to be
expected in midden deposits and can be an indicator of how a site’s occupants view refuse. As
Beck (2006) observed, broken ceramic vessels are often viewed as part of regular refuse and are
discarded as such in communal middens. This is a likely explanation for the distributions found
throughout Grand Bay’s midden deposits. Cluster analysis, I hope, will reveal that the clusters of
each material category coincide with one another. If they do not, their distribution could be the
result of other cultural behaviors related to refuse disposal and natural processes that affect the
post-depositional distribution of these materials.
Table 7.1: Moran’s I for Archaeological Materials in L002

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>.082</td>
<td>4.777</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR(^a)</td>
</tr>
<tr>
<td>Shell</td>
<td>.065</td>
<td>4.059</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>.182</td>
<td>10.005</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
</tbody>
</table>

\(^a\)CSR = Complete Spatial Randomness

**Stratum L003**

As with L002, the three material categories analyzed exhibited spatial clustering at the p<.01 level. Again these results are expected for a midden and cluster analysis will identify the actual nature of these distributions.

Table 7.2: Moran’s I for Archaeological Materials in L003

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>.263</td>
<td>13.589</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR(^a)</td>
</tr>
<tr>
<td>Shell</td>
<td>.189</td>
<td>10.262</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>.141</td>
<td>8.558</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
</tbody>
</table>

\(^a\)CSR = Complete Spatial Randomness

**Stratum L005**

Within L005 the random spatial distributions of ceramics and shell are of particular interest as this type of distribution is highly unexpected for a midden. These results are also unexpected based on the distributions shown in Figures 6.3 and 6.14. In these maps it appears that there are areas of clustering in the middle of Trench 446 for all three categories. The
clustering of vertebrate remains may represent a processing area within this cultural stratum and its associated occupation period.

**Table 7.3: Moran’s I for Archaeological Materials in L005**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>.012</td>
<td>1.4850</td>
<td>.134</td>
<td>Random</td>
</tr>
<tr>
<td>Shell</td>
<td>-.008</td>
<td>.616</td>
<td>.538</td>
<td>Random</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>.053</td>
<td>3.458</td>
<td>.001</td>
<td>Clustered, &lt;1% likelihood result of CSR&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>CSR = Complete Spatial Randomness

**Stratum L006**

As mentioned, L006 was the only cultural layer whose coral component was subjected to spatial autocorrelation analysis in addition to the other three categories. The results are given in Table 7.4. The relationship between ceramics is weak as the p-value was .051. The distribution of coral was found to be random. I would have expected this analysis to reveal that there was clustering of this material category based on the distribution map, Figure 6.9. The weak spatial association between ceramics may again represent a processing area for shell and vertebrates.

It is likely that there are clusters in Trench 446 based on the distribution maps, Figures 6.5, 6.14, and 6.24. Hearth stones were found in Square 16 of excavation Level 10 and turtle bone and ceramic griddle pieces were found in the same square in excavation Level 9 of this stratum. In addition, an abundance of charcoal, ash, and charred seeds were recovered from this same square as well as Squares 17 and 21 in this stratum. This evidence suggests that, if a cluster is found within this area of Trench 446, it may have been an area for food preparation. Again,
cluster analysis results will, hopefully, show that artifacts do cluster within this area supporting this interpretation.

**Table 7.4:** Moran’s I for Archaeological Materials in L006

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
</table>
| Ceramics                | .021          | 1.952   | .051    | Clustered, <10% likelihood result of CSR
| Coral                   | .008          | 1.284   | .199    | Random                                            |
| Shell                   | .058          | 3.538   | .0004   | Clustered, <1% likelihood result of CSR
| Vertebrate Remains      | .033          | 2.925   | .003    | Clustered, <1% likelihood result of CSR

\( ^a \text{CSR} = \text{Complete Spatial Randomness} \)

**Habitation Component**

Spatial autocorrelation tests were conducted for the major material categories in cultural strata HL001 and HL002 of the habitation component at Grand Bay. In HL001, stone was excluded from this analysis as the layer did not contain at least 30 features with weights. In addition, the stone and vertebrate components of HL002 were excluded.

**Stratum HL001**

The results of spatial autocorrelation for ceramics, shell, and vertebrates are given in Table 7.5. As discussed in Chapter 6, there appears to be concentration of these three materials in the southeast corner of Trench 563. Because these excavation trenches are located in a habitation area of the site, this clustering may be evidence of primary refuse, part of the fill from a posthole, the result of post-depositional processes such as erosion, or secondary refuse that is an extension of L002 into this area of the site.
Table 7.5: Moran’s I for Archaeological Materials in HL001

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>.128</td>
<td>8.687</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR(^a)</td>
</tr>
<tr>
<td>Shell</td>
<td>.039</td>
<td>3.438</td>
<td>.0005</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>.070</td>
<td>5.232</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
</tbody>
</table>

\(^a\)CSR = Complete Spatial Randomness

Stratum HL002

Table 7.6 summarizes the results of spatial autocorrelation analysis on the ceramics and shell materials from HL002. Both categories exhibited strong spatial clustering relationships. Based on the distribution maps, Figures 6.27 and 6.29, I suggest clusters will be in the southern half of Trench 561 and may also be in the area of the hearth pit in Squares 10 and 15.

