The Tutu Archaeological Village Site

A multidisciplinary case study in human adaptation

Edited by Elizabeth Righter

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Excavations at the Tutu site represent a dramatic chapter in the annals of Caribbean archaeology. The site was discovered in 1990 during initial site clearing for a shopping mall in St Thomas, US Virgin Islands. Investigations were conducted in response to the imminent destruction of the site for development. Under severe time constraints, the site was excavated under the direction of Elizabeth Righter with the assistance of a team of professional archaeologists and volunteers. Utilizing resources and funds donated by the local community and grants from the nineteenth Legislature of the Virgin Islands Government and the American National Foundation for the Humanities (NFH), the project employed a multidisciplinary sampling strategy designed to recover material for analysis by experts in fields such as physical anthropology, archaeology, palaeobotany, zooarchaeology, bioarchaeology, palaeopathology and photo imaging.

This volume reports the results of applied analytical techniques that stand at the cutting edge of technological methods for palaeoenvironmental reconstruction; interpretation of human remains, and understanding of human social, cultural and economic adaptive strategies during 1,200 years of site occupation. These innovative and comprehensive investigations lay a solid foundation for future comparative studies of prehistoric Caribbean human populations and cultures.

At the time of the Tutu investigations, **Elizabeth Righter** was Senior Archaeologist in the Division for Archaeology and Historic Preservation (DAHP) of the Department of Planning and Natural Resources (DPNR) of the Virgin Islands Government. After three years as a consultant to that office, also known as the State Office of Historic Preservation or SHPO, Righter now is writing up the results of her many years of research in the Caribbean Islands and is President of her own archaeological consulting firm in Bradenton, Florida.

Interpreting the remains of the past
Editor: Mary K. Sandford

Volume 1

Stories From the Skeleton
Behavioural reconstruction in human osteology
Robert Jurmain

Volume 2

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Dedication

This book is dedicated *In Memoriam* to volunteers, Margaret Caesar, Phillip Caesar, Jim Cohen, Tom Lawrence, Tom Linnio, Fred Gjessing and Cameron Scobie; and to three people who made this project happen: Claudette Lewis, Alan Smith, and my teacher and guide, my father, Bukk Carleton II.

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Since 1973, **Emily R. Lundberg** has primarily concentrated on prehistoric archaeology and cultural resources management in the US Virgin Islands and Puerto Rico. Her dissertation for the PhD received from the University of Illinois in 1989 dealt with the pre-ceramic occupation of St Thomas. Her current projects concern ceramic-age research, undertaken as an independent consultant.

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Dolores Piperno is currently the Director of the Center for Tropical Paleoecology and Archaeology at the Smithsonian Tropical Research in Panama, where she has worked as a staff scientist since 1988. She carries out research with plant microfossils (phytoliths, pollen, and starch grains) to study past human ecology, paleoenvironmental changes, and agricultural origins and dispersals in the lowland Neotropical forest.

Elizabeth Righter received her BA and Master's degrees in Anthropology from Harvard University and completed studies toward her PhD at the University of Hawaii in Honolulu and Bryn Mawr College in Pennsylvania. Between 1982 and 1997, she was Senior State Archaeologist in the Virgin Islands State Office of Historic Preservation (SHPO). In this role, she directed archaeological excavations and data recovery at the Tutu Archaeological Village site, which involved supervision of more than 30 professional archaeologists and 200 lay volunteers in the field, fund raising to support this cooperative government-private sector venture, and subsequent follow-up laboratory work and report writing. Presently, as an independent archaeological consultant, she is conducting research on Guana Island in the British Virgin Islands, and writing up the results of her many years of Caribbean field research.

Mary K. Sandford is Associate Dean of the College of Arts and Sciences and Professor of Anthropology at the University of North Carolina at Greensboro. She received her Masters and Doctoral degrees in anthropology at the University of Colorado. Her research focuses on skeletal biology, paleopathology and paleonutrition. She is the editor of *Investigations of Ancient Human Tissue: Chemical Analyses in Anthropology* (1993, Gordon & Breach).

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Elizabeth S. Wing, a retired professor, is now Curator at the Florida Museum of Natural History in Gainesville, Florida, where she is responsible for their program in Environmental Archaeology, including collections of plant and animal remains from archaeological sites, comparative collections for the identification and interpretation of archaeological remains, and soils from archaeological deposits. The regional focus of this program is the southeastern United States, the West Indian Islands, the circum-Caribbean mainland and northwestern South America. Her research involves the study of animal remains from West Indian sites and integration of these studies with studies of archaeological plant remains.

Introduction to the series

This series provides a forum for presenting innovative ideas and methods relative to our understanding of the human past. The concept developed during preparation of my edited work, *Investigations of Ancient Human Tissue: Chemical Analyses in Anthropology* (Sandford, 1993a). While researching and writing that volume, I became acutely aware of the need for comprehensive and timely works focused on topics within the intersection of archaeology and physical anthropology.

That book examined the promise and pitfalls of using elemental and isotopic analyses in understanding past diets, nutritional patterns and disorders. Such topics, and the manner in which we elected to address them, influenced the scope and goals of the present series in several fundamental ways. The inauguration of these analytical techniques in anthropology signaled intensification of multidisciplinary approaches. These techniques made their debut in anthropology during the 1970s and the decade itself was one of fervor and optimism, as students seized upon such new technologies in hopes of gaining a better and more accurate understanding of the human past.

The enthusiasm that marked the introduction of trace element analysis in anthropology was tempered by recognition of the vast complications surrounding its use. Moreover, as with any method adopted from another discipline, most anthropologists simply lacked the training necessary for using the techniques or interpreting data. Remembering this as we prepared *Investigations of Ancient Human Tissue* some two decades later, we endeavored to contextualize our case studies with basic information on both theory and method, striving to make these techniques more accessible and understandable to a larger number of our colleagues.

The need for work with the requisite breadth to explore the reaches of a multidisciplinary perspective, or the depth to probe the intricacies of a specialized technique, is even more compelling now. Indeed, what seemed to be quite extraordinary a mere twenty years ago has been far outpaced by innovations and discoveries of today. Scientific visualization and digital technology have revolutionized our ability visually to assess and quantify the objects of our investigations, while providing us with the means, through virtual technology, to share our latest findings with colleagues around the world. Advances in biotechnology have expanded the bounds of our imagination; the ability to extract DNA from tissue may help us resolve issues emanating from such concerns as the history of disease to the origins of humankind. As we begin the new millennium, it is staggering to contemplate the matters we will be discussing, debating and endeavoring to understand in another twenty years. In providing a forum for cutting-edge ideas and techniques, it is my hope that this series will serve both to chronicle and propel our understanding of the human past.

Mary K. Sandford

Foreword

Antillean archaeology poses interesting questions relevant to general theories about human and environmental history. Did the archipelagic setting shape the trajectory of human history or at least point humans in particular directions? Were the islands more prone to immigration than were continental regions? Did Antillean communities maintain long-term relationships with communities on the mainland? How did island cultural evolution compare to that of the mainland? Did the islands' environmental circumscription speed up the rise of complex societies and processes of conquest in prehistory, or did their isolation buffer them? Alternatively, did indigenous human settlement in the Caribbean islands influence local environmental history? Did humans extinguish many species in the islands? Could the low rainfall of some areas have been caused by extensive deforestation in either prehistoric or historic times? Is such human influence a factor in the distribution of fauna, usually attributed to purely environmental factors?

Approaching such questions effectively through research requires the collection of specific types of data. First of all, we need good control of the passage of time to chart changes in relationships between different entities and factors. For any period, we need concrete evidence of the sizes and organization of human sites and the functions of structures and activity areas. To assess regional interaction through time, abundant excavated artifacts and raw materials are needed for analyzing styles of art, manufacturing methods, and sources of materials. To inquire about environmental effects on humans, we need to know the state of the environment at particular times and places, for it would be unwarranted to assume it has always been the same in the Caribbean. To evaluate economic change and human impacts on the environment, we need evidence of changes in technology, population, and resource use through time as well.

Few indeed are research sites in the Antilles and northern South America that provide this kind of interdisciplinary information. Such sites can be counted on the fingers of one hand: two sites in Puerto Rico, Maisabel investigated by Peter Siegel and his colleagues, and Caguana investigated by Oliver and his colleagues; the Hope Estate complex on St Martin investigated by Hofman and his colleagues; Golden Rock on St Eustatius investigated by Versteeg and his team; and the Tanki Flip site in Aruba, also investigated by Versteeg and his colleagues. Maybe we archaeologists have specialized too much. Perhaps National Science Foundation (NSF)- and National Endowment for the Humanities (NEH)-funded research has become so streamlined, trendy, and success-oriented that it cuts out collection of comprehensive data that could falsify hypotheses and lead in new theoretical directions. Those of us interested in settlement patterns may have relied overmuch on surface collections – impossible to date without stratigraphic excavations and often unrevealing of occupations deep beneath the surface. Others of us interested in cultural studies often neglect to collect systematic bioarchaeological and geoarchaeological evidence, making it difficult to study the interaction between cultural and ecological spheres. Studies of ecological adaptation, for their part, often have been one-sided in favor of hunting and fishing, leaving out the all-important plants that furnished habitats for both humans and animals and most of the food base.

In this context, the Tutu site project, directed by Elizabeth Righter, is a landmark in both holistic archaeology and tropical archaeology. The Tutu project is an outstanding example of how problem-oriented data collection and rescue archaeology can provide as much or even more data of theoretical relevance than narrower "pure" research projects. The Tutu project also is a model in collaboration among researchers, government agencies, the private business sector, and the community. At each stage of the research, interaction of the interests, needs, and contributions of the different players had a synergistic effect, achieving an extended research schedule, expanded research agenda, and significant public education benefits.

Working under the gun of development, Righter's research team meticulously cleared, plotted, sampled, and excavated structures, burials, and activity areas over a wide area of the site. After careful re-scraping and cleaning of features that had been revealed by earth moving for mall construction, they excavated the midden areas and features by hand, sampled intensively, and recorded the results in detail. The archaeologists at Tutu intensively collected both animal and plant remains, and among plant remains, both macro and micro specimens. Furthermore, they also analyzed the isotopic, elemental, and pathological evidence from human skeletons, providing an excellent critical background for the interpretation of the food traces and environmental evidence. Like the earlier studies, the Tutu project illustrates the fallacy of the assumption that prehistoric biological remains are not preserved in humid tropical sites.

Few other sites in either the Antilles or eastern South America have produced the comprehensive, definitive, interdisciplinary site information contained in this volume on Tutu. In this book are detailed descriptions of the methods and findings of the research at Tutu. The many excellent illustrations record detailed plans and profiles of structures and micro-stratigraphy, chart and illustrate the abundant samples of artifacts and biological remains, and list radiometric date series from structures, features, and human skeletons of the different periods.

Due to the intensive fine screening and flotation carried out, the research produced a huge sample of fauna and flora. Considering the rich information that these remains provide, it is surprising that many researchers still eschew screens or only use coarse quarter-inch screening, since, without small screen mesh, excavations essentially throw away most of the subsistence and environmental evidence (Wing & Brown, 1979). Most of the fauna at Tutu were shellfish and fish, with more marine fauna than land fauna through time, a sequence long recognized by archaeologists in the Antilles. The fauna are mostly small species, only rarely over 2,700 grams.

Many other sites have produced more finds of larger species than of small species, not because these were more important in subsistence, but merely because coarse-grained sampling methods skewed the sample in their favor. Contrary to optimal foraging theory, at Tutu, the choice of species changed little through time as population grew and resource use intensified. The Tutu archaeologists found the harvesting levels of reef species quite stable over time, but the harvesting of marine resources seems to have increased as local human populations grew. Across the board, the size of individuals is smaller later in the sequence, due to the prey population effects of more intensive harvesting. There is little evidence of animal husbandry, although the first migrants brought in hutias and an insectivore. As in riverine Amazonia, the maritime tropical people preferred to rely on collecting and hunting as long as there were sufficient resources.

In the plant food system, arrowroots turned out to be important, as well as squashes, palm fruits, and other tree crops. Unlike the situation at some late prehistoric mainland sites in the middle Orinoco (van der Merwe, Roosevelt & Vogel, 1981), and upper Amazon (Piperno & Pearsall, 1998; Roosevelt, 1989a, 1999, n.d.), the evidence for maize at Tutu is sparse and suggests that the plant was probably not an important part of the food plant inventory. Manioc's relative importance also is uncertain. Maize's apparent absence from Saladoid deposits at Tutu may mean that the first Saladoid migrants left the mainland before maize cultivation was widespread. Taken altogether, the results of the Tutu bioarchaeological analyses suggest that subsistence was a broad-based horticultural system of root and seed cultivation, tree-fruit harvesting or possibly tree-fruit cultivation, and fishing and hunting, similar in structure to the most common system today in Amazonia (Roosevelt, 1994).

The environmental information from the Tutu archaeological deposit sheds light on the nature of human–ecological relationships through time. Despite the general openness of the St Thomas landscape and today's frequently arid conditions, the result of centuries of timbering, agriculture, ranching, and urbanization, phytoliths at Tutu reflect a predominance of closed, moisture-loving forest vegetation during prehistory. In contrast, grasses and weeds were present in much lower percentages in the archaeological samples than they are in modern, anthropogenic savanna woodlands subject to intensive cutting and annual burning (Lovett & Wasser, 1993; Bonnefille, 1995). However, among the common forest taxa identified in the Tutu site are useful trees of rainforest disturbance successions: several palms and the legumes, Acacia, and Cassia. Thus, people cut the local forest but allowed it to regenerate and protected the useful species of succession, as in managed forest fallow systems in Amazonia today (Balee, 1989). The analysts suggest that disturbance and utilization of the vegetation in the immediate site area became more intensive through prehistoric time, an occurrence not unexpected for a growing community.

To judge from the condition of the many skeletons excavated from the site, the quality of life of Tutu people seems to have been good overall. There are relatively few marks of chronic, severe physiological stress in the skeletons of the young, the group expected to be the most vulnerable to effects of diet and disease problems. Although the evidence for stress increases somewhat through time, health status remains favorable, compared to other archaeological populations. Marks of mechanical premortem trauma are uncommon, especially the pathologies that osteologists associate with interpersonal violence (Cohen, 1989).

In addition to the rich bioarchaeological materials recovered from Tutu, cultural objects are abundant and elaborate. Diverse objects were made of a range of materials: pottery, rock, shell, and wood. As in other tropical areas, the nature of discarded materials reveals that pottery and some lapidary objects were made locally (Roosevelt, 1989a). The abundance of fine pottery art at Tutu gave the researchers an excellent opportunity to create a detailed cultural sequence by analyzing the distribution of modal ceramic attributes by radiocarbon-dated micro-stratigraphic units. As they point out, this is the only Lesser Antillean site where fine chronological control of pottery change has been possible. This method of analysis, pioneered by Irving Rouse, allowed the archaeologists to divide the Cedrosan Saladoid deposit into 3 successive Saladoid assemblages. I had a comparable experience with Rouse's method in ceramic analyses carried out at Orinoco sites (Roosevelt, 1997); and, having worked at prehistoric pottery sites both in the Orinoco and Lower Amazon, I was fascinated to see the repeated echoes of continental cultures in this Antillean site. For me, the Saladoid assemblages at Tutu were remarkably similar to those of the Ronquin Sombra phase and its early Corozal I descendant, and the late Ostionoid seemed like pottery of the Arauquinoid series (Roosevelt, 1980, 1997). As in the Orinoco sites, at Tutu there was a shift from well-smoothed, regular vessel contours, sharply defined and angled rims, and the tidy, sinuous grooving found in the Saladoid assemblages to the irregular vessel contours, direct, rounded rims, and sloppy but sharp and intricate incision, punctation, and appliqué of the late Ostionoid. Such parallel stylistic changes suggest continuing social interaction and stylistic communication between islands and mainland peoples, but what the pottery changes mean in terms of social, aesthetic, and demographic processes is difficult to say.

The patterns of similarity between Tutu and other Antillean sites and sites in mainland regions show that there existed a widespread, long-term shared sphere of cultural interaction, despite local differences in subsistence and social trajectories. Does Tutu offer any evidence of site unit intrusions that might indicate conquest? Basic pottery manufacturing methods seem stable, as if the area was continuously occupied by a population acculturated to the same manufacturing customs. However, the calibrated radiocarbon sequence does reveal a hiatus in occupation of the site, as well as a discontinuity in culture. One example of this is the suspension of elaborate modeled, incised, and painted pottery decoration during the last Saladoid assemblage and a gap in radiocarbon dates between it and the late Ostionoid assemblage. A period distinguished by pottery lacking elaborate decoration common during almost a thousand years of earlier development also occurs in parts of Marajo Island soon after AD 1100 (Roosevelt, 1991). Some archaeologists believe that there could have been an environmental disaster, but an alternative theory is that widespread social disruption occurred as ancient communities began to move toward more centralized and stratified organization.

What evidence does the Tutu research offer about how the community was organized and how it changed through time? Of the structures identified at Tutu, some of the larger residential structures look like Amazonian malocas, rounded communal dwellings with several related families in each residence. In some areas of Amazonia, as with the Shipibo at Lake Yarinacocha, malocas were discontinued under Western influence in favor of square or rectangular nuclear family structures. Even so, however, the individual family structures were often built in clusters, housing extended families. The multifamily residential group, however it was housed, seems a stable, long-term pattern in the eastern tropical lowlands. At Tutu, the continuity in general house pattern does not mean there is no change through time in the function of these groups. For example, the researchers point out that later buildings have intriguing structural details in common with ethnohistoric records of Taíno dwellings, such as the door structure.

Interestingly, although there are indications of social differentiation during both periods of occupation, the archaeologists found no compelling structural and artifactual evidence for the existence of coercive central authority at Tutu. Righter feels that "we cannot assume that the site was outside the influence of some overall central authority during the late occupation. Although there are signs of continuity at the village, I do not think that it was totally independent of what was going on in the rest of the Tutu sphere of sociopolitical influence, given the burial patterns and house types, and the presence of Taíno-like zemis and ball belt fragments in the Ostionoid deposits at the site." The structures and skeletons of Tutu did not show evidence of either epidemic interpersonal violence or significant interpersonal differences in faunal consumption. Probably, the site community had little of the type of socioeconomic differentiation characteristic of discrete class organization, although some individuals may have achieved unique roles, commemorated in the different burial treatment. With time, residences at Tutu appear to have become more substantial and permanent, as also happens in lower Amazon prehistory (Roosevelt, 1993). In addition, in the later period some houses are larger and richer in objects. Perhaps larger co-residential groups were more differentiated. Alternatively, with more members, they could have had more hands to labor and build up possessions or gain gifts through the influence of greater numbers.