Table 7.6: Moran’s I for Archaeological Materials in HL002

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Moran’s Index</th>
<th>z-score</th>
<th>p-value</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>.198</td>
<td>9.890</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR(^a)</td>
</tr>
<tr>
<td>Shell</td>
<td>.099</td>
<td>5.681</td>
<td>0</td>
<td>Clustered, &lt;1% likelihood result of CSR</td>
</tr>
</tbody>
</table>

\(^a\)CSR = Complete Spatial Randomness

Summary

Although the Global Moran’s tool does not give specific information on how these distributions are clustered or randomly distributed, inferences can be made based on its results and the distribution maps. I am able to conclude that, in general, the distribution of ceramic, shell, and vertebrate remains are clustered for the midden deposits and for HL001 in the habitation area. Clustering of shell and vertebrate remains in the midden deposits could be
indicative of a variety of site formation processes, including processing and cooking areas. For those strata that had clustering of these three categories, do clusters of ceramics coincide spatially with those of bone and shell? If so, what does this tell us about midden formation patterns and the behaviors behind refuse deposition at Grand Bay? If they do not coincide, what formation processes could create the clusters and patterns observed in the distributions?

As shown in the distribution maps in Chapter 6, it was expected that there would be some clustering of ceramic, vertebrate remains, and shell artifacts in the excavation trenches. These three materials categories comprise the largest portion of the archaeological assemblage in terms of quantities and overall weight of materials recovered. Coral fragments and artifacts are a very small part of the archaeological assemblage in both weight and quantity, and my initial hypothesis was that the distribution of this material category would exhibit clustering in L006; therefore, the evidence of a random distribution was unexpected. My hypotheses that the clustering of this material being the result of a tool manufacture area, storage area, or the dumping of materials from a spatially separated activity area may still be valid. Further analysis of Grand Bay’s stone assemblage may reveal more coral artifacts and fragments that were misidentified in later cultural contexts.
Results of cluster analysis performed on the artifact assemblages from Grand Bay are presented in this chapter. The second section discusses these results and their implications for site formation processes at Grand Bay.

Results

For the sake of brevity, only the distributions that exhibited positive autocorrelation, or clustering, as shown in Chapter 7 were analyzed using the Anselin Local Moran’s I tool in ArcGIS to determine where clusters occur within these distributions. Specifications for each test are as follows: zone of difference was chosen for the spatial relationship; Euclidean distance as the distance method; ROW standardization to take into account sampling biases or aggregation of data; and a distance threshold that matched that used in the analysis of spatial autocorrelation. Thus, a distance threshold of 2 m was used for all material categories in the midden component. In the analysis of habitation materials, the distance threshold was 1 m.

The results of this spatial statistic produce a shapefile output in ArcGIS that identifies if excavation units are part of clusters of higher values (HH) or lower values (LL). In addition, this analysis can identify spatial outliers as either higher values surrounded by lower values (HL) or lower values surrounded by higher values (LH).
**Midden Component**

Table 8.1 presents the results of the cluster analysis for the midden cultural strata. The table lists the excavation unit (TR) and stratum layer (L) in which each type of cluster or outlier occurred. The spatial outliers occur within each of the material assemblages with half of them occurring in L006. I would have expected the results to show that there were more outliers within the shell and vertebrate assemblages as the abundance of materials recovered in the environmental sample squares likely reflects biases within the distributions because of the excavation method utilized for their collection.

**Table 8.1: Midden Assemblage Cluster Analysis Results**

<table>
<thead>
<tr>
<th>Material Category</th>
<th>HH Clusters</th>
<th>HL Outliers</th>
<th>LL Clusters</th>
<th>LH Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>TR415L002</td>
<td>TR446L002</td>
<td>TR446L002</td>
<td>TR446L006</td>
</tr>
<tr>
<td></td>
<td>TR446L003</td>
<td>TR446L006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>TR415L002</td>
<td>TR446L002</td>
<td>TR446L002</td>
<td>TR446L006</td>
</tr>
<tr>
<td></td>
<td>TR446L003</td>
<td>TR415L006</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TR446L006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>TR415L005</td>
<td>TR415L003</td>
<td></td>
<td>TR446L005</td>
</tr>
<tr>
<td></td>
<td>TR446L006</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Habitation Component**

Table 8.2 lists the results of the cluster analysis for the habitation excavation units in layers HL001 and HL002. Cluster analysis of the assemblages support what was suggested by the distribution maps and spatial autocorrelation results – there are areas of clustering among ceramics, shell, and vertebrate remains in Trench 563. The LL clusters of ceramics in Trenches 561 and 592 were unexpected.
Table 8.2: Habitation Assemblage Cluster Analysis Results