Would the growing community have eventually fissioned if not integrated by a central agency? Maybe not. Like some residential communities on Marajo Island, Tutu held together for periods of hundreds of years despite the lack of central authority. The literature on heterarchy suggests the need to investigate the non-centralized, non-hierarchical methods of long-term community integration (Arnold, 1996; Ehrenreich, Crumley, & Levy, 1995) that could have been responsible for this stability.

Many particular cultural features of the site are difficult to interpret with present knowledge. Some disposal customs are opaque. Some shallow human burials were usually covered with a cap of mounded soil, a pattern also found in late prehistoric burials at Corozal, Venezuela (Roosevelt, 1997). Perhaps the locations of burials were marked by the mounds, but the mounds could also have obscured burial pit locations. As in some early cultures of the coast of Peru, during the late occupation at Tutu, children's burials have more offerings than adult burials (Roosevelt, 1999). Does this mean children were especially valued or were they feared as potent sources of malign spirits needing appeasement? What was the meaning of the turtle burials, which also occur in other Antillean sites and in late prehistoric sites at Santarem in the Lower Amazon, Brazil (Roosevelt, 1994)? Such practices of the ancient neotropical communities were part of an elaborate tapestry of regional culture. Elucidating the nature and rationale of this great indigenous American tradition constitutes a compelling challenge to future generations of tropical anthropologists.

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Preface

The Tutu Archaeological Village site was discovered on 20 September 1990 by Mr Tom Linnio, who, as an environmental officer of the Virgin Islands Department of Planning and Natural Resources (DPNR), was making a routine inspection of a land parcel being cleared for construction of a shopping mall. The mall site had been stripped of topsoil which was being stored in large mounds for sale prior to construction. During his inspection, Mr Linnio observed two partially exposed human skeletons and a wide scatter of prehistoric artifacts that extended over an area of approximately 2.20 hectares. Immediately recognizing the research potential of the site, Mr Linnio reported the find to this author, Ms Elizabeth Righter, former Senior State Archaeologist for the US Virgin Islands.

Because of its relatively flat terrain and treeless expanse of open land, the site offered an unprecedented opportunity to study the remains of an entire prehistoric village and to document house types, village structure and related sociocultural patterns. This type of research had never before been conducted in the Virgin Islands. However, the site was in imminent danger of complete destruction.

The shopping mall was to be constructed on private property, which was not part of the local Coastal Zone Management (CZM) area; there was no federal funding and ostensibly no requirement for federal permits that would have triggered compliance with Section 106 of the National Historic Preservation Act of 1966 (P.L. 89–665, as amended). In 1990, there was no local antiquities act to protect either unmarked human burials or significant archaeological resources threatened by local government actions and commercial development outside the coastal zone. The developer, therefore, was not required under any territorial or federal statute to consider the impacts of his project on cultural resources, and he could not be required to fund an archaeological survey and evaluation of the site. For similar reasons, the developer could not be required by law to put the site, or portions of it, into preservation. The political climate favored mall development, and the developer verbally promised many amenities that would benefit the community.

As Senior State Archaeologist, the author approached the then Commissioner of the DPNR and State Historic Preservation Officer (SHPO), Mr Alan Smith, requesting his assistance. After the Commissioner had evaluated the significance of the site and the options for recovery of its important scientific information, it was agreed that the Office of Historic Preservation of the Virgin Islands, known as the DAHP, would undertake responsibility for data recovery. The Commissioner agreed to negotiate with the developer and granted the author permission to work at the Tutu site full time until construction of the mall began. Endorsement of the investigation by the government was the first step in a delicate set of political maneuvers that eventually led to increasing support for the archaeological excavation of the Tutu site. Nevertheless, at the time that the Commissioner gave the project his blessing, there were no staff, funds, or equipment with which to carry out the Department's intentions. The only contribution to the data recovery was Ms Righter's time and labor.

Mall developers agreed to provide access to the property until construction began and to assist with fund raising. They also donated an unoccupied building for use by volunteer archaeologists from off-island. The developers, while expressing support for the research, had little understanding of the painstaking nature of archaeology and assumed that the archaeologists would be "out of their hair" in a very short time. An impossible deadline of three months until construction start-up was imposed.

Undaunted, the author enlisted the assistance of Dr Emily Lundberg, Research Associate for the project. Without benefit of a field station, trees, or other shelter, the first two weeks of research were carried out in the pouring rain with small supplies carried in backpacks. No storage space was available on the site, and larger equipment was left out at night buried in tall grass. A sign indicating that scientific work was in progress was propped up at the entrance to the site. This was the only protection afforded the site; and, throughout the entire course of the research, when the site was left unattended, it was never vandalized or disturbed in any manner.

Land surveyors, Travis Gray and Humphrey Ongondo, of John Campbell Design Group, St John, volunteered to lay out the framework for a grid of 5 m^2 units over the entire site and to provide future Autocad mapping of exposed features and other aspects of the site. Utilizing tapes and a transit, this author and Emily Lundberg subdivided the grid into smaller units. Chris Shearman and Associates contributed supplies for water screens and Doug White and Tom Linnio each contributed to establishing a water screening system at the site. Because of the presence of a deep well on the property and electrically pumped water, it was possible to set up a continuously operating water screening and flotation system. Shortly thereafter, a systematic surface collection was conducted, assisted by weekend volunteers from community groups such as the St Thomas Historical Trust, the Environmental Association of St Thomas (EAST), the Rotary Clubs of St Thomas, the Boy Scouts and the Girl Scouts. Other local citizens also volunteered hours or days of their time (see Acknowledgments).

Citizens, concerned about the imminent loss of the site to shopping mall construction, formed an *ad hoc* committee of prominent businessmen to support the project. The resultant partnership was an outstanding example of private sector–government cooperation. The St Thomas Historical Trust, with the assistance of its president, Douglas White, and his staff, set up a separate nonprofit financial account to accept and monitor contributed funds; and Christopher Green, Architect, and his assistant, Gail Choate, undertook the enormous task of fund raising. Within a matter of weeks, a field tent had been donated and erected by the Virgin Islands National Guard. Soon thereafter a 30-foot-long ocean shipping container was donated by Antilles School, for use as a makeshift field laboratory and secure on-site storage area. With encouragement of the developer, and prodding by one of its employees, Joyce Craig, the local telephone company, VITELCO, donated USD 10,000 to the project. This breakthrough enabled the DPNR to enter into an agreement with archaeologists from the Southeast Regional Office (SEAC) of the National Park Service (NPS) to send a crew to assist the author and Dr Lundberg and other volunteers at the site.

Although the original deadline for completion of data recovery at the Tutu site had been three months, when the December 1990 deadline arrived, the developer was not ready to proceed with construction. An extension was granted and plans were made for work through April 1991.

The first prehistoric house posts and a human burial were excavated by the NPS team in December of 1990. These findings received a great amount of local publicity; and, at that point, a full-scale project was launched.

The *Daily News*, a Pulitzer Prize-winning Gannett publication, donated three full-page advertisements that were utilized by the Tutu project to raise funds, thank contributors and advertise upcoming fund-raising events. Several very successful events took place under the energetic supervision of Denise Michelini, Bill Groggin and others. As the number of visitors to the site increased, daily tours were offered for a small fee. Tour guides were volunteers who devoted many long hot hours to trekking across the site in the hot sun, and explaining the procedures to an awed public. Films were produced by Channel 8 and by the Public Service Channel, Channel 12. The site received a visit from then Governor Farrelly and from the cast of the Hollywood movie, *Dances with Wolves*. Dr Douglas Ubelaker of the Smithsonian Institution visited the site and gave of his professional time and expertise to excavate a number of human burials and train volunteers. He later reported on the experience in his 1996 book, *Bones*. Dr Ricardo Alegría, the father of Puerto Rican archaeology, also made a visit to the site.

The Tutu project received generous funding and contributed supplies of all kinds. In order to help stretch the funding, two major resort hotels, Point Pleasant Resort and Stouffer Grand Resort Hotel, donated elegant rooms for the use of off-island professional archaeologists and qualified volunteers. Restaurants donated meals for hungry archaeologists, while car-rental agencies such as Seabreeze Car Rental, Independent Car Rental and Dan Bayard Motors donated vehicles which were used to transport supplies and to pick up archaeologists at the airport and deliver them to their hotels. Armed with contributed amenities, the project was able to attract professional archaeologists and physical anthropologists from the United States, Puerto Rico and Europe, who agreed to work six long days a week for their plane fare, a meal allowance and accommodation in a luxury hotel. In order to familiarize volunteers with the project and to obtain a consistent level of work at the site, volunteers whose transportation and living costs were supported by the project were required to be on site for at least two weeks.

Reflecting the interdisciplinary approach of the project, at the outset, recognized experts in Caribbean archaeology, zooarchaeology, paleopathology and paleobotany were contacted and their assistance with materials analysis was enlisted. Their advice was also sought as to the appropriate methods for sample collection. This precaution insured the recovery of samples that were uncontaminated and suitable for statistical analysis, and also established standards for recovery of a wide range of samples that would be comparable to similarly collected samples at other sites. Materials recovered from the field each day were registered, and artifacts needing special care were attended to in the field trailer. Recovered samples and artifacts were then moved to an improvised field laboratory in a vacant building donated by the developer. After the fieldwork ended, the author, with the assistance of Tom Linnio and Robert Pederson, personally moved the entire collection to an air-conditioned laboratory at the (DAHP). For the next five years, a cadre of dedicated volunteers, under leadership of Monique Purguy and Ann Heartburg, worked one day a week in the DAHP laboratory and another group worked one night a week at the author's home, where, under her supervision, every ceramic sherd from the collection was washed, numbered, catalogued and photographed.

In order to obtain financial contributions, it was necessary to demonstrate the presence of important archaeological material, and explaining the more esoteric aspects of method and theory to the developer and the public was a daily challenge.

Because of fluctuating funds, investigations did not always continue at full pace. Sometimes only the author and one or two assistants were at the site; and, at other times, a group of 12 or more volunteers and archaeologists would be present for several weeks. A small corps of local volunteers worked almost every day, supported by others who volunteered when they could.

In total, after a series of three- to four-month deadlines, the fieldwork for the project extended to 11 November 1991. Before the project ended, volunteers assisting with data collection and analysis had included 30 professional archaeologists, 5 physical anthropologists, 10 graduate students, 3 land surveyors, numerous other anthropologists and scientists in other fields, and more than 500 members of the community (see Acknowledgments). Ultimately the percentage of the site investigated and the amount of information retrieved are far greater than would have been required by federal historic preservation legislation for mitigative data recovery. In 1991, the remainder of the site was obliterated by earth moving that completely restructured the terrain of the shopping mall site. In 1992 the Tutu Archaeological Village project won an American Express Historic Preservation Award.

The project is committed to materials analyses and publication of the research, two important aspects of responsible archaeology. Unlike many Virgin Islands projects, whose materials still sit on shelves awaiting analysis, the project was extremely fortunate in the generosity of the community, assistance from other archaeologists and volunteers, and a gift of USD 50,000 from the Virgin Islands government which provided funding for the materials analyses. Subsequently the author applied for and was granted an Interpretive Research Award of USD 47,500 from the NEH in Washington, DC (Grant No. RK–20224–95). These funds provided for additional analyses and supported the preparation of the current volume.

Elizabeth Righter

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Introduction

Elizabeth Righter

Archaeological evidence indicates that the Tutu Archaeological Village site was initially occupied shortly after the beginning of the Christian era and abandoned sometime around the time of Christopher Columbus' arrival in the New World. Two major periods of site occupation took place: one between cal. AD 65 and cal. AD 900 and the other between cal. AD 1150 and AD 1500. Although earlier dates were obtained they could not be associated confidently with other evidence of site occupation. On the later end of the time scale 2-sigma date ranges extend to cal. AD 1635, but the lack of fifteenth-century European trade goods in any of the recovered material suggests that either the inhabitants of the Tutu site were not present at the time of European contact or they abandoned the site very shortly thereafter.

The Tutu site is the first Ceramic Ages prehistoric settlement in the Virgin Islands to be investigated in a holistic manner. The challenge of documenting and interpreting the complex interplay between the natural environment and human subsistence, culture, sociopolitical organization, and spiritualism underlies the theoretical and methodological approach to the Tutu site. In order to expose and record the full range of archaeological evidence, both midden and non-midden areas were investigated and interpreted. In consultation with leading experts in a number of related fields, charcoal and other samples were carefully excavated from stratified midden deposits and subjected to state-of-the art analyses. This approach permitted interpretation of the relationship of site elements, in chronologically controlled contexts. Analysis of the paleopathology of human remains from the site is one of the most extensive and comprehensive for the Caribbean islands; and these studies combined with results of paleobotanical, faunal, trace element, stable isotope and other analyses provide significant information pertaining to health and diet as well as to patterns of subsistence and natural resource exploitation. Large expanses of non-midden areas were exposed to reveal patterns of post holes, structures and burials in relationship to each other, and to a central open area or plaza, and other features.

The results of the project demonstrate the wealth of information contained in both midden and non-midden areas of a settlement, challenge our survey methodologies and suggest increased use of remote sensing techniques. The results also challenge existing federal historic preservation legislation which limits consideration of archaeological resources to impact zones. The use of interdisciplinary analysis, so often set aside in the Virgin Islands for lack of funds, also set a precedent for future research, re-emphasizing the complex nature of prehistoric settlement sites and the interrelated nature of the archaeological data that they contain.

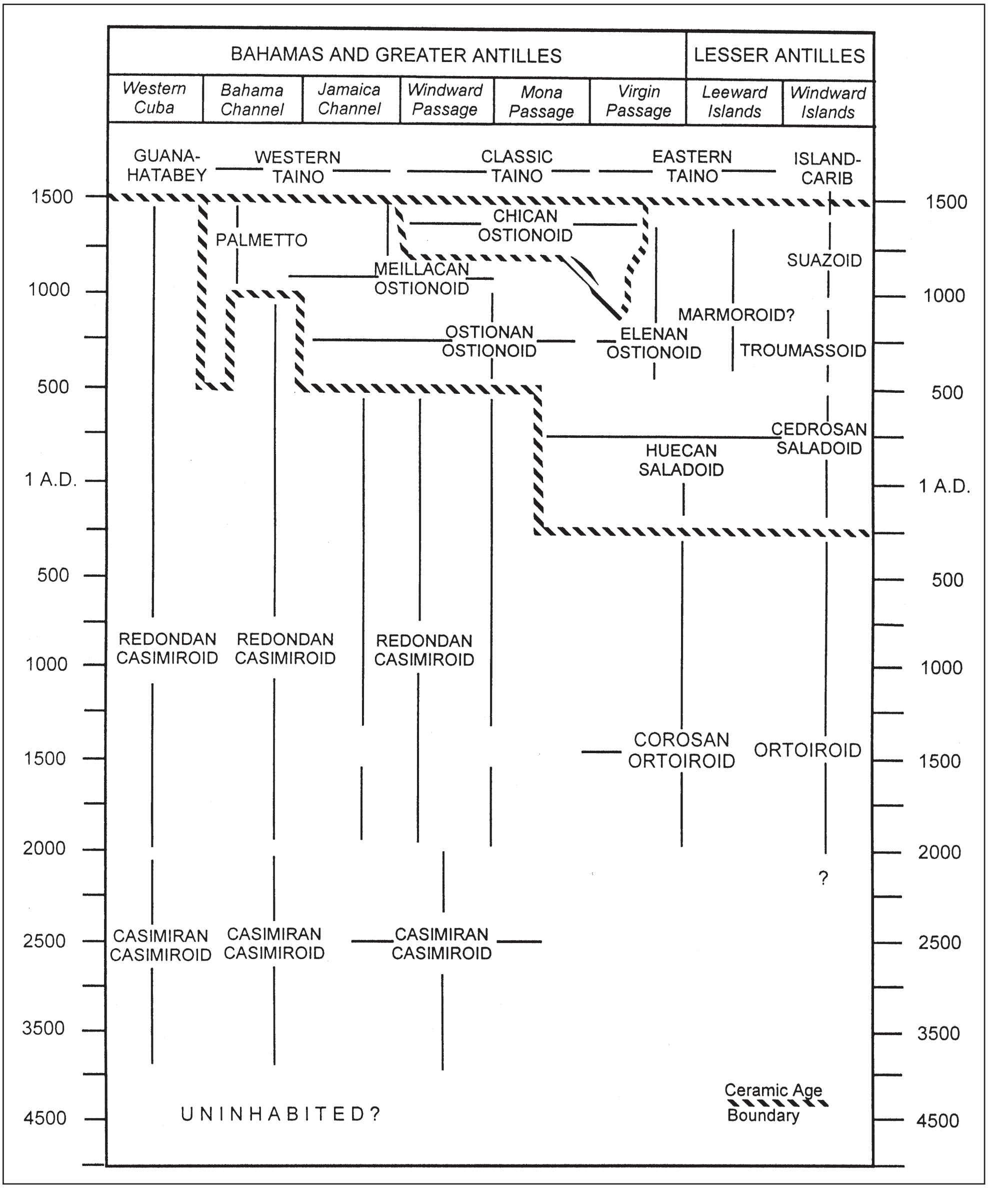


Figure I.1 Cultural chronology of the Bahamas, Greater Antilles and Lesser Antilles: ceramic series and subseries (Rouse, 1992, with modifications by Oliver, 1993: 28, Figure 6; redrawn by PCI). Reprinted with permission from Hayward *et al.* (1997).

As the first of its kind in the US Virgin Islands, the Tutu project is one among a growing number of Caribbean island projects which are contributing new information to an evolving theoretical model (see Curet, 1992; Curet & Oliver, 1998; Hofman & Hoogland, 2000; Oliver, 1998; Siegel, 1992, 1996; Versteeg &Rostain, 1997; Versteeg & Schinkel, 1992). As this data base grows, so does our ability to document the diversity of adaptation among island populations, make meaningful inter-island comparisons and trace movements and interactions between these groups within a chronological framework. These data also document social, political and cultural change.

The major purposes of the current volume are to:

1 present the methodological and theoretical basis of the project;
2 describe field methods and present the findings of the field research;
3 present results of interdisciplinary analyses of a wide variety of carefully collected samples from the site;
4 compare these results and determine the degree to which they support and supplement each other;
5 interpret the archaeological evidence to identify changing patterns of human adaptation at the Tutu site;
6 compare findings at the Tutu site with those of other sites; and
7 make a significant contribution to the data base for the Caribbean islands.

CULTURAL CHRONOLOGY

Most authors contributing to this volume place the cultural components of the Tutu site within the existing cultural chronology developed for the Caribbean islands and widely used among Caribbean archaeologists (Figures I.1, I.2). This chronology, ordered in terms of *space–time* units (cultural chronology) and *time–form* units (cultural taxonomy), was largely developed by Irving Rouse in the course of over six decades of archaeological work in the Antilles and Venezuela (Cruxent & Rouse, 1958, 1961; Rouse, 1937, 1939, 1952; 1954; 1960; 1962, 1965, 1972; 1982, 1986, 1992; Rouse & Faber Morse, 1995; 1999). The Caribbean cultural chronology has been modified, continuously updated and refined to accommodate new archaeological finds, and to render more clearly the implied broad cultural processes of diffusion, migration, local independent development and regional interaction (Oliver, 1992, 1995; Oliver & Righter, 1998). Ceramic series and subseries, and time periods referenced in this volume, are defined and described in Rouse, 1992.

THE VIRGIN ISLANDS DATA BASE

The first serious archaeological investigations in the Virgin Islands were conducted by Theodoor deBooy (1919) at Salt River, St Croix and Magens Bay, St Thomas on behalf of the Museum of the American Indian, Heye Foundation. DeBooy's analysis of fauna from Magens Bay, an enlightened technique for his day, resulted in identification of two extinct species, *Isolobodon portoricensis* (a hutia) and *Nesotrachis deBooyi* (a rail), that were food resources for the prehistoric inhabitants of the site (Miller, 1918). See Chapter 4 for a comparison between recently excavated fauna of the Magens Bay site (Elliott, 1990) and the Tutu site.

The deBooy investigations were followed by those of Gudmund Hatt, who, with deJosselin deJong, conducted extensive investigations at the same two sites, as well as at the Hull Bay and Krum Bay sites on St Thomas, the Coral Bay site on St John and several other sites in the Virgin Islands (Hatt, 1924; Lundberg, 1989). Hatt's investigations at Salt River, St Croix, uncovered human remains, mounds of cultural refuse and a ball and dance court demarcated by nine upright stones, of which four were carved with figures. These investigations have been extensively reviewed by Faber Morse (1990, 1991, 1995).

During the 1960s, Bullen & Sleight (1963; Bullen, 1962; Sleight, 1962) investigated a number of sites on St Thomas and St John. On St Thomas, their excavations at Magens Bay followed

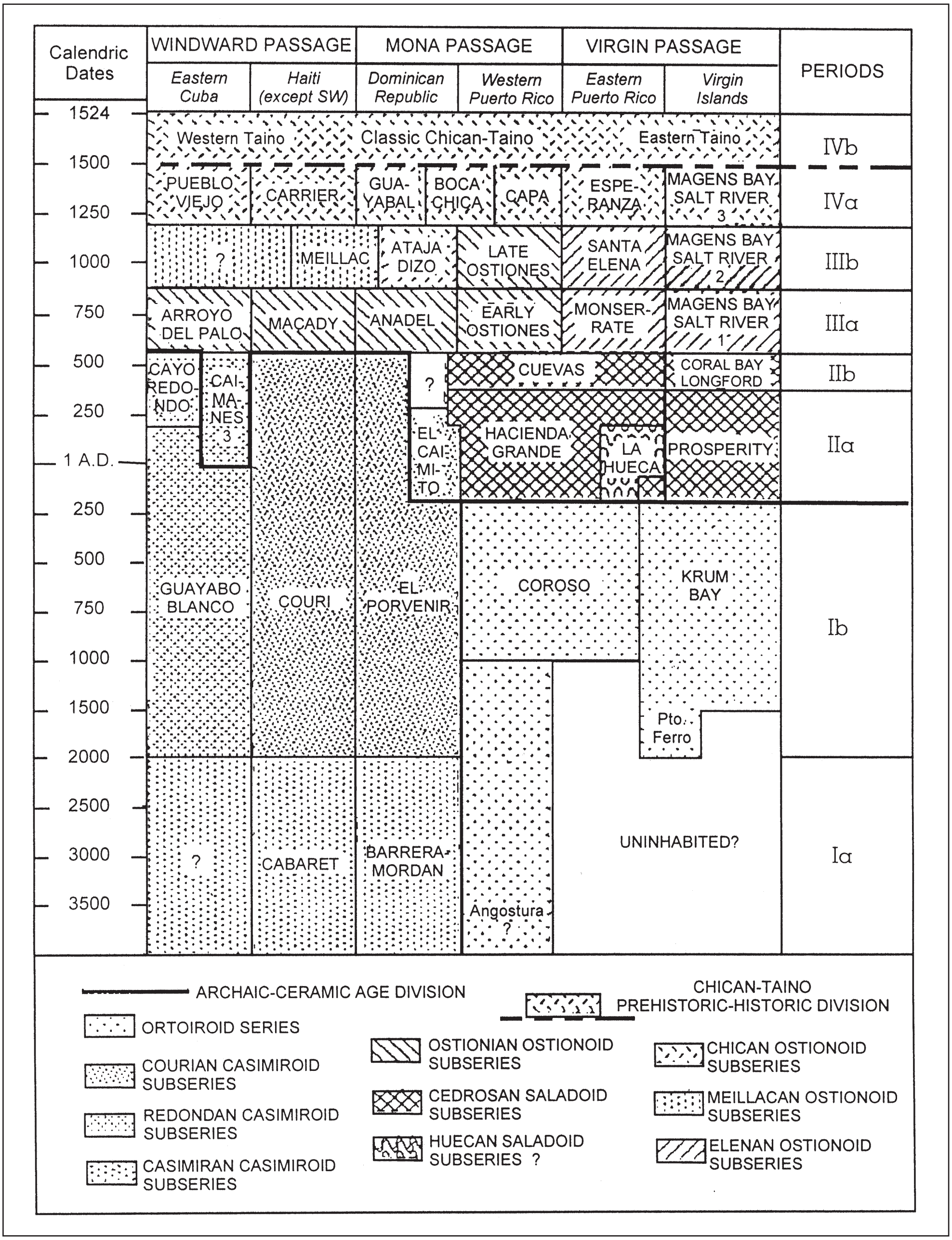


Figure I.2 Cultural chronology of the Greater Antilles: ceramic styles and subseries (Rouse, 1992; with modifications by Oliver, 1993: 17, Figure 5; Rouse & Faber Morse, 1995; Faber Morse, 1995; redrawn by PCI). Reprinted with permission from Hayward *et al.* (1997).

those of Kreiger (1938) and, at the archaic Krum Bay site, radiocarbon dates were obtained for several levels of the site (Bullen, 1973). Sleight's survey of St John sites remains an invaluable contribution to the Virgin Islands' archaeological record.

In 1973, the Government of the US Virgin Islands established an Office of Archaeological Services (OAS) whose responsibilities were archaeological research and education. Under this program, a number of sites were tested and several were nominated to the National Register of Historic Places. In 1976, a federally funded office of historic preservation, the (DAHP, equivalent to) the State Historic Preservation Office or SHPO, was established. Its mission was protection and preservation of cultural resources in compliance with the federal historic preservation program.

Between 1980 and 1982, under contract to the DAHP, Johnston compiled the Virgin Islands Inventory of Historic Places; and, between 1982 and 1997, as full-time archaeologist to the DAHP, Righter conducted research at a number of sites in the Virgin Islands, including the Tutu site. After establishment of the DAHP, however, the majority of research consisted of archaeological surveys, and limited data recovery conducted by a variety of contracting firms in compliance with historic preservation legislation. During this time National Park Service archaeologists also conducted research on all three islands, and off-island archaeologists were encouraged to conduct research projects. As a result, a number of privately funded research projects currently are underway on St John and St Thomas. In 1998, 15 years after its initial presentation to the Virgin Islands legislature, the Virgin Islands Antiquities and Cultural Properties Act was passed.

Overview of Virgin Islands prehistoric sites

As of 1997, the Virgin Islands Inventory of Historic Places listed a total of 210 prehistoric sites: 56 on St Thomas (Figure I.3); 118 on St Croix, and 36 on St John (Johnston, 1981, 1982; Righter & Lazelle, 1997). The Tutu site is the 54th prehistoric site to be identified on the island of St Thomas in the US Virgin Islands (Reg. No: 12VAm 3-54). Apart from this project, and limited data recovery required in compliance with historic preservation regulations, most Virgin Islands prehistoric sites have not been comprehensively investigated.

On St Croix, 26 single and multi-component sites contain ceramics of the Cedrosan Saladoid series. Most of these sites are situated directly on the north, west and south coasts of St Croix; however, the St George's site is situated more than 1 km inland from the south shore; and, on the north coast of St Croix, a complex of sites with Saladoid components is located in a large valley upriver from the Salt River estuary.

Four Saladoid sites have been recorded on St John and four on St Thomas (Righter, 1990, 1992, 1995).

Sites containing Ostionoid series ceramics also are found on all three islands. On St Croix, the majority of Ostionoid sites have been found on the north and south shores; however, the Fairplain site, one of the most extensive on St Croix, is located at the juncture of tributaries of Bethlehem Gut, slightly inland from the south shore (Righter, 1995). The late Ostionoid/Contact Period component of the Salt River site on St Croix is best known for its association with a visit by Christopher Columbus and his caravelle during Columbus' second voyage to the New World in 1493 (Morrison, 1942).

On St John, a series of Ostionoid settlement sites, each apparently representing a different phase, is situated along the northwest coast; and, despite generally rougher offshore waters and drier weather conditions, a variety of prehistoric sites also is known for the south shore of St John (Righter, 1992). Petroglyphs are present at Reef Bay and on Congo Cay in Pillsbury Sound, off of St John.

On St Thomas, the largest Ostionoid sites are located on the west end (Botany Bay) and on the north shore (Magens Bay and Hull Bay) of the island (Johnston, 1981). A few poorly known post-Saladoid sites also are present on Water Island and on Rotto Cay, a small island off the south shore in Mangrove Lagoon. The Tutu site, which contains both Saladoid and late Ostionoid components, is the only known major inland prehistoric settlement on St Thomas.

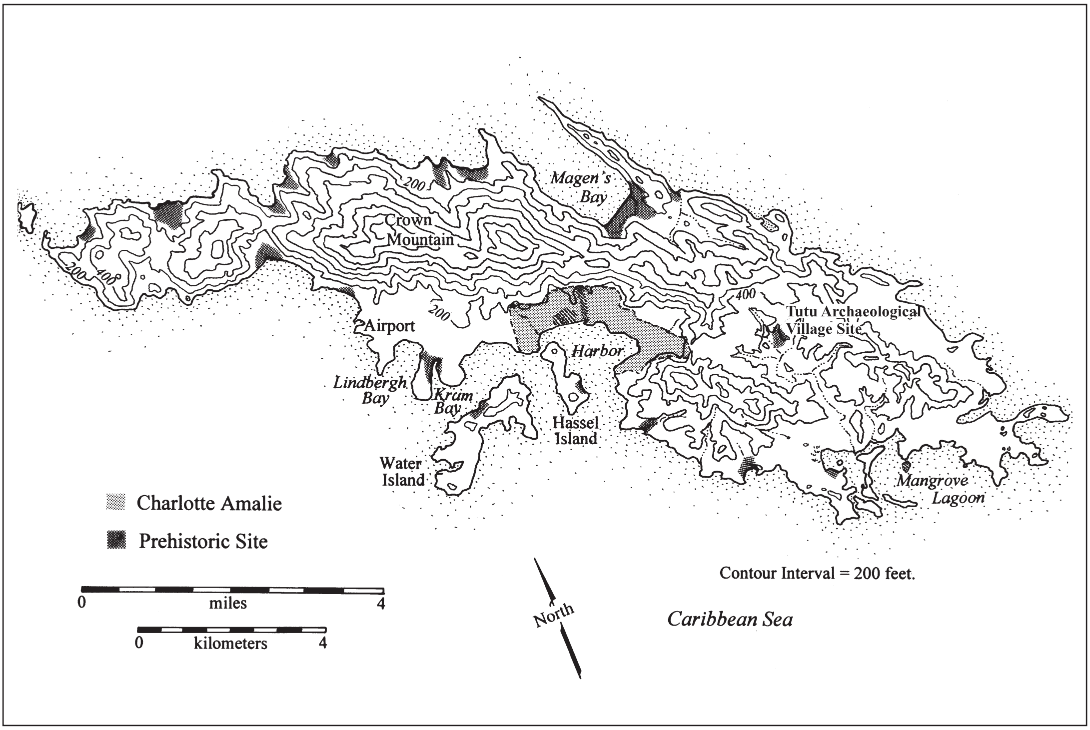


Figure I.3 Major prehistoric sites of St Thomas, USVI (graphic by Julie Smith).

THE CURRENT VOLUME AND ITS CONTENTS

Chapter 1 of this volume describes the background of the project, research rationale and field methods. It also describes samples collected and provides an overview of findings. As such, it is a site report abridged to accommodate the subsequent analytical chapters which are the essence of the volume.

By their nature, in the Caribbean especially, surviving archaeological remains represent only a small percentage of the cultural activity that took place at a site. Organic materials, often the largest part of the material culture, are subject to decay. Therefore, both the practical aspects of human life, such as subsistence and house forms, and the non-material aspects, such as spiritual beliefs and social organization, must be carefully interpreted from the archaeological evidence left behind (Righter, 1997). For example, evidence of plant cultivation or harvesting may be found in microscopic plant phytoliths recovered from soil samples collected in midden contexts (Chapter 3); or evidence of overfishing and stress on food resources can be observed in faunal remains (Chapter 4). Sometimes it is necessary to compare analytical results from a number of related fields to address a question fully. For example, results of analytical studies in Chapters 4, 7, 8, 9, and 10 may be compared to understand the combination of factors that affected the diet and health of the Tutu inhabitants. Accordingly, the central section of the volume is a series of records prepared by individual analysts who report the results of their application of the most up-to-date techniques to a wide variety of recovered samples.

This information is integrated with site specifics and compared to findings at other comprehensively investigated Caribbean sites. The final chapter compares results of the field investigations and materials analyses to focus on interpretation of the site as a whole. This interdisciplinary approach is intended to contribute an important building block in the development of a comparative prehistoric data base for the Caribbean Islands.

It is always desirable that collected samples from an archaeological site be of a quality and significance to permit continuing research, especially as new questions arise and new analytical tools become available to the field of archaeology. The analytical results presented in this volume are but a beginning. The ceramic collection and the botanical remains from the site will be subjected to additional refined analyses in the future; and it is anticipated that the collection of prehistoric Caribbean human remains from Tutu will provide material for future specialized studies as our analytical tools continue to sharpen. Among anticipated near-future studies are examination of phytoliths extracted from abdominal soils of human burials; in-depth analysis of lithic remains; and mitochondrial DNA analysis to examine inter- and intra-population relationships during the two major occupational periods at the Tutu site.

Chapter One

Background of research and sample collection at the Tutu site

Elizabeth Righter

ENVIRONMENTAL BACKGROUND

Physical setting

The Tutu Archaeological Village site is nestled in an inland valley, about 1.75 km from the nearest seacoast, on the eastern end of the island of St Thomas, US Virgin Islands. St Thomas is one of a chain of islands that extends along the eastern edge of the Caribbean Sea and stretches from Trinidad off the northern coast of South America to the western end of Cuba (Figure 1.1). Located about 55 km east of Puerto Rico (18° 20' N, 64° 56' W), St Thomas is geologically more closely related to this island than to islands of the Lesser Antilles to the east and southeas,; and is, therefore, usually included among islands of the Greater Antilles. St Thomas (Figure 1.2; Figure I.3) is about 5 km wide at its widest point, 24 km long, and has an area of about 83 km^2. In form, St Thomas consists of a long east–west ridge, rising to about 500 m at its highest point, with numerous fast-descending spurs to sea level. Little level ground is present, except at bay heads, where run-off from sharply dissected ravines has created gently sloping land; in summit areas generally above 300 m in elevation; and in the valley of Turpentine Run, where the Tutu site is located. Soils of St Thomas are mostly thin and rocky, particularly on the coast and steep ridge slopes (Pearsall, 1997).

When discovered, the Tutu site (Figures 1.3, 1.4) comprised about 2.20 hectares of predominantly flat pasture land at the base of an amphitheater-shaped hollow, surrounded by low hills; today the site is a shopping mall. In 1990, a branch of Turpentine Run (a currently intermittent water course known locally as a “gut”) extended along the western and southwestern boundaries of the site (Figure 1.5) and drained to the south shore of St Thomas, emptying into what is today known as the Mangrove Lagoon (Introduction: Figure 3). In the past, tributaries of this gut also extended along the northeastern, eastern and southeastern boundaries of the site. For the prehistoric inhabitants of the Tutu site, this location offered many advantages, including flat land; immediate access to fresh water; a continuously blowing trade wind; a protected defensible position; fertile soil; access to large trees for house and canoe building; and access to the coast via a major stream. In addition, except from certain vantage points on high ridges to the northwest and from a few locations along a low ridge to the northeast, the site was hidden from view by land or sea.