<table>
<thead>
<tr>
<th>Material Category</th>
<th>HH Clusters</th>
<th>HL Outliers</th>
<th>LL Clusters</th>
<th>LH Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>TR563L001, TR561L002</td>
<td>TR561L001, TR592L001</td>
<td>TR592L002</td>
<td>TR561L001, TR592L001</td>
</tr>
<tr>
<td>Shell</td>
<td>TR563L001, TR561L002</td>
<td>TR561L001, TR592L001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertebrate Remains</td>
<td>TR563L001</td>
<td>TR561L001, TR592L001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

Results of cluster analysis allow for better interpretation of the various formation processes that create the archaeological record we encounter today. Understanding what cultural and natural processes affected the distribution of artifact assemblages creates opportunities for archaeologists to ask more relevant questions regarding site organization, use of space, ideologies, resource exploitation, exchange systems, and adaptations to natural or cultural stressors. From the results of the cluster analysis presented in this thesis, my goals are to answer the following general questions: How was space organized and used at Grand Bay? Is there evidence for overexploitation of marine resources throughout the site’s occupation? Are there any activity areas that are indicated within these results that were not identified during excavation or from the distribution maps?

**Midden Component**

Cluster analysis of the artifact assemblages within Grand Bay’s midden component was performed to answer the following questions raised by the results of the spatial autocorrelation tests and mapping of the distribution of artifact weights: Do clusters of ceramics, shell, and vertebrate remains coincide with one another? If so, what can be inferred from these patterns?
How do the clusters change between the cultural strata and what inferences can be drawn? Are there clusters of archaeological materials in Trench 446 of L006 around Squares 16, 17, 21, and 22? If so, could these clusters be representative of another hearth pit, or perhaps an extension of stratum L003A?

**Stratum L002**

Squares that had a HH designation for all three categories in Trench 415 were Squares 16, 17, 21, 22, and 23. Square 19 was also designated HH for both shell and vertebrate remains. Squares 11 and 12 had a designation of HH for vertebrate remains. Thus, a strong association between these artifact categories is established and suggests that all refuse was treated the same when discarded. It may be suggested that the midden had grown so large by this time that this portion of the midden was used more frequently. Changes in where dwellings were constructed at Grand Bay during this later occupation period could indicate that they were located further inland and this portion of Trench 415 was used because of its proximity to the dwellings or, simply, that the area of Trench 446 was not used as much.

The spatial outlier in the vertebrate assemblage is in Trench 446. This outlier was designated as an HH outlier and is Square 9, an environmental square. This again the supports the use of wet-screening midden deposits to recover smaller artifacts. As seen in many of the distribution maps, this often results in noticeable disparities between the amounts of vertebrate remains and shell recovered in the sample squares as compared with the other squares. This outlier also indicates that bias could be introduced into analyses of the vertebrate assemblage if these environmental squares were not included in excavation. Figure 8.2 is the resulting map for the vertebrate remains.
An area of LL vertebrate weight values is located in Squares 12, 18, 22, 23, and 24 of Trench 446. One square, 22, also had a designation of LL for the ceramics distribution. These outliers are neighbors of an environmental square.

**Stratum L003**

Almost all of Trench 446 in this stratum is comprised of an HH cluster for ceramics, see Figure 8.4. Squares 8, 9, 15, 20, 22, and 25 were the only squares that were not part of this cluster. Squares 1 through 5 had no associated archaeological materials for this stratum. Looking again at the distribution map, Figure 6.2, these squares have weights that are in the first two classes. Based on the weights for Square 17 and 22, 26.8 kg and 7.1 kg, respectively, I would have expected Square 22 to be designated as a LH outlier.
The HH cluster, shown in Figure 8.5, in the shell context of stratum L003 is comprised of Squares 6, 7, 11, 12, 16, 17, and 21. The weights for these squares ranged from 1.2 kg to 4.8 kg while those in the other squares of L003 ranged from 0 kg to 1.0 kg. The HH cluster of vertebrate is also comprised of these squares with the exception of Square 21. Figure 8.6 illustrates this cluster within the vertebrate context.

As with the other midden deposits, this cluster was expected. However, the reliability of its size cannot be guaranteed as there were fewer than 30 features included in the analysis. Excavation of Trench 445 may shed light on the extent of this cultural stratum and provide a more detailed look at why it does not extend into Trench 415.

**Figure 8.2:** Cluster analysis map of shell in L002
Figure 8.3: Cluster analysis map of vertebrate remains in L002

Figure 8.4: Cluster analysis map of ceramics in L003
Figure 8.5: Cluster Analysis Map of shell in L003

Figure 8.6: Cluster analysis map of vertebrate remains in L003
Vertebrate remains were the only category in L005 to exhibit spatial clustering. The results of the cluster analysis revealed an area of HH values in Trench 446. Squares 1, 6, 7, 11, 12, and 17 make up this cluster. This result supports the distribution observed for the stratum in Figure 6.23.