Colonial and modern land uses in the surrounding hills and valleys of Tutu, construction of a dam on the western branch of Turpentine Run, and diversion of the eastern branch have altered the ground water patterns in the vicinity of the site (Geraghty & Miller, 1993). It is probable that,

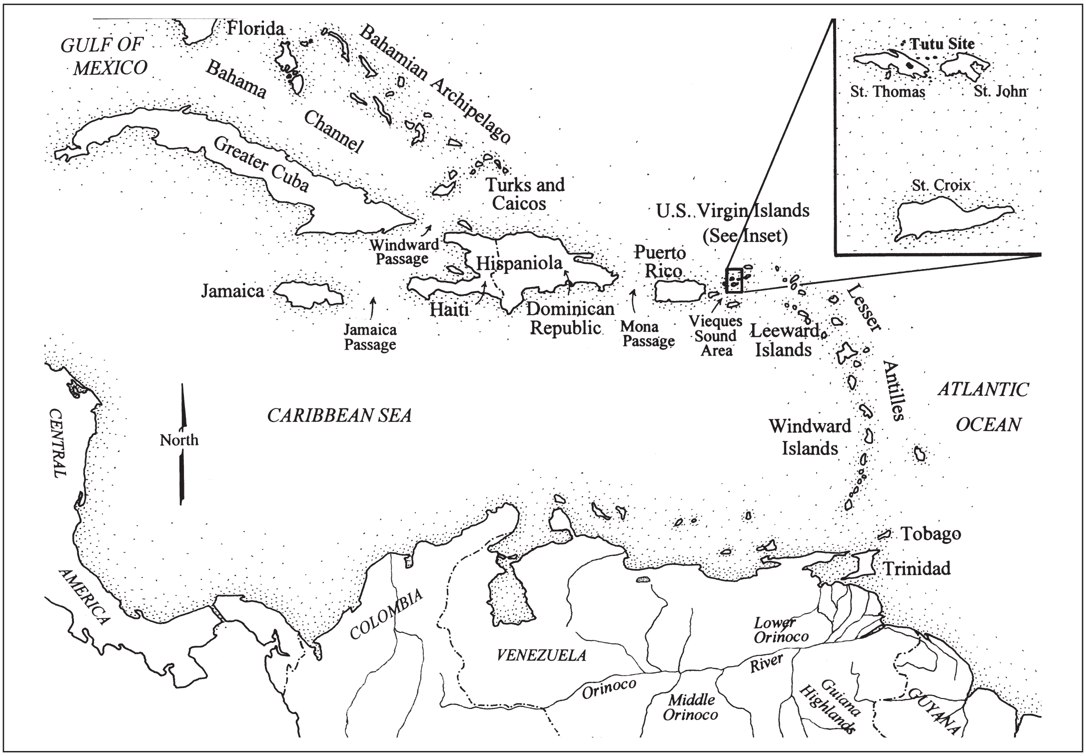


Figure 1.1 Caribbean island archipelago, showing location of St Thomas and the Tutu site in relation to the Greater and Lesser Antilles (graphic by Julie Smith).

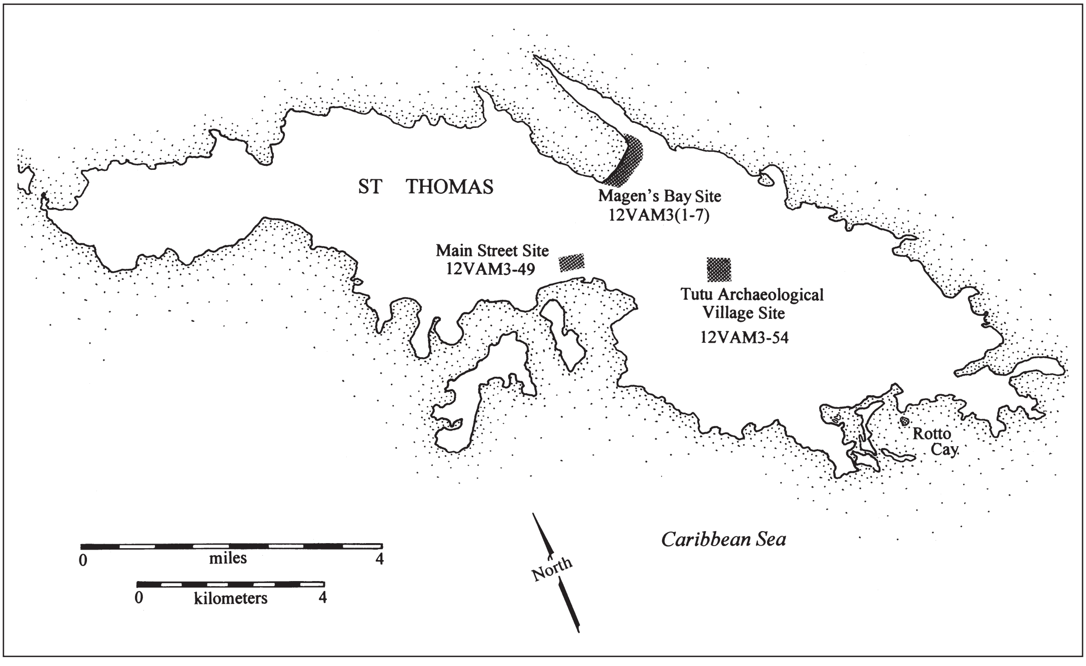


Figure 1.2 Map of St Thomas, USVI, showing the Tutu site in relation to the Magens Bay and Main Street sites (graphic by Julie Smith).

in the prehistoric past, Turpentine Run was a continuously flowing stream (Righter, 1995). In 1991, the author and John Davis, of the Soil Conservation Service, conducted a visual survey of the presently greatly altered stream bed, and concluded that, prehistorically, the Run may have been navigable from its mouth to a point about 0.60 km southeast of the Tutu site (Figure 1.5). As well as providing access to more open waters between St Thomas and islands to the east and west, the Mangrove Lagoon was rich in marine resources and must have been a primary habitat exploitation area. Certainly, the abundance of marine resources recovered from midden deposits at the site indicates that the inhabitants of the site had access to and made good use of the sea.

Terrain

The following descriptions pertain to the site when it was discovered in 1990 and before it was massively altered by earth moving related to mall development. The Tutu site was a flat-topped ridge in a river valley, with elevations ranging between about 56 m and 63 m above mean sea level (amsl) (Figures 1.4, 1.5). On the eastern and western sides of the ridge, the land sloped to the meet the banks of the Turpentine Run's tributaries; and, beyond the northern portion of the site, the land rose steeply to a hilltop outside the mall property. On the southern end of the site there was a small rise which concealed the prehistoric site from view from the south. Adjacent to the southeastern edge of the site a house had been built on a small knoll which was little altered from its configuration on an historic 1918 map (Figure 1.3).

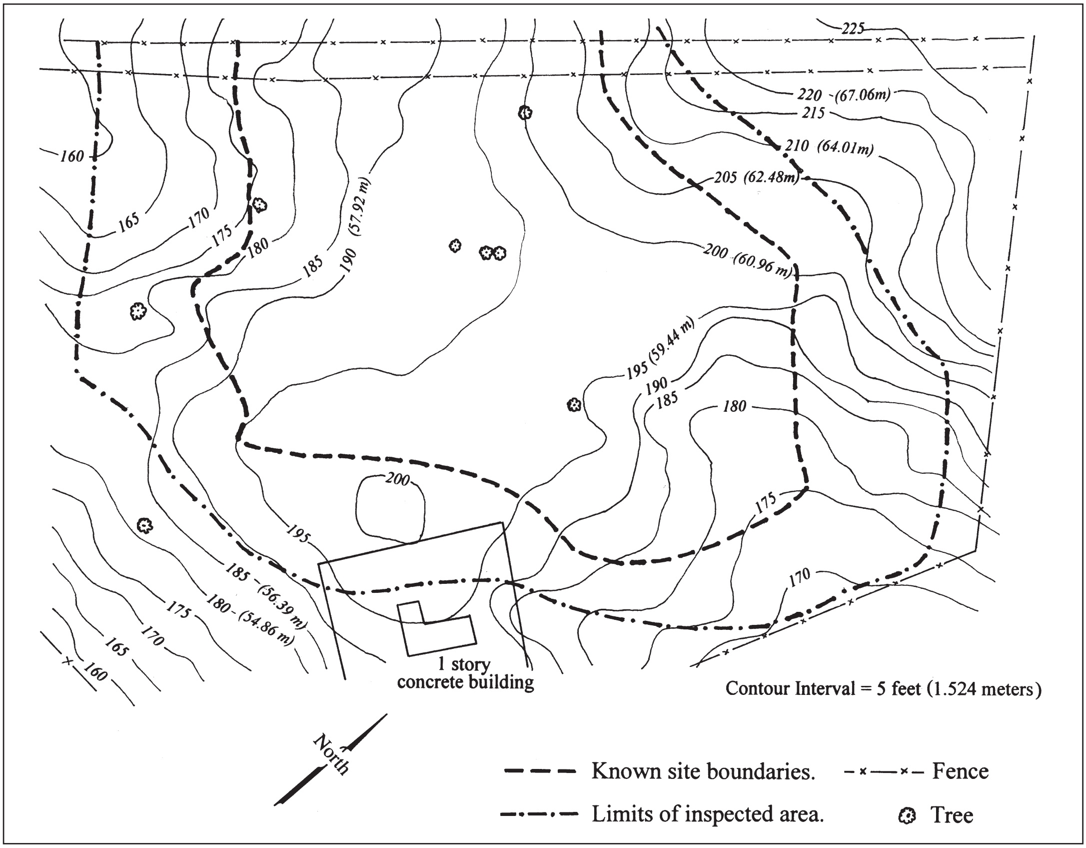


Figure 1.3 Map showing the location and topography of the Tutu site *c.* 1918, prior to major development on the island of St Thomas and prior to disturbances to the Tutu site (adapted from US Coast and Geodetic Survey Map No. 3771, US National Archives, Washington, DC).

Figure 1.4 Overview of the Tutu site (arrow), looking south from a ridge to the north (photograph by Elizabeth Righter).

Climate and rainfall

The climate of St Thomas is maritime tropical (Rivera, Frederick, Farris, Jensen, Davis, Palmer, Jackson & McKinzie, 1970: 73). Throughout the year, daytime high temperatures usually range between about 87°F during the summer months and 80°F in the cooler winter season. Temperatures almost never get below 67°F at night, and rarely get above 90°F in the hottest months, August through October, when the trade winds lessen (Pearsall, 1997).

Trade winds prevail from the northeast, east and southeast throughout the year and wind velocity varies daily. A velocity of more than 24 kph is more common in winter than in other seasons (Rivera *et al.*, 1970: 73). Windbreaks are required to protect crops and young trees in open flat areas like the Tutu site; and the site's prehistoric inhabitants apparently also felt the need to construct screens or fences to channel the wind (Chapter 12). In the Virgin Islands, rainfall generally averages between 16.53 cm (42 in.) and 17.71 cm (45 in.) per year (Bowden, Fischman, Cook, Wood & Omasta, 1970; Eggers, 1879; Pearsall, 1997; Sleight, 1962). Normally there are two rainy seasons, one in May and June, and another more extensive season in the month of November. February through April are the driest months. In general, the combination of strong trade winds and the sharp east–west mountain ridge of the island leads to a pattern of low rainfall on the eastern and southern portions of the island and moister conditions on the northern and western sides. In some areas of the island, moisture lost through evaporation, and transpiration rates, exceed the average annual rainfall; and periods of drought occur almost every year. The pattern of drought varies within the boundaries of an island, and from island to island; and, while portions of one island are undergoing the hardships of severe drought, a neighboring island may be green and lush (Pearsall, 1997).

Historically, the pattern of tropical storms and hurricanes also has been irregular. Normally occurring during the months between June and November, two or three major hurricanes can pass over St Thomas within a 6-year period; followed by as many as 40 years without a major storm. Hurricane damage includes negative impacts to the coral beds and terrestrial wildlife of the island. Several years are required for restoration of healthy coral communities to sustain populations of reef fish; replenishment of popular food sources such as the marine gastropod, *Cittarium pica*; and return of terrestrial animals such as birds and the insect life that sustains them. Large trees are often truncated, removing the upper canopy; and trees, shrubs and other plants are either killed or denuded of leaves, resulting in a lack of relief from the sun and parched soils during the hot dry months that follow the hurricane season. Impacts of drought and hurricanes, when they occurred, must have affected the lives of the inhabitants of the Tutu site, and it is not difficult to imagine abandonment of the site for several years, as a result of such natural phenomena (Pearsall, 1997).

Site vegetation

The forests of St Thomas were cut during the Colonial period, and the vegetation of St Thomas today is manipulated by humans (Pearsall, 1997). Reconstruction of past vegetation patterns, based partially on studies of remnant vegetation in Puerto Rico, the Virgin Islands, and other Caribbean islands, indicates that the vegetation of St Thomas today bears little resemblance to that of the prehistoric period (Pearsall, 1997).

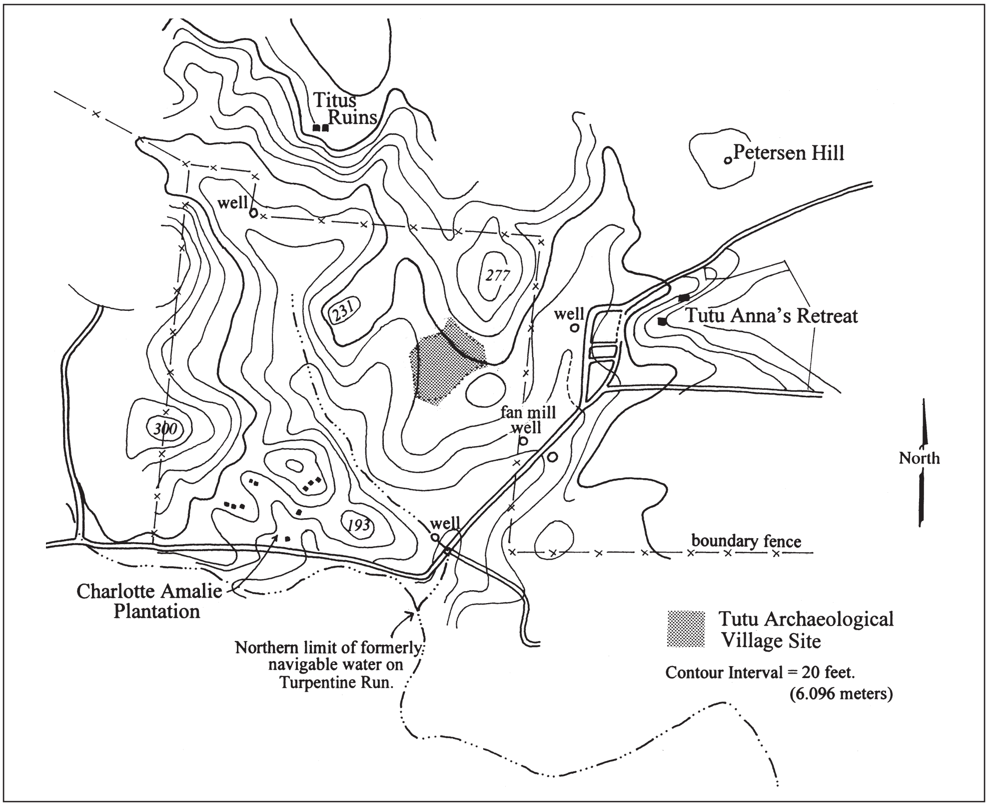


Figure 1.5 Contour map of the Tutu site and surrounding area. Information obtained from a pre-1990 survey map by V.I. Engineering (rendered by Julie Smith).

The Tutu site today lies within the croton, acacia terrestrial vegetation zone; and there is indication that *Croton* sp. and cf. *Acacia* spp. also were present in the prehistoric environment of the Tutu site (Chapter 2). During 1991, a brief botanical survey of the Tutu site and its environs was conducted by the author and Ms Toni Thomas, botanist at the Extension Service of the University of the Virgin Islands. At the time, the few trees that had existed on the site (Figure 1.3) had been cut and burned, but on the southwestern fringe, several large *Melicoccus bijugatus* (genip) trees were still standing. Re-vegetated portions of the site and areas of remaining pastureland could be characterized as disturbed shrubland,;possibly former woodland. Noted were grasses and small secondary growth species, including *Mimosa pudica* (locally known as creechy-creechy); *Croton* spp. (maran); *Jatropha gossypifolia* (physick nut); *Leucaena leucocephala* (tan-tan); and patches of *Panicum maximum* (Guinea grass). Small trees included *Crescentia cujete* (calabash); *Tababuia heterophylla* (pink cedar); and *Acacia tortuosa* (cassia).

Site fauna

Animals observed on the Tutu site prior to and during the archaeological investigations were limited to *Bos* sp. (cattle); *Ameiva exul* (ground lizards); *Anolis* spp. (anoles); *Iguana iguana* (common iguanas); Colubridae (non-poisonous snakes); *Eleutherodactylus* sp. (frogs), some of which seemed to appear spontaneously in mud puddles after rainstorms; a number of birds including *Charadrius vociterus* (kildeer), *Buteo jamaicensis* (redtailed hawk), *Amazona vittata* (Puerto Rican parrot); Columbidae (pigeons); *Falco peregrinus* (peregrine falcon); and songbirds. Also observed were insects, including a variety of spiders, hornets, ants, crickets, mosquitos and butterflies. It is likely that Gecarcinidae (land crabs), and mammals such as *Herpestes auropunctatus* (mongoose), *Mus musculus* (house mouse), *Rattus norvegicus* and *Rattus rattus frugivorus* (Norway and black rat) and *Artibeus jamaicensis* (fruit bat), also were present at the site (personal communication, Amy Dempsey, Bioimpact, 1999; Lundberg, 1989: 30).

Geology and soils

In 1983, Gerahty & Miller (1993) conducted a geologic survey in the environs of the Tutu site, and, in particular, obtained information from outcrops exposed on the northeast side of the new shopping mall. In the upper basin of the Turpentine Run valley, they found thin alluvial and colluvial deposits, varying in thickness between 0 and 6.16 m. Sediments consisted of unconsolidated, unstratified poorly sorted mixtures of clay, silt, gravel, cobbles and boulders transported from the upper valley and foothills by gravity and flash floods.

Underlying the alluvium/colluvium was a moderately weathered, fractured volcanistic rock in which the original rock components had been partially replaced by clay, chlorite and oxide minerals. This rock was a grey to greenish grey volcanic andesitic tuff and breccia with a fine-grained matrix and occasional clasts ranging in diameter between 1 cm and 5 cm. Visible mineral grains in the matrix included plagioclase, epidote, pyroxene, hornblende and chlorite. It was in decomposed soils of this type that the majority of features at the Tutu site were preserved.

Underlying the finer grained tuffs and breccias were a poorly sorted breccia, slump blocks, and cobbles up to 20 cm in diameter. These deposits were compositionally similar, with the primary difference between lithologies being grain size. These rocks weathered to a very weak, foliated, clay-rich mineral, which contained almost entirely alteration minerals such as kaolinite, sericite, chlorite and calcite.

Iron staining and thin calcite veins, common along fracture lines that were observed by Gerahty & Miller (1993), also were present in exposed areas of the Tutu archaeological site. Also observed were light brown to tan, sandy to clayey silts of fractured and highly weathered saprolite. Intrusive diorite, a coarse-grained rock composed mainly of sodic plagioclase and hornblende, with variable amounts of quartz, biotite and/or pyroxene, also was found near the Tutu site. Samples obtained were a very dense, dark green to black rock matrix with visible, abundant plagioclase and pyroxene phenocysts (large and well-shaped crystals). The diorite contained abundant, thin veins of calcitic mineral throughout the rock matrix. Along with some imported materials, occupants of the Tutu site used many of the locally occurring rocks and minerals to manufacture beads, tools and other artifacts.

Soils of the Tutu site belong to the Cramer series of the Cramer Isaac Association. They have a clay loam surface layer between 18 cm and 48 cm thick and depth to bedrock is between 25 cm and 50 cm (Rivera *et al.*, 1970: 12). Soil clays from 14 samples collected at the Tutu site were analyzed by x-ray diffraction (personal communication, Warren Lynn USDA-NRCS Soil Survey Laboratory, Lincoln, Nebraska). Results indicated moderate to dominant amounts of kaolinite, small to abundant amounts of calcite and smectite, small amounts of chlorite, vermiculite and mixed layer smectite/chlorite, and a trace of quartz. Calcium carbonate was determined by chemical analysis. Values for the samples ranged between 4 percent and 69 percent, with an average of 32 percent. The source mineral is likely calcite in thin veins, mentioned previously.

LAND USE HISTORY OF THE TUTU SITE

The history of land use on the Tutu site has been gleaned from Colonial tax records, supplemented by census data and a few existing historical maps (Knight, 1997). With the exception of extremely rare plantation maps, archival records for St Thomas, in general, yield little information about the specific geographical locations of features and land uses within the boundaries of plantations and other land parcels.

The Tutu site was situated on a portion of a plantation which, since the eighteenth century, has been known as Estate Charlotte Amalie, and, until 1990, was used primarily for farming, grazing and low-density residential purposes. This plantation was first established by the settlement of a small nuclear plantation in 1676,; almost 200 years after the end of the prehistoric occupation of the Tutu site. It is unlikely that the prehistoric site was a part of the original nuclear plantation; it appears, rather, to have been situated on one of the four land parcels that was acquired and added to the nuclear plantation sometime prior to 1773 (Knight, 1997). Until some time before the nineteenth century, the population on this larger plantation, which was then 250 acres in size, probably remained clustered in individual residential areas associated with agrarian or industrial activities on the estate. After consolidation of the loosely bound plantations, a diversified, agro-industrial operation was created, with residential and industrial buildings, most likely established where the core of the original plantation had been (Knight, 1997).

H.B. Hornbeck's map of 1835–1839 (re-drafted in Figure 1.6) clearly depicts the industrial sugar works and associated buildings, residential units, and a cluster of workers' cottages to the south of the Turpentine Run tributary that bordered the west side of the Tutu site. Twelve cultivated plots, and at least three large tracts of cleared land (probable pastures), also comprised the landscape of the plantation. Of the 12 depicted cultivated areas, 8 were located at a distance from the Tutu prehistoric site, and 3 appear to lie either to the west or southeast of the site. A fourth plot, however, in the northeastern portion of the property, may have included a small portion of the Tutu site, and perhaps was the source of a remnant population of *Indigofera tinctoria* (indigo) found growing on the site during 1990. At the time of Hornbeck's map, therefore, the Tutu site had been only marginally affected by farming practices and apparently was undisturbed by residential uses.

After Emancipation, the Charlotte Amalie plantation was primarily used for animal husbandry, and, by 1917, had become a rural population center. This population, however, remained concentrated close to the industrial complex, while the majority of the estate was in large tracts of unoccupied pasture or bush. When the estate was sold off in parcels, between 1943 and 1947, the

Table 1.1 Historic artifacts recovered from surface contexts and soil overburden of the Tutu site

Material	*Area*	*Type*	*Decoration*	*Color*	*n*[a]	*Comments*
Glass	1	Bottle glass	None	Amber	1	Bottle body fragment, 6 mm thick
	1	Bottle glass	None	Amber	1	Fragment of thin glass, 2 mm thick
	1	Bottle glass	None	Olive green	1	Bottle body fragment, 6 mm thick
	4	Bottle glass	None	Olive green	1	Bottle body fragment, 3 mm thick
	4E	Crystal glass	Shaped, faceted	Clear	1	Base and attached stem fragment of a crystal goblet with pontil mark on bottom of base
	6	Bottle glass	None	Dark olive green	1	Body fragment of a modern beer bottle, 3 mm thick
	7	Bottle glass	None	Pale olive geen	1	Bottle body fragment, 4 mm thick
	12	Bottle glass	Patinated	Olive green	1	Bottle body fragment, 3.5 mm thick
	13	Bottle glass	None	Dark olive green	1	Wine bottle base section, *c.* AD 1790, 7–10 mm thick
Clay	1	Whiteware	Transfer	Blue floral	3	One rim sherd and two body sherds of a British transfer design plate, *c.* AD 1805–30
	1	Pearlware	Annular	Brown	1	British late eighteenth-century rim sherd
	1	Earthenware	None	Dark pink/ orange	1	Body fragment of an earthenware jug, 5 mm thick
	1	Kaolin clay	None	white	1	Kaolin clay pipestem fragment; borehole 2 mm in diameter
	1	Creamware	None	Yellow/white	1	Late eighteenth-century plate fragment, 4.5 mm thick; British ware
	1	Refined white earthenware	Transfer	Black	1	Plate fragment, 3.5 mm thick
	1	Pearlware	Hand-painted	Green-edged on white	1	Rim sherd, 3 mm thick, late eighteenth century
	1	Brick	Plain	Dark orange	1	Brick fragment
	3	Brick	Plain	Dark pinkish orange	2	Two fragments of one brick
	4	Whiteware	Plain	White	1	Body sherd of a plate, 4 mm thick
	4	Porcelain	Hand-painted	Blue on white	1	Body fragment, 2 mm thick

(continued on next page)

Table 1.1 (cont.)

Material	*Area*	*Type*	*Decoration*	*Color*	*n*[a]	*Comments*
Clay (continued)	5	Refined white earthenware	Hand-painted	Blue on white	1	Fragment of a plate rim, 4 mm thick
	5	Brick	Plain	Orange/salmon	1	Brick fragment, low fired
	5	Brick	Plain	Salmon	2	Brick fragments, low fired
	6	Porcelain	Plain	White	2	Basal sherds of a porcelain plate, 5–10 mm thick basal ring attached
	7	Pearlware	Hand-painted	Blue on white	1	Plate fragment, 4 mm thick
	8	Refined white earthenware	Hand-painted	Blue on white	1	Body sherd, 3 mm thick
	9N	Earthenware	Plain	Orange	1	Tile fragment, 17–20 mm thick
	9W	Pearlware	Hand-painted	Green-edged on white	1	Rim sherd of a plate, 4 mm thick
	9W	Earthenware	Plain	Salmon	1	Body fragment, 9 mm thick
	9W	Stoneware	Wheel-marked	Coral	1	Basal fragment of a nineteenth-century seltzer bottle, 8–10 mm thick
	9W	Earthenware	Plain	Pinkish orange	1	Two fragments of one tile, 11 mm thick
	9W	Earthenware	Plain	Salmon	1	Two fragments of one tile, 9 mm thick
	9S	Pearlware	Hand-painted	Blue and black	1	Basal fragment of a plate, 3–6 mm thick
Metal	1	Iron	Wire	Rusted	1	Rusted wire nail fragment
	1	Iron	Hand-wrought	Rusted	1	Rusted hand-wrought nail fragment with curled end
	1	Iron	Hand-wrought	Rusted	1	Metal sleeve of a wooden-handled gardening or farming tool
	4	Metal	None	Grey	1	Modern metal fish-hook complete
	8	Metal	None	Grey	1	Modern washer
	4	Lead	None	Grey/black	1	Buckshot, 2.5 mm in diameter
Other	4	Mortar	None	White with red	2	Mortar fragments with crushed red brick

Note
[a] n = number.

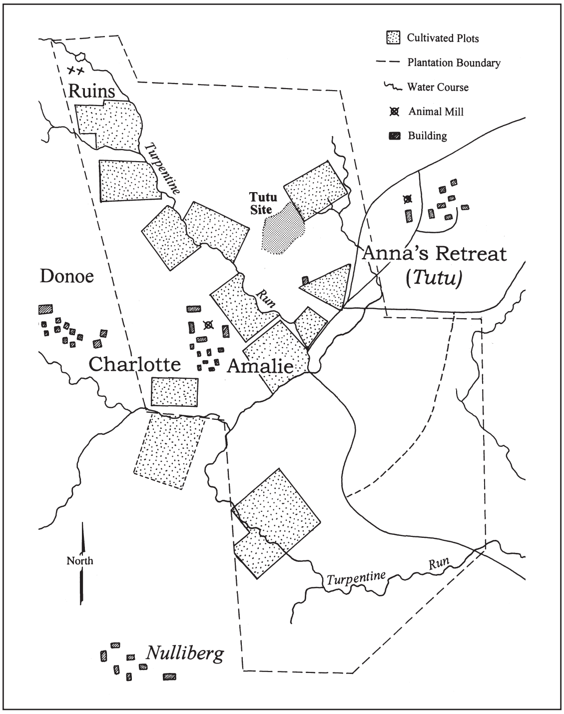


Figure 1.6 Charlotte Amalie plantation *c.* 1835–39. Map adapted from Hornbeck 1835–39 (graphic by Julie Smith).

parcel that contained the industrial core and the Tutu site continued to be run as an active livestock and dairy operation (Knight, 1997). In the late 1980s, a 27-acre parcel was leased for development of a shopping mall. A topographic survey of this site (Figure 1.5) was conducted sometime soon afterwards, and, in 1990, earth-moving activities to prepare the land for development led to discovery of the previously unrecorded and unknown Tutu prehistoric site.

Site conditions when archaeological investigations were initiated

When the Tutu site was first examined by archaeologists in 1990, there were no buildings on the site. A pasture fence extended along its northwestern border and, in the northwest central section, a small natural area that contained a well head and utility pole had been fenced off with barbed wire (Figure 1.7). A row of other utility poles stood on the east southeast boundary of the site. Remains of two modern stakes were discovered during the archaeological excavations, but there was no evidence of any other fences or historic structures on the site. All historic artifacts (Table 1.1) were recovered from surface contexts or soil overburden.

Except for a remnant population of *Indigofera tinctoria* on the site, there was no indication of cultivation or plowing. Prior to discovery of the site, uprooted tree stumps either had been hauled to the center of the site for burning, or burned in place. Heavy machinery maintenance had taken place in the area where archaeological Trenches 3 and 4 were later excavated (personal communication, Lionel Berry, heavy equipment operator). A small population of cows grazed the land throughout the archaeological data recovery. It seems clear, therefore, that, until topsoil was mechanically stripped from the land in preparation for shopping mall development, Colonial and post-Colonial land use had been limited to pasturage and possibly to indigo cultivation.

When the Tutu site was discovered, most of the site's topsoil was stockpiled in two large mounds, Soil Mound No. 4 on the western central edge of the site, and Soil Mound No. 6 on the northeastern edge. Soil Mound No. 4, which was about 7 m high, 55 m long and between 10 m and 20 m wide (Figure 1.7), could not be removed during the course of the archaeological investigations. The machine-scraped ground surface to the west of the mound had been densely re-vegetated, masking the effects of mechanical scraping. Later subsurface testing revealed that the mechanical equipment had moved in a generally east to northeasterly, or uphill, direction, leaving some deep midden deposits in place. Soil Mound No. 6, approximately 5 m in height, 50 m long and 30 m wide, covered a strategic portion of the northeastern section of the site, and also could not be removed. Under the eastern edge of Soil Mound No. 6, the terrain sloped to the east and southeast; and, on the slope, a thin layer of topsoil had been pushed from downslope uphill into the mound, exposing midden deposits.

Mechanical stripping had begun about 10 m south of the northern boundary of the archaeological site, leaving topsoil in place to the north and stripping it away to the south. Underlying clay loams and midden deposits were exposed in the northwestern portion of the site (Figure 1.7a: Areas 1, 8, 9N) and on the northeastern slope (Area 4). In the north northeastern section of the site (Areas 2, 3, 12), traffic by heavy equipment had exposed a white "marl" subsoil in some areas and had left loose surficial powdery mixed deposits of topsoil and decomposed andesite in others. No cultural material was visible on the exposed ground surface or in soil furrows of these areas. The grey color of overlying loose surficial soils in portions of Areas 4N, 6 and 12 was attributed to tree and brush burning (personal communication, Lionel Berry, heavy equipment operator). In the southeastern portion of the site, bedrock was exposed.

The center of the site, east and northeast of Soil Mound No. 4 (Areas 5 and 6), was the lowest point of the site. The ground surface here had been repeatedly scraped; and, after a heavy rain, ponded water was present for a few days. Several small soil mounds, situated in various locations about the site, were manually removed during the archaeological investigation, while the well head and fenced area around it remained undisturbed.

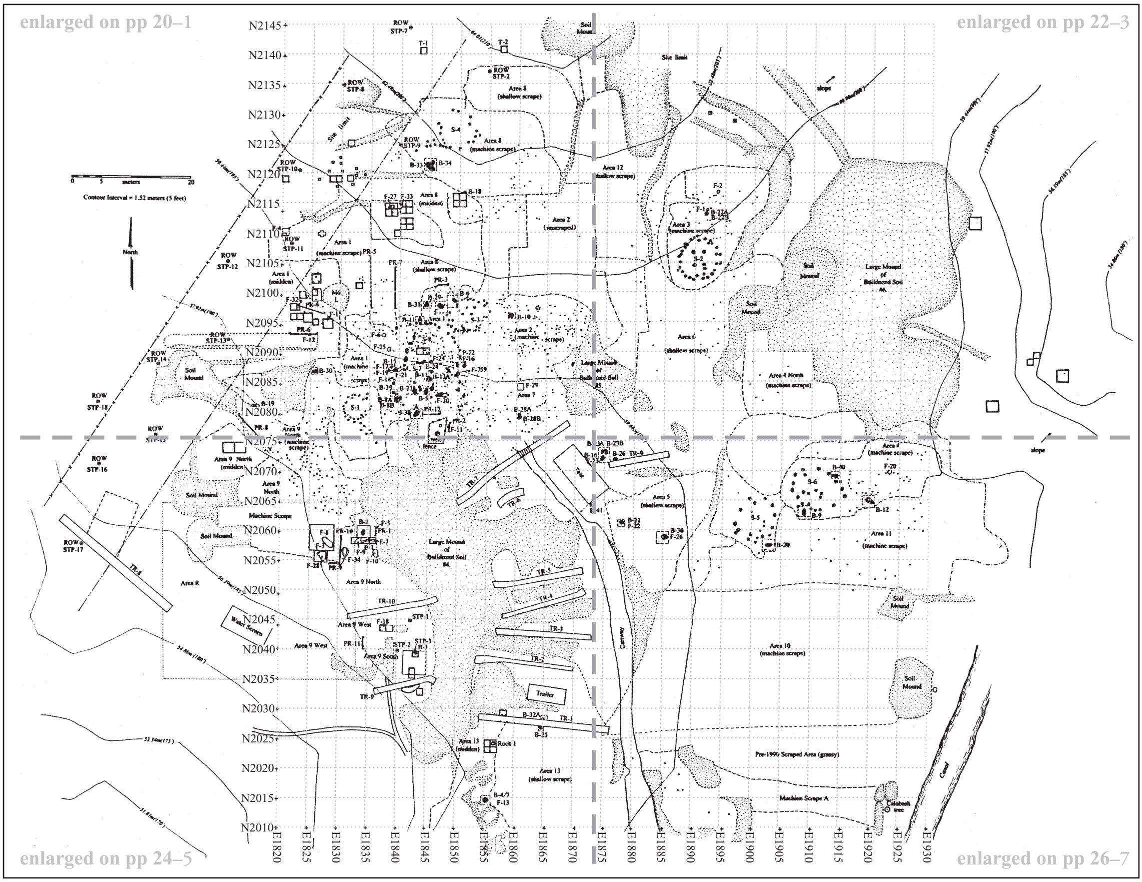


Figure 1.7 Overview (reduced scale) of detailed map of the Tutu site, November 1991 (recorded by Elizabeth Righter and Travis Gray). This map, in sections, is repeated at a larger scale in Figures 1.7a–d.