The LH outlier, Square 16 in Trench 446, is a result of no finds being recovered from this square. This is because in the associated excavation levels, Square 16 belongs to L003 for Level 6, L003A for Levels 7 and 8, and L006 for Level 9. The HL outlier in Square 17 of Trench 415 is an example of how environmental sample squares can bias the assemblage and produce results that are not true clusters or outliers. This square contained 1.3 kg of remains while Square 19 had 1.1 kg. The weights of vertebrate remains throughout the remainder of this stratum were less than 0.6 kg, with thirteen that had weights less than 0.1 kg.

Figure 8.7: Cluster analysis map of vertebrate remains in L005
**Stratum L006**

Figures 8.8, 8.9, and 8.10 show an area of HH values formed in Trench 446. The distribution maps given in Chapter 6 indicated that a clustering of the three material categories would occur within this area. Because these three materials cluster around Squares 16, 17, and 21, I hypothesize that this is either an extension of L003A or a separate substratum that represents another hearth pit was used within this area of the site. While this could be the result of a hearth cleaning from a dwelling located elsewhere at the site, hearth stones were found in excavation Level 10 and turtle bone, other zooarchaeological and archaeobotanical remains, and charcoal and ash were found in Level 9. Some of the recovered shell constituents were burned in addition to a pile of seeds or nuts.

The LH outlier in the ceramics distribution, Square 23 in Trench 446, is an anomalous outlier as this square did not contain any archaeological materials for this stratum.

Figure 8.8: Cluster analysis map of ceramics in L006
Figure 8.9: Cluster analysis map of shell in L006

Figure 8.10: Cluster analysis map of vertebrate remains in L006
**Habitation Component**

Through cluster analysis, I hoped to answer the following questions related to the habitation component: Do archaeological materials cluster within the southeastern corner of Trench 563 in HL001? If so, what inferences can be made about these clusters? Do clusters form around Squares 10 and 15 where a hearth pit was excavated in HL002? Is there evidence of clustering in other features, such as postholes?

**Stratum HL001**

Within HL001 of the habitation area, ceramics, vertebrate remains, and shell formed clusters of high values in the southeastern portion of Trench 563 as seen in Figures 8.11, 8.12, and 8.13. Based on the available data and results of the Local Moran’s I analysis, several hypotheses could explain this clustering: 1) the cluster is the result of post-depositional natural formation processes; 2) the cluster is primary refuse associated with a longhouse erected in this area of the site; 3) the cluster is disturbed posthole fill or midden deposits associated with the interment of burials F0006 and F0164; 4) the cluster is primary refuse that had not been removed to a secondary location before the site’s abandonment and is associated with a structure that was erected at a later time period than the longhouse; 5) the cluster is secondary refuse associated with the formation of a refuse dumping area separate from that in Trenches 415 and 446; or 6) the dumping area associated with Trenches 415 and 446 has a larger extent than previously thought and this cluster is on the edges of its boundaries. The first hypothesis is conceivable, but post-depositional processes, such as erosion and hydroturbation from storm run-off, may be only part of what caused this cluster of archaeological materials. Part of Trench 563 at this level of excavation was subsoil that contained habitation and burial features, and the area east of this
Figure 8.11: Cluster analysis map of ceramics in HL001
trench is also subsoil that is visible because of erosion. The formation of an extensive rain gully further suggests that the distribution of surface artifacts and materials has likely been disturbed.

Of these hypotheses, the second seems the least likely. One of the postholes associated with the longhouse, F0107 in Trench 561, contained sherds of a Caliviny polychrome pot having a date range of ca. AD 650-800. A radiocarbon date from a charcoal sample collected in F0016, a posthole in Trench 537 also associated with this longhouse, has a date range of ca. AD 690-890. These two lines of evidence indicate that these postholes, and the longhouse they supported, were created during or after this time period. This hypothesis is also unlikely based on the radiocarbon dates obtained from the two burials in this area of Trench 563, F0006 and F0164, and the dates associated with L002. Burial F0006 has been dated to AD 1050-1250, while burial F0164 has been dated to AD 1040-1260. L002 has an approximate date range of AD 1000-1250 based on both radiocarbon dating and diagnostic ceramics. As HL002 is, most likely, contemporaneous with L002, these two burial pits may have been dug into the subsoil through the overlying midden. Thus, an association with the earlier dated longhouse is the least likely explanation for the observed spatial patterning in this area of Trench 563.

The third hypothesis is possible. Intentional placement of grave goods within burial pits is an uncommon occurrence at Grand Bay and neither of these burials contained grave goods. Also, the date associated with burial F0006 lends more plausibility to this hypothesis that the clustering observed is the result of disturbed midden deposits or posthole features which were razed to cover the burial pits. Osborne (2013:55) notes that the majority of Grand Bay’s burials were located within 1 m of identified postholes, indicating that burials are household-specific.
Figure 8.12: Cluster analysis map of shell in HL001
The fourth hypothesis is also possible, but cannot be supported by the data used in this analysis and published reconstructions of Grand Bay’s occupation. Many of the undefined features contained with Trenches 561, 563, and 592 may be associated with more recent dwellings similar to those described in Curet (1992). He found that house structures changed over time from large, communal houses to smaller, single family houses. While this change in spatial organization may be present at Grand Bay, further examination of the materials associated with these undefined features, and the spatial distribution of the features themselves, is required to provide evidence that would support or refute this hypothesis. Osborne’s (2013) conjecture that burials are household specific also could support this hypothesis if the burials located beneath this cluster are older than the materials in the cluster itself.

The last two options, in conjunction with post-depositional disturbance, are the most likely given the current evidence. The weights of ceramics found in this area of clustering are similar to those observed in Level 1 of Trenches 415 and 446. Based on this information, I suggest that this part of the habitation area is contemporaneous with this level of the midden component, and may be part of stratum L002. Excavation of the area between Trenches 446 and 563 would be required to determine if they are indeed contemporaneous. Unfortunately, the majority of this area is covered by dense shrubbery, cacti, and trees or has been lost due to coastal erosion as seen in Figure 2.8. Even if excavation were to extend to this area, disturbance of deposits from floralturbation would affect interpretations about the contemporaneity of the two areas.

The HL shell and vertebrate outliers in Trench 591 are likely associated with fill dirt for the postholes in these squares.
Figure 8.13: Cluster analysis map of vertebrate remains in HL001
While approximately 25% of Grand Bay’s ceramic assemblage has been examined to establish chronological trends (Fitzpatrick et al. 2009), the published results are a generalization for the entirety of the site; therefore, I cannot say definitively what this cluster represents. Future investigations into Grand Bay’s spatial organization need to include all notes kept by project ceramicist, Mary Hill Harris, for sherds examined from this excavation trench. If the cluster of materials in Trench 563 is found to contain diagnostic ceramics associated with an earlier time period than the burials, the cluster likely formed as the result of removal of fill from the area to prepare burial pits and was then used as a covering once the pits had been closed. This finding would support the second hypothesis. If, however, diagnostic ceramics are associated with a later time period, I suggest that this area was being used for either primary refuse discarded in a later dwelling or secondary disposal of refuse away from a dwelling located elsewhere, and not yet defined, at the site. This finding would support the last three hypotheses.

**Stratum HL002**

Only ceramics and shell exhibited spatial clustering as vertebrate remains were too few to obtain reliable results for either the spatial autocorrelation or cluster analysis tests. In both distributions, there were HH clusters in the area of the hearth pit as well as several smaller postholes. Of particular interest is the amount of squares in Trench 592 that had LL designations for the ceramics distribution. Many of these squares had weights between 236.8 g and 526.8 g, the lowest class in the distribution. The HL outlier in this distribution was environmental square 7 in Trench 592. Looking at the distribution again, this square had the highest weight of ceramics found within this stratum, 3.3 kg.
Figure 8.14: Cluster analysis map of ceramics in HL002
Figure 8.15: Cluster analysis map of shell in HL002
Because the clusters in the two distributions coincide and exist in the area of the hearth pit, I suggest the material excavated from this area is evidence for primary use of this pit within a habitation structure. No radiocarbon dates are associated with this hearth pit or the area immediately surrounding it, thus, I am unable to state during which occupation period this hearth pit was used. If this stratum is contemporaneous with L002 in Trenches 415 and 446, this hearth pit may have been used during the Late period of site occupation (ca. AD 1000-1250). It could also have been used during the Middle period (ca. AD 850-1000) and subsequently covered by midden deposits.

Summary

The results of cluster analysis on archaeological assemblages at Grand Bay have shown that, in general, ceramics, vertebrate remains, and shell form associated clusters in the excavation trenches. It can be said that Grand Bay’s occupants generally viewed broken ceramic vessels as part of the everyday garbage. What is noteworthy about these common distributions is that over time, they move around within the midden deposits with certain areas likely being used intensively for a period of time before another area becomes the preferred dumping ground.

It does not appear that burials F0093 and F0132 adversely affected the distribution of archaeological materials in Trenches 415 and 446. These burials were associated with strata L005 and L006.

I began this cluster analysis thinking that I would see a divergence between animal bone and shell that may have indicated a shift in resource exploitation. This was not the case at this level of analysis, but could change with more in-depth zooarchaeological analyses. The cluster analysis results also proved the usefulness of wet-screening to obtain small, often overlooked,
artifacts. Many of the outliers and a few clusters of shell and vertebrate remains were found to be either neighbors of the sample squares or the sample squares themselves. Without these sample squares, unknown quantities of faunal remains may not have been recovered severely impeding the understanding of changes in subsistence patterns, exploitation of marine resources, and whether or not over-fishing and stress on marine ecosystems occurred at Grand Bay.