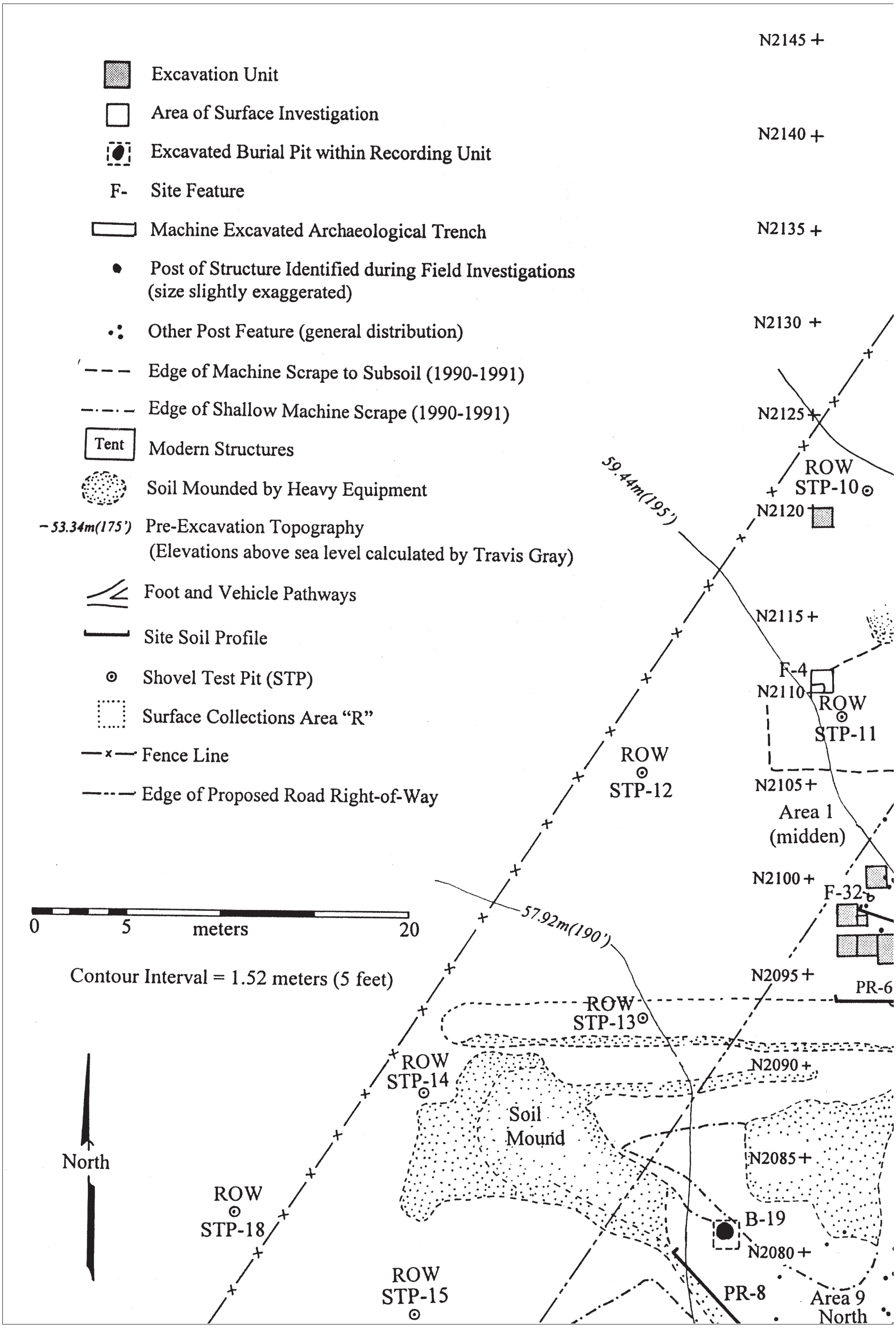
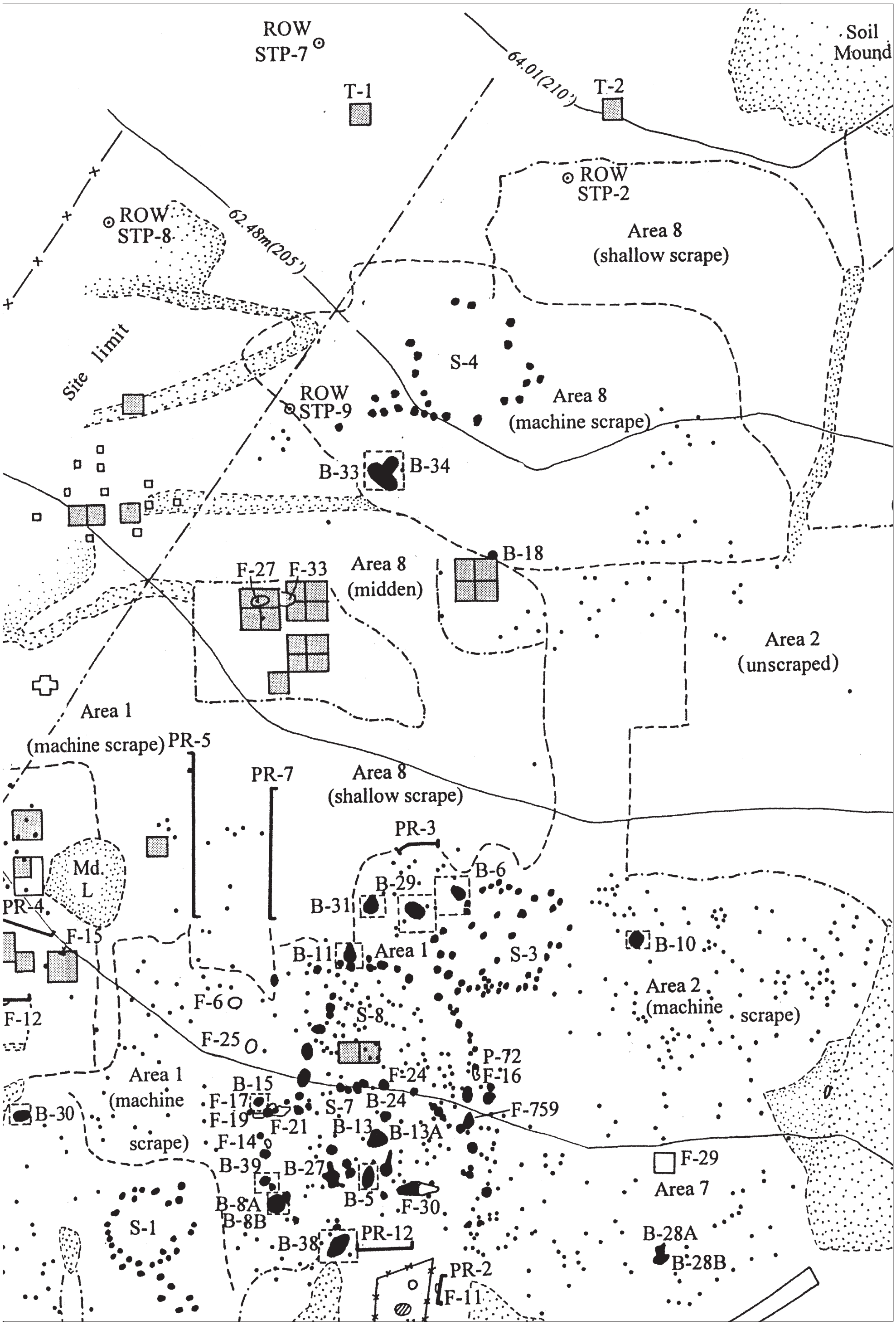


Figure 1.7a Site map (northwest quadrant).


ROW
STP-7
Soil
Mound
64.01(210')
T-1
T-2
ROW
STP-2
ROW
STP-8
62.48m(205')
Area 8
(shallow scrape)
Site limit
S-4
Area 8
(machine scrape)
ROW
STP-9
B-33
B-34
B-18
F-27
F-33
Area 8
(midden)
Area 2
(unscraped)
Area 1
(machine scrape)
PR-5
PR-7
Area 8
(shallow scrape)
PR-3
Md.
L
B-6
B-29
B-31
PR-4
F-15
B-11
Area 1
S-3
B-10
Area 2
(machine scrape)
F-12
F-6
S-8
F-25
P-72
F-16
Area 1
(machine scrape)
B-15
F-24
F-17
F-19
F-21
S-7
B-24
F-759
B-30
F-14
B-13
B-13A
B-39
B-27
F-29
Area 7
B-8A
B-8B
B-5
F-30
S-1
B-38
PR-12
B-28A
B-28B
PR-2
F-11

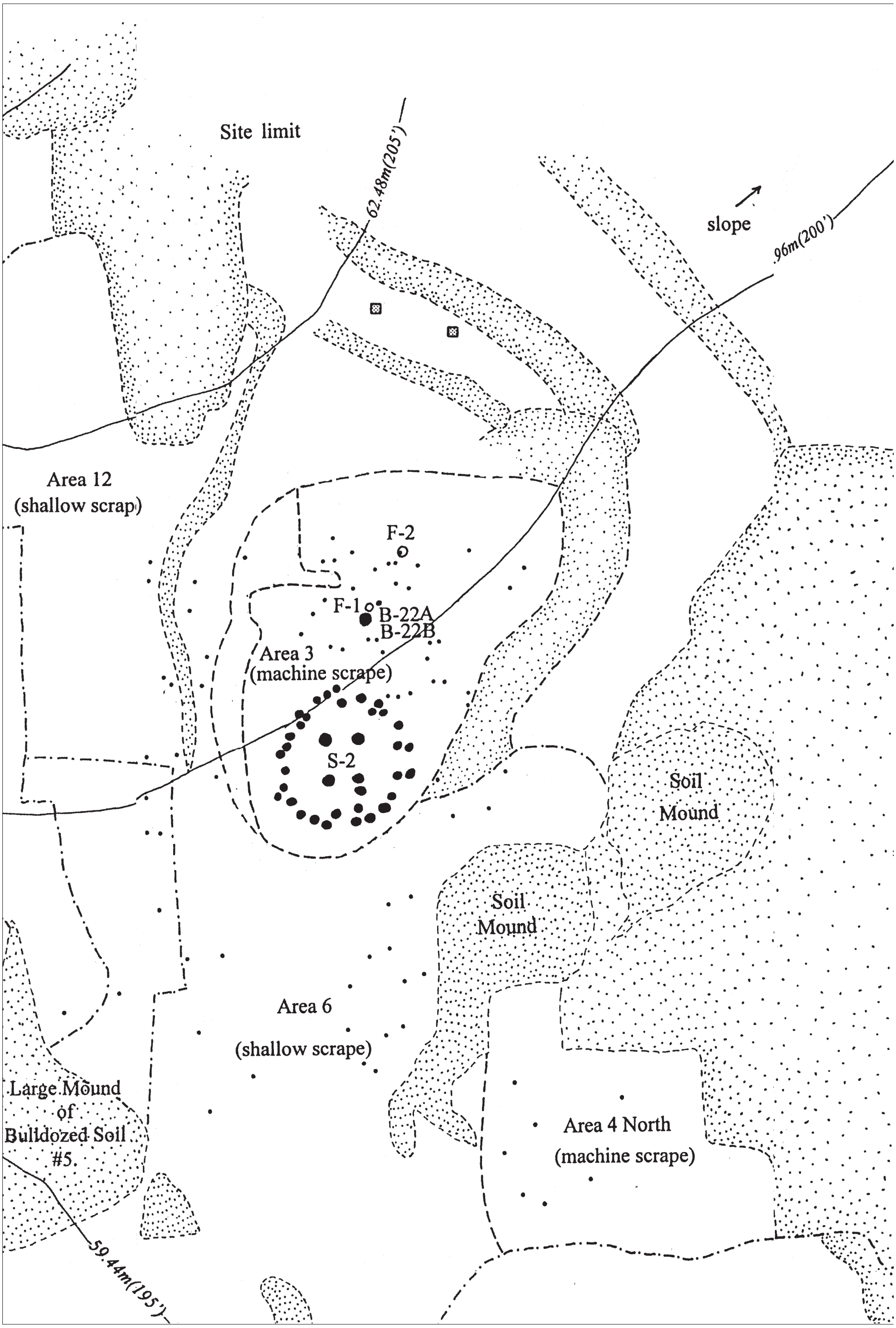
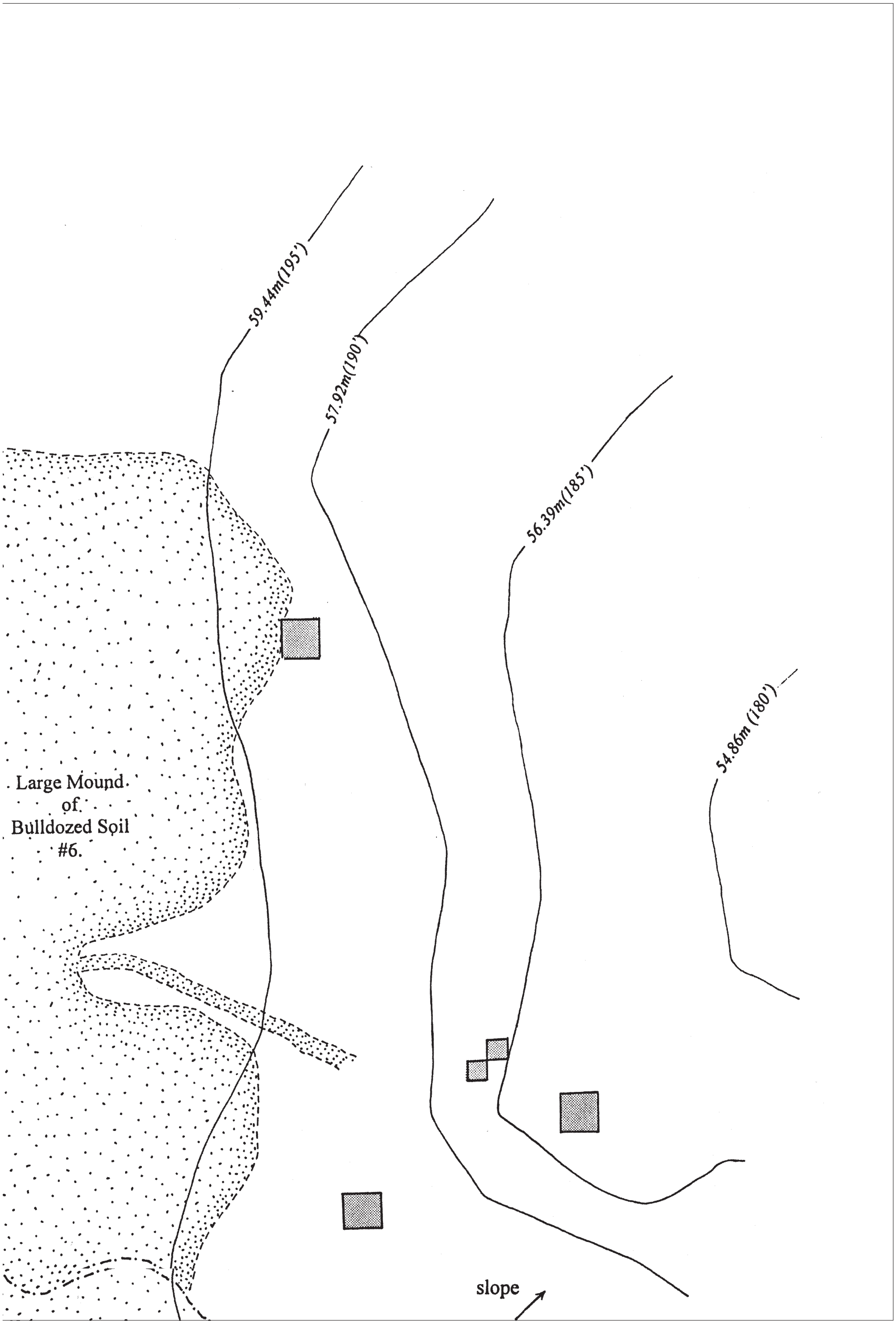


Figure 1.7b Site map (northeast quadrant).


59.44m(195')
57.92m(190')
56.39m(185')
54.86m (180')
Large Mound of Bulldozed Soil #6.
slope

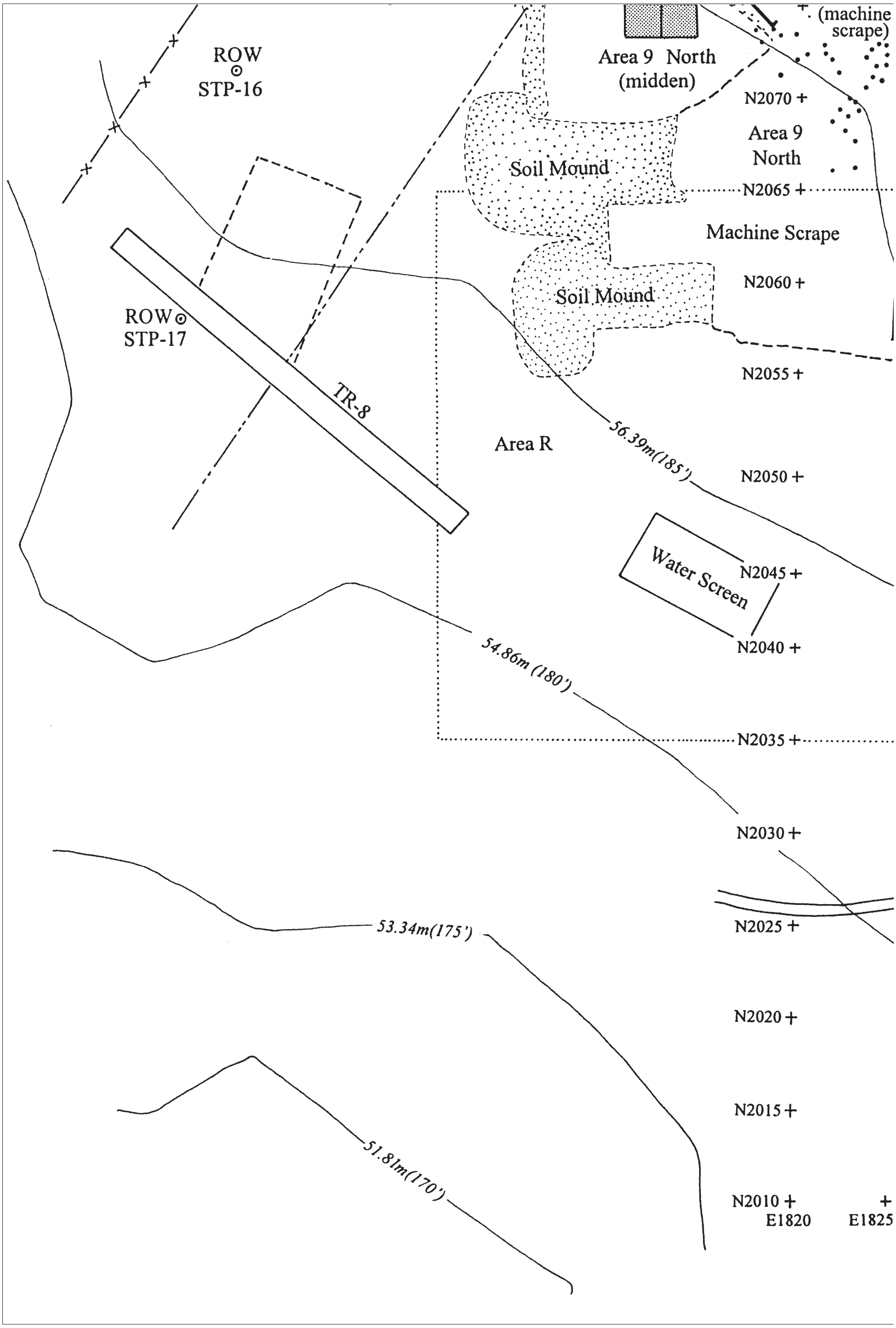
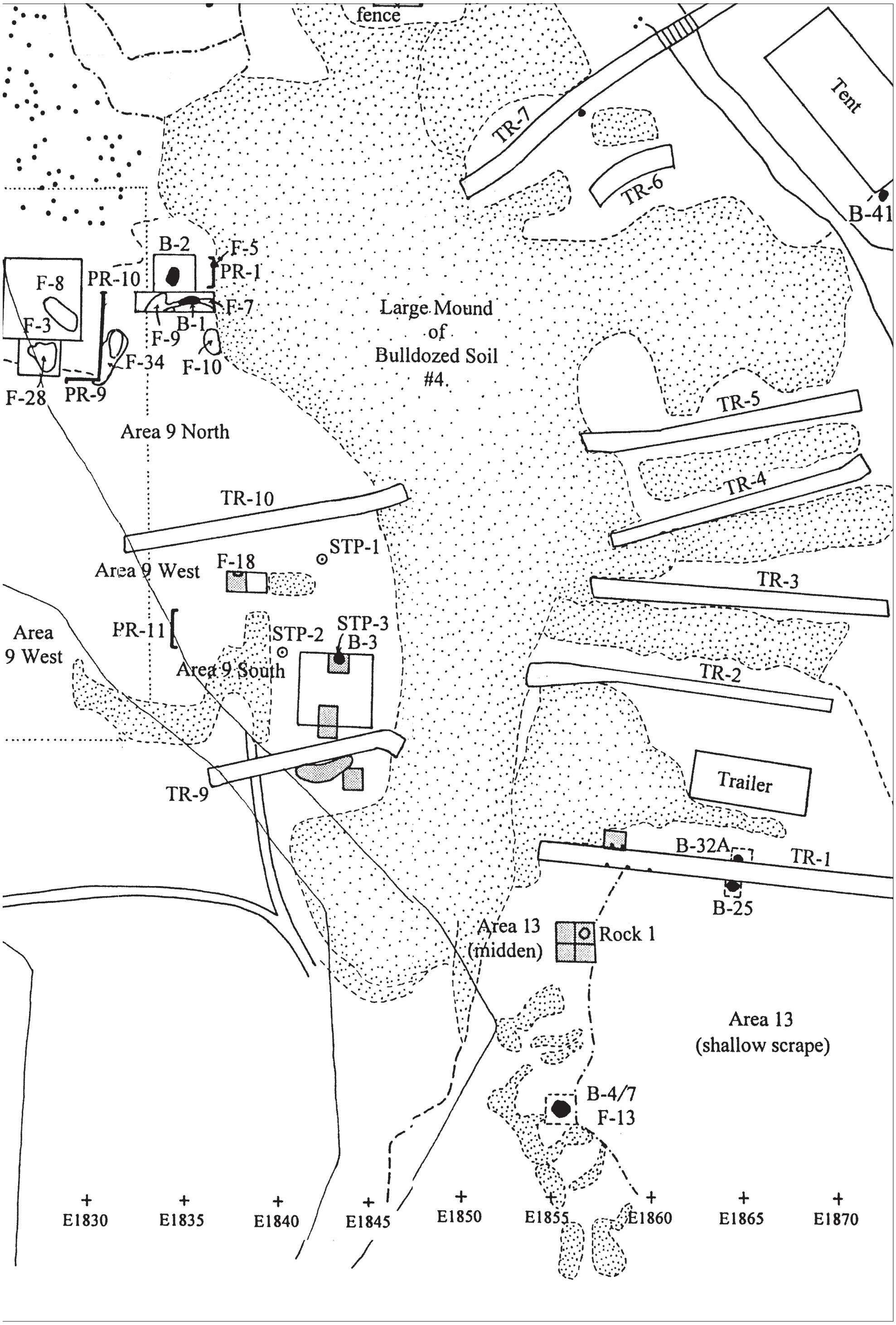