At present, LeFebvre’s (2005, 2007) analysis of vertebrate remains provides information on fishing strategies and vertebrate exploitation for only a small time period during Grand Bay’s occupation, ca. AD 1100-1300. She found that, during this time period, the majority of identified archaeological fish specimens were from fishes whose habitat was the offshore coral reef, which contrasts expected results for over-fishing (LeFebvre 2007:941). Another characteristic used to determine if over-fishing occurred is the size of fish found in the zooarchaeological record. As populations over-fish a certain habitat zone or fish species, the sizes of fishes tend to decrease over time. At Grand Bay, LeFebvre (2007:942) found that: 1) the overall small size of fish may indicate that over-fishing occurred near the end of the site’s occupation; 2) these smaller fish may represent juveniles captured because the adult population had been overexploited; and 3) future analyses may reveal that fish size was consistent through time and that small mature fishes or juvenile individuals were intentionally captured.

Giovas’ (2013) analysis of Grand Bay’s invertebrate assemblage reflected an emphasis on marine resources with exploitation of larger or easily collected mollusks, such as nerites snails and queen conch, increasing throughout the site’s occupation. She found over several centuries of intensifying exploitation, nerites maintained or increased in mean size, appearing to be evidence for sustainable foraging behaviors (Giovas 2013:335). The evidence presented in her
analysis was therefore not consistent with resource depletion patterns observed elsewhere in the prehistoric Caribbean.

Results of the cluster analysis of materials in the habitation area have provided additional avenues for future investigations into how space was utilized at Grand Bay. Due to limitations in the available data and published reports, I am able to suggest, tentatively, that the cluster in Trench 563 of the habitation area is the result of secondary refuse disposal. Stratum HL002 is likely an expansion of stratum L002 associated with Trenches 415 and 446, or it could be the result of a new dumping area that was used just prior to the site’s abandonment.

Overall, this analysis provides evidence to support basic inferences about the formation of the midden deposits at Grand Bay through cultural and natural processes. To my knowledge, it is also the first example of applying this type of statistical analysis to examine and interpret Lesser Antillean and, in general, Caribbean archaeological assemblages.
Chapter 9:
Conclusion

Archaeological sites are valuable, non-renewable resources. Unfortunately, coastal archaeological sites are being quickly, or are already, destroyed or submerged due to sea-level rise and other natural processes whose impacts are being further exacerbated by human-induced processes. In this thesis I have aimed to examine how the spatial distributions of artifact assemblages at the coastal site of Grand Bay reflect cultural refuse deposition behaviors and site organization, evaluate the negative effects of coastal erosion on these assemblages, and highlight the utility of spatial statistics for archaeological research. In the following pages I use the results of three methods of spatial analysis presented in this thesis to propose recommendations for future excavations and spatial analysis at Grand Bay as well as summarize the inferences made about the nature of Grand Bay’s assemblages as they relate to site formation processes.

Considerations for Future Research at Grand Bay

The impacts of coastal erosion on Grand Bay have been drastic in the last fifteen years. Increased storm activity in this part of the Caribbean has caused much of this erosion, but at Grand Bay a bigger problem exists – sand mining. Fitzpatrick et al. (2006:258) estimate that approximately 13000 kg of cultural material is lost every year in the area of Trench 446. As of 2010 the coastal profile had retreated approximately 5 m and destroyed much of Trench 446 (see Figure 2.8). Although sand mining was outlawed at Grand Bay in 2008 and there was a
subsequent reduction in the retreat of the profile, this activity is still occurring as the ban is not being effectively enforced.

I am hopeful that the analyses presented in this thesis will provide further evidence for the immediate protection of Carriacou’s archaeological and historical resources. These results can potentially provide a means for understanding better the structure of Grand Bay’s midden deposits and how future excavations can be tailored to higher risk areas. Grand Bay may be but one site of many within the Caribbean, but its role in understanding the settling of the southern Lesser Antilles, dietary practices of these populations, exchange networks, and impacts on the local terrestrial and aquatic environments is vital for the future of Caribbean archaeology.

Based on distribution maps and cluster analysis, I suggest that, if future excavations continue by alternating trenches in a checkerboard pattern, focus should be on the area west of Trench 415. A rain gully running southwest to northeast below this trench has eroded and greatly disturbed the midden deposits. Therefore, I would suggest Trenches 413 and 444 be opened to investigate the midden boundaries and depth further.

In terms of site protection and management, work needs to be done to ensure that the sand mining ban is effectively enforced. One way would be to limit access to the beach through the use of padlocked gating along access roads. This will require further collaboration between the CAFP, landowners, and government officials, but may be one of the only ways to stop this destructive activity completely.