Figure 1.7c Site map (southwest quadrant).


fence
Tent
TR-7
TR-6
B-41
B-2
F-5
PR-1
PR-10
F-8
F-7
F-3
B-1
F-9
F-10
F-34
F-28
PR-9
Large Mound of Bulldozed Soil #4.
TR-5
TR-4
Area 9 North
TR-10
TR-3
STP-1
F-18
Area 9 West
Area 9 West
PR-11
STP-2
STP-3
B-3
Area 9 South
TR-2
Trailer
TR-9
B-32A
TR-1
B-25
Area 13 (midden)
Rock 1
Area 13 (shallow scrape)
B-4/7
F-13
E1830
E1835
E1840
E1845
E1850
E1855
E1860
E1865
E1870

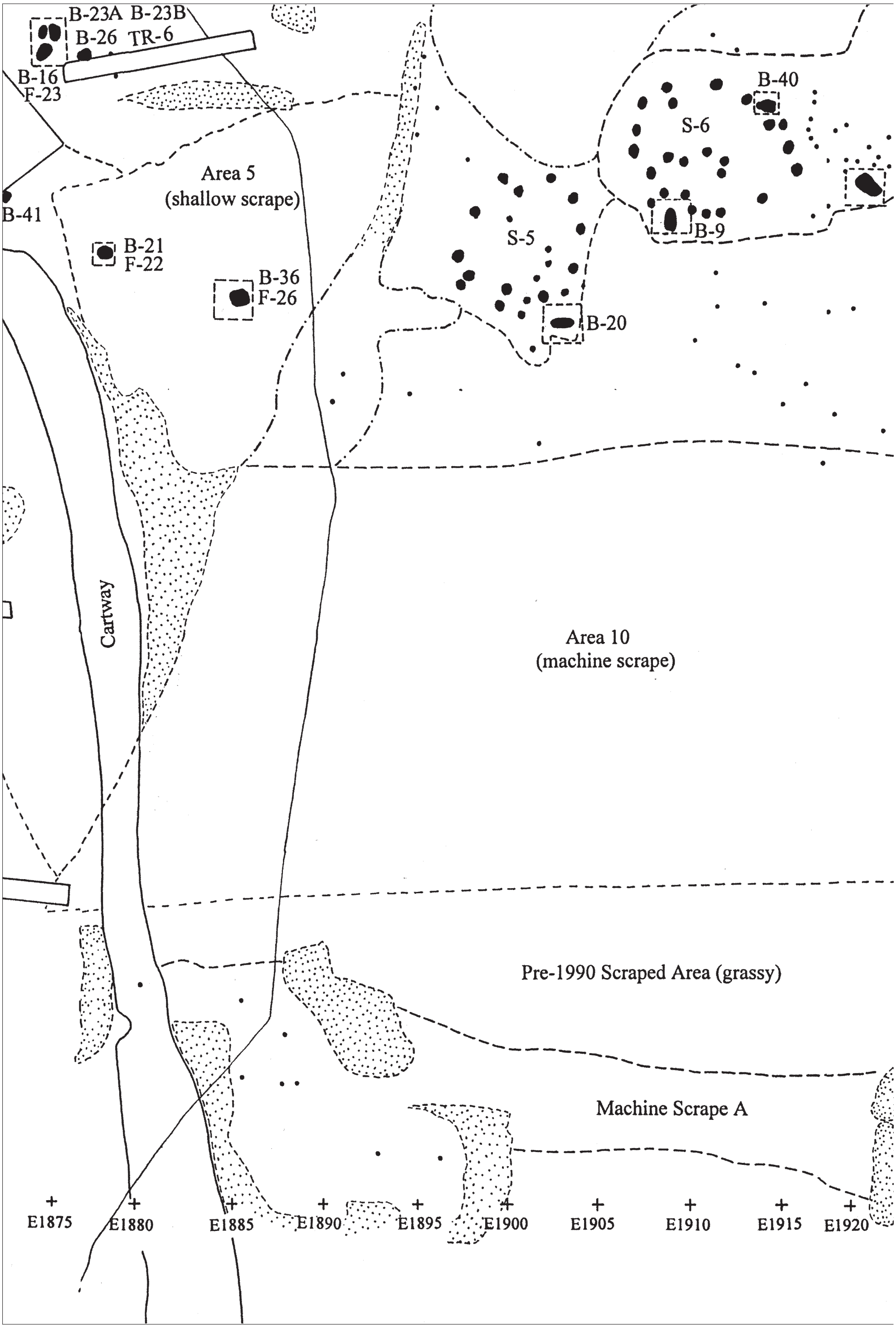
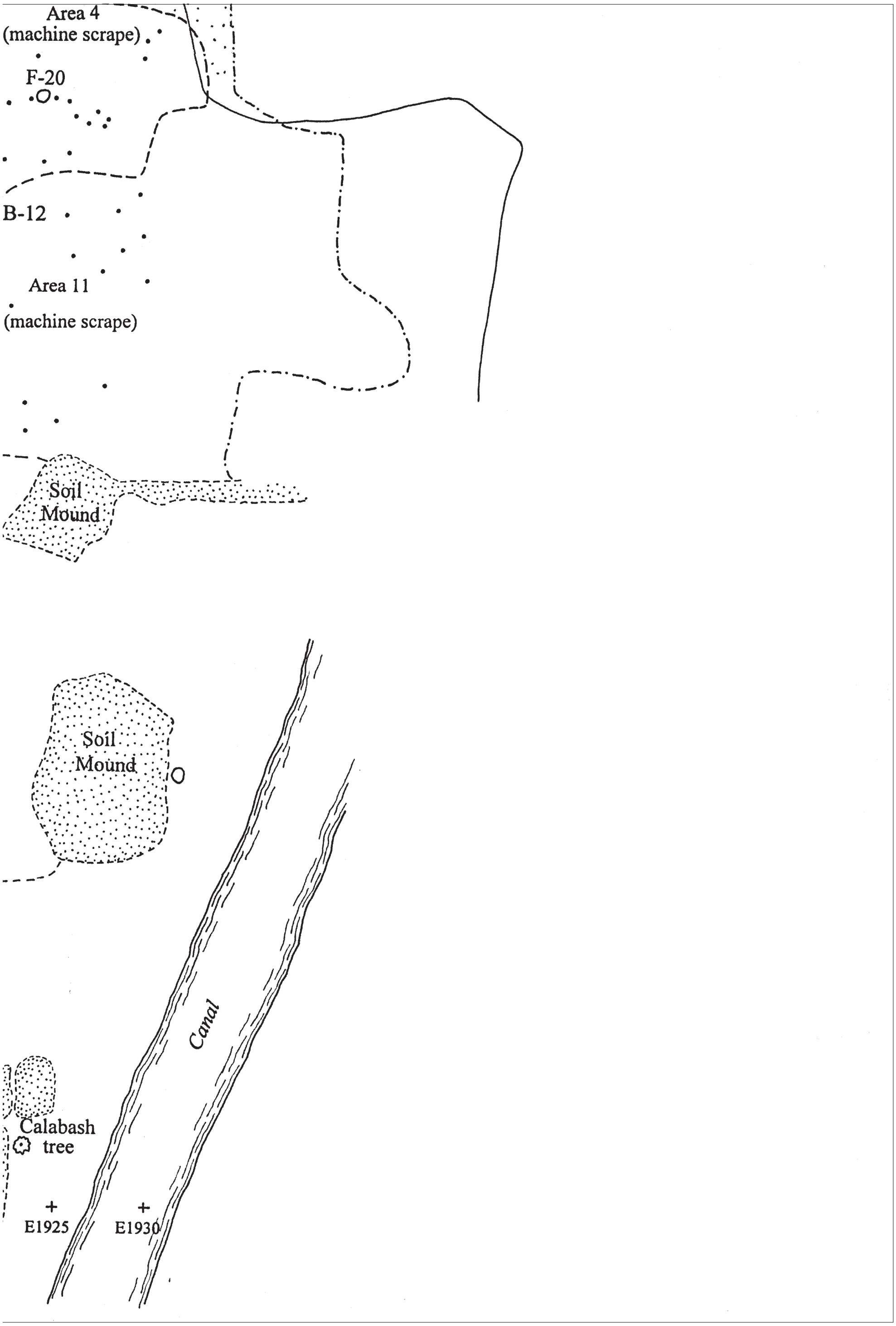


Figure 1.7d Site map (southeast quadrant).


Area 4
(machine scrape)
F-20
B-12
Area 11
(machine scrape)
Soil Mound
Soil Mound
Canal
Calabash tree
E1925
E1930

RESEARCH RATIONALE

Research rationale for the project was based upon a desire to expand the existing prehistoric archaeological data base for the Virgin Islands by investigating a large cross-section of a single site. Emphasis was on investigating those areas of the site where cultural material was sparse on the ground surface, but prehistoric structures and other features were undoubtedly present. Until the Tutu project, site investigation in the Virgin Islands had been limited, largely, to excavation of small units or trenches in midden deposits, with the goal of recovering ceramic sherds and other artifacts in order to refine the existing cultural chronology: the so-called "telephone booth" approach (Rouse, 1992: 75). Several major coastal sites had been subjected to repeated investigation by a variety of different researchers, yet house types, habitation areas and site layout had not been identified. The nature and full extent of these sites remain virtually unknown. Radiocarbon dates for the Virgin Islands are few (Lundberg, Righter & Caesar, 1992),; and, in the majority of cases, even dates assigned to Virgin Islands ceramic styles in the current cultural chronology (Introduction: Figures 1 and 2) are not supported by radiocarbon dates.

In the past, a shortage of funds had precluded undertaking large projects, and, until initiation of the Tutu project, the interest of the general community and its willingness to provide generous support were not realized. In general, in the US Virgin Islands, environmental protection laws, enacted during the past few decades, have limited large scale investigations to "impact areas" in which sites are identified on the basis of presence or absence of subsurface cultural material. Non-midden areas have been given little attention.

In its openness and distance from coastal areas, the Tutu site offered a unique opportunity to expose large contiguous areas of a site and discover the layout of an entire settlement (Righter, 1991a, 1991b; Righter & Lundberg, 1991). The St Thomas community was ready to provide manpower and funding. After fieldwork began, discovery of intact midden from both the early and late site occupations increased the possibilities for documenting continuity and change in a wide range of cultural and social behaviors. Deadline extensions allowed expansion of the project's goals to include an interdisciplinary approach to materials analysis. This approach also previously had not been applied to a Ceramic Age site in the Virgin Islands. The rationale behind the Tutu project, therefore, was recognition that the special conditions of the Tutu site provided an unprecedented opportunity to conduct an innovative project which would be multidisciplinary in nature, expansive in scope, and unrestricted by past theoretical models. A second motive was the opportunity to document an outstanding and unprotected prehistoric site before it was destroyed by mall development.

Among research goals of the Tutu project were the following:

1 Reconstruction of the paleoenvironment to

   i identify the physical setting and subsistence base of the site's inhabitants;
   ii document human adaptation to the natural environment of the site and its environs;
   iii investigate man's exploitation and utilization of available resources;
   iv relate these activities to human diet and health; and
   v investigate the relationship between control over natural resources and sociopolitical change (Chapters 2–4, 7–11).

2 Identification of economic, social and ceremonial behavior reflected in artifacts crafted and utilized by the site's inhabitants. Reconstruction of manufacturing techniques and patterns of exchange, trade and resource procurement (Chapters 1, 5, 11 and 13).

3 Refinement of the current the ceramic typology and cultural chronology for the Virgin Islands (Chapters 5 and 6).

4 Exposure and investigation of post holes to identify structures and document their sizes, shapes and distribution on the site, the first such information for the Virgin Islands. Interpretation of changing settlement and burial patterns in terms of sociopolitical change (Chapters 1, 12 and 13).

5 Use of state-of-the-art analytical techniques in a number of disciplines to analyze carefully collected samples from the Tutu site. Application of the results to documentation of the interplay between physical environment, economic needs, social and cultural behavior and cosmic beliefs of the site's inhabitants (Chapters 2–13).

RESEARCH DESIGN

Roosevelt (1989b: 413; 1991) aptly stresses the advantages of site assessment by means of nondestructive remote sensing techniques. In the case of the Tutu site, however, fund raising was necessary, and, before this could take place, the public demanded that the prehistoric nature of features and artifacts be verified by radiocarbon dating. Considering this, as well as the impending destruction of the entire site and its previously scraped condition, the approach taken was the most effective alternative.

Fluctuating available labor and the constant threat of construction start-up affected the research design and its priorities throughout the project, preventing development of a long-term research design, application for research grants or establishment of a field school at the site. While the overall goal of the project was far-reaching, short-term objectives had to be planned in three-month increments. The initial research objective called for recovery of a maximum amount of settlement pattern information in the shortest amount of time, in the most expedient manner possible. After discovery of midden deposits, and with deadline extensions, the research design was revised to include a combination of hand-excavated data recovery of intact deposits and features, and mechanical re-stripping of areas where previous scraping had exposed subsoil and bedrock. Research findings in progress would be mapped with a computer-based mapping program (Autocad Release 9/10). Experts in a wide range of related disciplines would be contacted to obtain their advice about sample recovery and to learn of their willingness to work with the project.

The approach ultimately taken was to proceed in a cautious and scientific manner, as if there were no restrictions on time. This proved to be a wise decision, since, eventually, the research was permitted to extend for a little more than a year; and, although it was sometimes necessary to make tough decisions and to sacrifice one type of information for another, all in situ deposits were sampled; and, in scraped areas, a large percentage of identified features wase carefully manually excavated. The majority of project goals was realized. To complete the requirements for responsible archaeology, results of the field research and materials analyses are reported in this published volume.

FIELD METHODOLOGY

Approach to fieldwork

At the outset of the project, all volunteers were provided with instruction sheets describing methodology designed for the site. Volunteers who were not archaeologists spent one full day training with a professional archaeologist or with a volunteer who had successfully completed training. These volunteers then worked at the water screens or excavated post holes. Data recovery of midden deposits, burials and other features, sample collection and flotation were conducted only by professional archaeologists, graduate students under supervision of trained archaeologists, and by Joyce Craig and Joshua Kehrburg, trained volunteers with exceptional excavation skills.

Pedestrian archaeological survey and shovel testing

Initially, in order to define the limits of surficial evidence of the site and record site conditions, a pedestrian archaeological survey was conducted of the entire mall property (10.80 hectares). Shovel tests were executed in a proposed access road right-of-way (approximately 8 m wide) on the northwest side of the site, where construction was scheduled to take place immediately. Ceramic sherds were found in Shovel Tests Pits (STP) 9, 11, 12, 14 and 16 (Figure 1.7a) on the northwest edge of the site; but shovel tests on neighboring parcels failed to produce convincing evidence that the site extended north of the mall property.

Discontinuous midden deposits exposed on flat or slightly elevated terrain in the northern and northwestern sections of the site were mapped. Buried deposits southwest of Soil Mound No. 4 were located by shovel testing. Site topography and elevations recorded before machine scraping indicate that midden deposits on the site originally probably were thicker; and, in Area 9W, they most likely had been mounded above grade to the east. The remainder of the site, most of which had been previously scraped to the base of Horizon B soils, or to bedrock, was surficially surveyed to search for other exposed midden areas and to define site boundaries to the east, southeast and south. Overall, it was concluded that the nucleus of the settlement was confined to the mall property.

Several local citizens stated that they remembered a rock alignment in the vicinity of the site, but they were unable to remember its exact location. Throughout the project, searches for this alignment were conducted on the mall property and on adjacent properties. A rock which closely resembled an upright from the ball and dance court at Salt River, St Croix (Hatt, 1924, and personal observation of uprights at the Danish National Museum in Copenhagen) and several errant large rocks were identified, but these were not in situ, and a rock alignment was not found. A number of physiographic areas that might have been suitable ball court locations also were noted, but, in most cases where these occurred, ground surface and terrain had been so extensively altered that a proper assessment could not be made.