Public archaeology programs and events should also remain a vital part of the CAFP. I suggest that student participation in the development of public archaeology programs and events be a required part of earning credits for the study abroad program. Students could be required to attend and participate in the school and public lectures given by the CAFP directors. For upper
level undergraduates and graduate students, this could include presentations on their own archaeological research interests as they relate to Grand Bay. These programs or events also could include training sessions for local residents, business owners, and government officials in various archaeological practices. Because of CAFP’s presence on Carriacou for over a decade, many of the locals and CHS members have become involved in the excavations and monitoring of archaeological sites around the island. In fact, in 2011 a new site, Point Bay, located approximately 2 km north of Grand Bay was discovered after a local fisherman informed the project’s directors about several exposed archaeological burials along the coast (Kaye et al. 2011). If this discovery had occurred while CAFP was off-island, training of locals and CHS members in proper recording of these finds would result in the inclusion of knowledge about Carriacou’s prehistory that may be lost due to continued coastal erosion before further in-depth survey or excavation could occur.

In terms of heritage tourism, some work has been done to encourage tourists to visit the Carriacou Historical Museum through the creation of new street signs guiding people to its location. Future work could take heed of the work at Montserrat’s Carr Plantation. As mentioned in Chapter 4, the project in charge of the plantation’s excavation and management received a preservation grant from the Archaeological Institute of America to create school programs, place interpretive signs at the site, develop a guided walking tour of the site, and build a protective barrier around the site (Archaeology 2012). Not all of these steps (such as the fencing) are feasible at Grand Bay, but with the help of on-island colleagues, a program could be developed through the museum to provide year-round tours of the site. The placement of interpretive signs at Grand Bay, with permission from landowners, would be a simple and easy task toward developing Carriacou’s heritage tourism industry. Information provided on these signs should, at
the very least, include: 1) the dates associated with Grand Bay’s prehistoric occupation; 2) illustrations and descriptions of diagnostic artifacts recovered on-site; 3) interpretations of Grand Bay’s subsistence economies and technological adaptations; 4) regulations against sand mining and looting of archaeological materials from the site; and 5) the consequences associated with violations of these regulations.

Research at Grand Bay, and its neighboring site, Sabazan, has resulted in numerous publications as well as several undergraduate theses and research projects, master’s theses, and doctoral dissertations. It has also resulted in many conference presentations and posters by both the CAFP directors and students involved in the on-going excavations. Although there is now a wealth of information available about Grand Bay’s prehistory, there is much more work to be done to understand fully the site’s role in Caribbean prehistory.

One possibility for future research would be a spatial analysis similar to that of Curet (1992) that analyzes the spatial organization of the habitation area. We currently know that the excavated postholes provide evidence of a possible longhouse, but further examination of these features may indicate other dwellings or structures used for specific activities. It would be impossible to take a measurement for every artifact recovered because the midden deposits at Grand Bay are so extensive. However, point-based spatial analyses could be performed using total station measurements of special finds and defined activity areas such as the hearth pit in Trench 446. Further work on creating a three-dimensional representation of the site will also provide more information about its spatial organization and a better understanding of how the midden deposits were formed.
**Grand Bay Site Summary**

While there are inconsistencies and incomplete data in the dataset utilized, several conclusions may be reached. The first is that, through inspection of artifact weight distributions and utilization of two spatial statistics analyses, I determined that ceramics, vertebrate remains, and shell artifacts generally exhibit associated spatial clustering in the midden deposits. As discussed in Chapters 7 and 8, this associated clustering is to be expected of artifacts recovered from a midden deposit. Based on ethnographic refuse disposal studies summarized in Chapter 3, I conclude that these patterns are the result of a cultural practice that treats all refuse in the same manner, giving no one artifact type preferential treatment in its disposal. Examination of excavated postholes and the analysis of ceramics suggest Grand Bay was continuously occupied from ca. AD 400-1400. Therefore, because Grand Bay is considered a permanent settlement site, the tendency to dispose of refuse away from dwellings was done, most likely, in an effort to keep living spaces free of refuse and scavengers (e.g., Beck 2006).

By examining the weight distributions of ceramics, inferences can be made about changes in ceramic production. In the uppermost stratum of Grand Bay’s midden deposits, L002, a significant amount of ceramics, over 125 kg, was recovered. In earlier strata associated with both Trenches 415 and 446, L005 and L006, the weight of ceramics recovered decreases to 46 kg and 18 kg, respectively. As Rosenswig (2009) suggested, this can be the result of changes in ceramic production, use, breakage, and consumption rates. Based on the cultural chronology of the site provided in Chapter 2, Caribbean ceramics became less sophisticated over time and were crudely made with few, and eventually no, decorative elements. Thus, the ceramic assemblage at Grand Bay is proof of this shift in ceramic technology.
An increase in ceramics could also be an indicator for an increase in population at the site during the later occupation period, AD 1000-1250. However, because coastal erosion stripped away the vast majority of Trench 446 before earlier cultural strata could be excavated, an increase in the weight of ceramics recovered should not be the only line of evidence used to suggest an increase in population size. A general increase in both vertebrate and shell ecofacts over time, as well as depth of midden deposits, is further evidence of a possible increase in population.

Coral was often collected for tool manufacture and its utility is examined in two recent studies, Van Gijn et al. (2008) and Kelly and van Gijn (2008). According to Kelly and van Gijn (2008:124), tools made of this raw material “played a vital role in carrying out various activities and formed an integral part of the technological system.” Because of coral’s multi-purpose functionality and a reef system located within close proximity to the site, this raises several questions about its use at Grand Bay, why are more coral tools, beads, and other artifacts not recovered at Grand Bay? As previously mentioned, coral pieces may have been processed in the laboratory as part of the stone assemblage, resulting in a lack of data for this specific material type in more recent midden deposits. A closer examination of the already processed stone assemblage may shed light on the role coral played at Grand Bay. If this re-examination finds that there were fewer, or no coral artifacts or fragments, recovered from younger cultural strata, I suggest that Grand Bay’s inhabitants shifted their focus to shell and stone for the manufacture of tools and ornamental items. These findings could also indicate a shift in Grand Bay’s subsistence economy and maritime technologies. The shell materials used most often are from shallow and intertidal zones (Fitzpatrick et al. 2009) that could be easily, and more readily, collected by hand, while coral would either be collected as fragments that washed up onshore or from the reef.
system. On the other hand, re-examination of the stone assemblage may find that coral was used as a raw material for tool and ornament manufacture throughout Grand Bay’s occupation and human error introduced the bias observed in the current analysis.

The cluster analysis results revealed several noteworthy patterns. First, in relation to coral artifacts, there was no spatial patterning found within the cultural strata using the available data. Many of the coral artifacts were tools, parts of tools, beads, and fragments that may have been stockpiled for later use. Although coral artifacts were not separated into their own category in upper strata, the distribution, and weights, of materials associated with this category observed in L006 is reduced in L005. If the observed distribution is a manufacture or storage area, a reduction in artifacts may represent a shift in the type of raw materials preferred for use in tool and ornament manufacture.

Second, a cluster of ceramics, shell, and vertebrate remains formed in the northwestern quadrant of Trench 446 in L006. Examination of the finds database revealed that, within the context of the associated excavation squares in this cluster, an abundance of charcoal, ash, and burnt seeds, several hearth stones, pieces of a ceramic griddle, and turtle bone were recovered. Although I had firsthand knowledge that a hearth pit existed in this area of the midden, the spatial analysis reinforced this designation. What is unknown is whether this hearth pit is directly related to the one designated as L003A, or if it represents an earlier use of this same area for a similar activity. If the two were related, this would suggest that this area of the site was used on multiple occasions to process and prepare both vertebrate and invertebrate taxa for consumption shortly after their collection.

Third, cluster analysis revealed that excavation methods employed at Grand Bay were especially important for the recovery of smaller assemblage constituents, such as animal bone
and shell. In several of the cluster analysis results, the four sample squares designated for wet-screening were either designated as HL spatial outliers or were surrounded by LL clusters. For those that were designated as HL outliers, the weight of shell or vertebrate remains recovered within these squares was significantly higher than the weights of its neighboring squares. For the sample squares surrounded by LL clusters, the weights of the squares with the LL designation had significantly lower weights than their neighbors. In her analysis of vertebrate remains from three 50-x-50-x-10 cm column samples, LeFebvre (2007:937) states that, “based on atli measurements, 98% of the total sample bony fish biomass would not have been recovered” from Grand Bay’s deposits when using only 6 mm mesh for sample recovery. Thus, a reduction in the zooarchaeological component of the assemblage could have adverse effects on the analysis of subsistence patterns, changes in foraging behaviors, and determining if certain taxa were overexploited.

Last, cluster analysis revealed that certain areas within the midden component were used more intensively at different times throughout the site’s occupation period. The weight distribution maps also supported these results. As middens are essentially prehistoric garbage dumps, perhaps once a midden pile reached a certain size it was covered with soil to reduce the smell associated with the garbage pile and allowed to sit unused while another midden pile formed.

In conclusion, the spatial distributions of archaeological materials within the excavated midden deposits at Grand Bay have brought to light the effect cultural and natural processes have on archaeological site formation. Erosion has been a serious issue at Grand Bay and the analyses presented in this thesis highlight the effects nature has had on the site over the last several hundred years. Despite the few inconsistencies within the dataset and incomplete data for all
excavation levels examined, the inferences reported in this thesis about Grand Bay’s formation support previously published interpretations of population increase in later occupation periods. The analyses also support the intensification of marine exploitation during the later occupation periods. While using ArcGIS and spatial analysis is common practice throughout the field of archaeology, this thesis represents one of only a few which uses this software to examine intrasite spatial distributions of prehistoric Caribbean assemblages.
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