Establishing a grid

Professional surveyors, Travis Gray and Humphrey Ongondo, volunteered to use computer-based mapping equipment to lay a grid over the site, and to provide ongoing Autocad mapping as the investigations progressed. Site elevation was established and a 5 m grid was plotted, from which smaller units were manually subdivided with tapes, transit and plumb-bob, as needed.

Systematic surface collection

Following surficial examination of the shopping mall property, a systematic surface collection, in 5 m units, was conducted in areas where cultural material was exposed on the surface. Machine scraping of the site had transported some artifacts a distance from where they were originally exposed, obscuring their relationship to collection units. Nevertheless, the general distribution of midden scatters was clear. Diagnostic artifacts were piece-plotted and surficial features of each 5 m unit were mapped. Mapped soil furrows, tracks left by heavy equipment, and their direction of movement in each unit proved to be valuable interpretive tools. All collected artifacts and ecofacts were retained and preserved.

Water screening and flotation

A water system, attached to an electrically-pumped well, was installed, and large water screens were set up permanently on the site. Comparison of recovery rates from dry-picked and water-screened soils revealed that water screening resulted in a far greater recovery rate in a shorter period of time. The application of a gentle water spray to excavated bulk soils was far less damaging to cultural materials than was manual breaking of adhering clay pods during dry sifting.

Minute particles of carbonized plant remains, including carbonized seeds, were recovered by flotation. The flotation device used at the Tutu site was a modified SMAP-style flotation machine (Pearsall, 1989a), designed by Deborah Pearsall and built on the site by Emily Lundberg and Bert Bryson. This piece of equipment, attached to a constant water supply, was remarkable in its ability to process soils quickly and efficiently with minimal damage to fragile remains. A poppy seed test conducted before flotation of the 308 samples from the site indicated that, in general, the recovery rate was excellent (for a description of the poppy seed test, and discussion of dry screening versus flotation in clayey soils, see Chapter 2). Heavy fraction from each flotation sample was collected, dried and stored for later sifting by size in the lab. These samples included material caught in 0.159 cm (1⁄16 in.) mesh screen and even smaller residue.

Excavation of units and tests

In areas of the site set aside for manual excavation, pollen and faunal sample collection methodologies were advised by Dr Francis Heuber, Botanist at the Smithsonian Institute in Washington, DC, and Dr Elizabeth Wing, Curator at the University of Florida Museum of Natural History, zooarchaeologist for the project. Dr Wing advised that at least 15 l of soil per excavation level per unit be screened through 0.159 cm mesh screen. Tiny fauna recovered from these samples, and from flotation heavy fractions, insured that the Tutu faunal samples were truly representative of the full spectrum of edible and other fauna in middens and features of the site. An added advantage was recovery of tiny discoidal shell beads that otherwise might have been lost. Dr Wing indicated that, for her analyses, stratified midden deposits provided the most secure proveniences; and, in view of limited funds, only material recovered from these contexts, with excellent integrity, was sent to Dr Wing for analysis. Other faunal material from less reliable contexts of the site was quantified by weight and volume, tabulated by Jeremy Lazelle and preserved at the DAHP.

Excavation of each unit, predominantly supervised by Dr Emily Lundberg and the author, and, in one or two cases, by other professional archaeologists, proceeded extremely carefully. Soils were removed with hand trowels, and every effort was made to excavate according to natural stratigraphic levels. In some cases, individual disposal episodes were separately excavated. In midden areas, using a hand-held trowel, each excavator began at one side of an excavation unit and moved slowly across it to the other side, peeling back soils in thin uniform layers. This was done so carefully that almost all materials that required special handling, such as diagnostic artifacts and intact carbonized plant remains, were immediately observed as they were uncovered. These were mapped in place, by horizontal location and elevation, removed from the soil, and placed, with appropriate packing, in labeled plastic bags.

Carbon samples were removed with cleaned trowels, and wrapped in labeled aluminum foil pouches that were sealed in labeled plastic bags. Some samples were later divided and submitted for both radiocarbon dating and wood or plant identification. With trowels cleaned in denatured alcohol, soil samples to be analyzed for phytolith and pollen samples (ultimately no pollen was found to be preserved at the site) were collected from freshly exposed surfaces under ceramic vessels and other objects. Locations of collected samples were recorded and mapped. In order to retain the relationships that they had had in the soil, artifact clusters and pedestaled objects were left in place for photography and recording and later separately removed and bagged. Large non-human bones were removed by hand from excavation units and kept dry. Human burials were treated differently, as explained in Chapter 7. Decorated and fragile sherds were collected and individually wrapped, and items of especial interpretive value were plotted and photographed in place as they were excavated. Bulk soils were measured by volume before water screening.

All excavated soils were screened through 0.635 cm (1⁄4 in.) and 0.317 cm (1⁄8 in.) mesh screen and at least 15 l of excavated soil from each level were also screened through 0.159 cm (1⁄16 in.)

mesh screen. Between 15 l and 40 l of soil were collected from each level for flotation; and, in very culturally rich levels, additional flotation samples were collected. An excavation form was completed for each level and for each soil zone within a level. Separate feature forms were completed for features identified in excavation units. When excavation of a unit was completed, all four walls of the unit were profiled and photographed. Test units were excavated by the same methods.

According to a methodology advised by Dr Lundberg, each excavated level was assigned an alphabetical letter, while strata were assigned roman numerals. In the majority of cases, excavated levels and strata coincided. (In the few cases where strata and excavation levels did not match, samples recovered from these contexts were not analyzed.) Soil zones within a level were assigned roman numerals. In a few cases, thick stratigraphic levels were vertically subdivided arbitrarily in order to detect minor changes in artifact types or frequencies. A sublevel was assigned an arabic number subset to the excavation level letter. Because some archaeologists had been trained at other sites, there were some minor deviations from the prescribed strata labeling and feature numbering, but these were easily incorporated into the Tutu site system.

Interim datum points were established, usually at ground level along the sides of excavation units. Elevations of interim datum points were recorded with the Autocad system and referenced to the elevation of site datum which had been established when the grid was laid out.

Archaeological machine scraping and excavation of post holes

The rationale behind machine scraping, methodologies employed in excavation of exposed stains, and findings of these investigations, are described in Chapter 12.

Research areas

During field research, to facilitate reference, the site was divided spatially into research "Areas" numbered 1–13 (Figures 1.7a–d). These areas were defined by a combination of spoil pile locations, soil types, topography, amount of exposed cultural material and types of research approaches.

Excavation of burials and other features (methods)

Features

Site features and anomalies identified in excavation units were sequentially numbered with an "F" designation (Figures 1.7a–d). Site features outside of excavation units were excavated according to the methodology described for burials (this chapter and Chapter 7).

Human burials

Time constraints, fluctuation in available qualified excavators and other logistical problems made excavation of human burials the most challenging and controversial aspect of the fieldwork. Of the 42 skeletons identified at the site, 16 were recovered between October 1990 and June 1991 by volunteer professional archaeologists, including Doug Ubelaker from the Smithsonian Institution in Washington, DC. Of the remaining skeletons, Burial 41 was surface collected, but not excavated, and 25 were excavated by a team of professional physical anthropologists, archaeologists and graduate students recruited by David Anderson of the National Park Service. This group, supervised in the field by Dr Mary K. Sandford, came to St Thomas expressly for the excavation of human burials, which was completed within 10 successive working days. This approach was by far the most effective method of recovering human skeletal remains at the Tutu site.

In some cases, tops of burial pits had been previously disturbed by heavy equipment, and some skeletal or cultural material was exposed, but in most cases the majority of the burial pit was intact. Before excavation, the burial pit was included in a subdivision of the grid and its elevation and location were recorded. Because it was important to record information about the burial pit itself, skeletons were not pedestaled, and burial pits were treated in the same manner as other site features. A burial pit was first drawn in plan, and Munsell colors of the pit and surrounding soils, along with any surficial anomalies, were noted. The surface of a pit was then bisected in a north-south direction, and one half of the feature was opened until the first signs of human skeletal material appeared.

All portions of the skeleton, except the area of the body being immediately investigated, were kept covered during excavation. Beverage distributors in St Thomas contributed large umbrellas that were set up over burial pits as they were being excavated (Figures 1.8a, 1.8b). Every attempt was made to complete an excavation within three days, and incomplete excavations left overnight were covered with a soft material, plastic sheeting and thick plywood boards to protect them from the elements and from cows and other animals that might be wandering at night.

As a skeleton was exposed, it was drawn to scale in plan and elevations of bones and surrounding soil matrices were recorded. Sometimes, especially in the case of a double or complex burial, skeletal remains were drawn in profile as they were exposed. Other times, a skeleton was fully exposed before it was profiled. Photographs and elevations were taken throughout the excavation. Ceramic vessels, sherds, other artifacts and significant faunal items in a burial pit were recorded in place, and their relationship to the human remains was carefully documented in measured drawings and photographs. Relevant details of each skeleton and burial pit were recorded on burial forms that were completed in the field. After full recording, the remains were removed and carefully packed. In a few cases, complete skulls were removed intact. Burial 15, a bowl containing remains of a newly born or stillborn infant, was removed in its entirety with the skeleton still buried in the original soil matrix inside the bowl (Figure 1.9).

Figure 1.8a Overview of burial excavations at the Tutu site. Clark Larson in right foreground (photograph by David Anderson).

Figure 1.8b Excavation of Burial 6 by Mike Nessany and partner (photograph by David Anderson).

Several types of soil samples were collected from strategic locations in each burial pit. In some cases, all burial soils were removed and bagged for future analysis. In other cases, remaining burial soils were dry screened through 0.635 cm and 0.317 cm mesh screen. Burial pits were profiled in cross-section when recovery was complete; and any digging stick marks identified on burial pit walls were recorded.

Excluding human bone and artifacts associated with skeletons, material recovered from burial pit soil is listed in Table 1.2. Ceramic artifacts that accompanied skeletal remains are more fully discussed in Chapters 5 and 6.

Excavation of Trenches 1–10

In order to expose long profiles, and examine a portion of the site where midden and features appeared to be absent, Trenches 1–7 were opened on the east side of Soil Mound No. 4. To attempt an evaluation of topography under the mound, trenches were excavated as far possible into the east side of the mound.

Trenches 9 and 10 were opened to assess the area southwest of Soil Mound No. 4. Stratigraphy recorded in these trenches revealed the need to open additional excavation units adjacent to the trenches.

North and south wall soil profiles of Trenches 1–10 were manually drawn; and trench locations, grade elevations adjacent to trenches, and elevations of observed trench strata were recorded in Autocad.

Site profiles

Machine scraping had resulted in exposure of other long soil profiles (Figures 1.7a–d). The cleaned site profiles were utilized primarily in planning phases of field research at the site.

Site mapping

Investigation units, features, site profiles and surface conditions of the site were mapped manually with a transit and measuring tapes, and in Autocad Release 9/10. This recorded information is compiled and depicted in Figures 1.7a–d. Structures 3, 7 and 8, and some other types of information, were transferred to the site map from other data bases. On the site map, structure post holes and burial pits are slightly exaggerated in order to attract the eye of the reader to important features of the site. Twelve large-scale maps of scraped areas also were produced in Autocad Release 9/10 by Travis Gray. Information from these maps is included in Figures 12.2–12.7 (see Chapter 12).

Because surveyors were donating their time, Autocad mapping was conducted periodically and maps were updated as research progressed. Every time that a construction deadline approached, the entire site was re-mapped. Just as, in the prehistoric past the configuration of the site was fluid over time, so did its aspect change during investigation. Differences between maps and figures of this volume, therefore, relate to the amount of investigation, and the features and other information that had been uncovered, at the time of recording.

Laboratory procedures

Laboratory operations were supervised by Monique Purguy who listed and tracked each bag as it progressed through the lab. Volunteers first sorted faunal material to be sent to Dr Elizabeth Wing. During sorting, artifacts of shell, coral and bone, such as tools, ornaments, adornments and unusual items that could not be readily identified, were extracted and individually catalogued and photographed in the lab. After initial sorting, bags were set aside for later sorting of other types of material.

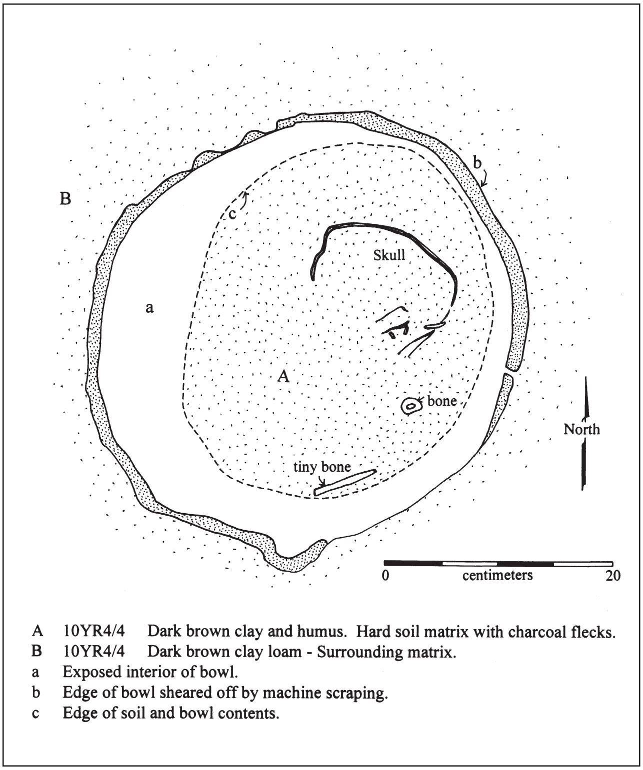


Figure 1.9 Plan view of Burial 15, a subadult buried in a bowl, Area 1 (graphic by Julie Smith from a field drawing by Elizabeth Righter).

It was noticed that many of the Tutu ceramic sherds were coated with "insoluble salts" (calcium carbonate) which needed to be removed in order to expose any decoration beneath and catalogue the sherds. When a certain type of red-painted sherd was placed in water, the red color seemed to float out into the water and dissipate. Noting Roosevelt's (1991: 349) observations that, at the Marajoara site in Brazil, "we were able to find traces of water-soluble polychrome paint on many sherds that would have been classified as plain or simply white slipped if they had been washed" and that a former practice of scrubbing pottery had greatly reduced the frequency of decorated pottery in some assemblages,; the current author wished to avoid similar loss. To solve the problem, the author met with Virginia Greene, Senior Conservator at the University of Pennsylvania Museum, to seek her advice. In a letter to the author (personal communication, May 18 1992), Dr Greene indicated that some pots probably had been red slipped after they were fired. She found that, while not actually "water-soluble," the slip tended to come off in water as a result of physical action. Dr Greene indicated that "since you can not tell in advance which sherds have this coating, it will be necessary to clean all sherds without rubbing or excessive action." Sherds with incrustations would "have to be cleaned in acid and then soaked in water to remove all traces of the acid, which can later do a lot of damage inside the sherds." Dr Greene then provided a detailed procedure for cleaning the Tutu sherds without removing the fragile exterior slip and these instructions were carefully followed.

Sherds from all excavated contexts, except two midden areas and post holes, were sent to Dr Lundberg for analysis. Ceramics from post holes were analyzed, weighed and tabulated by the author, Jeremy Lazelle and Ann Heartburg. These records are on file at the DAHP.

During the sorting process, lithic tools and implements; by-products of the manufacturing process; utilized items; lithic beads; crystals; ochre; water worn-stones; and any other lithic materials that were not obviously unaltered detritus were removed and separately bagged and labeled. Samples of detritus also were retained for a record of the distribution of naturally occurring lithic

Table 1.2 Faunal remains and ceramic materials recovered from burial fill at the Tutu site

Burial number	*Area*	*Shell count*	*Crab shell count*	*Bone count non-human*	*TG*[a] *count*	*Total faunal gram weight*	*Ceramic sherds*[b]	*Ceramic weight in grams*	*Other*
B-1	9N	58	1	63	25	60	26	67	
B-2	9N	Lithic residue only							
B-3	9S	254	3220	3562	243	2727	6	189	Greenstone preform, celt, bead
B-4/7	13	—	—	9	—	<1	—	—	
B-5	1	—	—	1	5	3	—	—	
B-8A, 8B	1	—	1	—	—	—	3	42	
B-9	4	3	—	2	—	2	2	14	
B-10	2	—	—	14	—	5	—	—	
B-11	1	1	—	3	—	18	5	26	
B-13	—	—	—	—	—	—	—	—	
B-15	1	22	—	1	1	48	36	60	
Soil above burial bowl									
B-18	8	7	1	3	1	<1	12	—	
B-19	9N	—	—	—	—	—	2	36	
B-21	5	—	—	—	1	<1	6	11	
B-22A, 22B	3	7	—	11	2	7	6	41	
B-25	13	—	—	—	—	—	3	2	
B-27 + post	1	124	—	77	10	179	—	154	
B-29	4	—	—	—	—	—	—	—	
B-30	9N	—	—	2	—	2	1	1	
B-31	1	—	—	—	—	—	—	—	Magenta soil coloration
B-32A	13	Gravel only							
B-33	8	13	—	2	—	2	—	—	
B-34	8	14	—	3	—	3	—	—	
B-36	5	7	15	51	1	36	—	56	
B-38	1	5	—	1	6	16	1	<1	
B-39	1	—	—	—	—	—	—	—	
B-40	4	4	1	Surface only		—	<1	—	
B-41	1	17	—	—	—	55	27	167	
Total						3158		867	

Notes

[a] TG = terrestrial gastropod.

[b] Ceramic grave goods are not tabulated. Burials from which only grave goods were recovered are not listed.

materials on the site. Jeff Walker made a preliminary examination of the Tutu lithic materials, but only flaked stone and core tools received comprehensive analysis (see Chapter 11). Stone beads and ceremonial objects such as three-pointers and green stones were analyzed by the author with the assistance of gemologist, Alan O'Hara. These findings are briefly discussed later in this chapter. The remainder of the lithic collection was inventoried by Jeremy Lazelle.

Charred plant remains recovered from 308 flotation samples were dried during the field investigations, carefully packed and sent to Dr Deborah Pearsall for analysis (Chapter 2). One hundred and five soil samples collected from excavation units and from burials were sent to Dr Dolores Piperno for phytolithic analysis (Chapter 3). Thirty-five samples of soil from burial fill remain in storage at the DAHP. Each of 61 soil samples collected for pH and organics analyses was divided in half and one set of samples was submitted to Dale Morton at the Agricultural Extension Service of the University of the Virgin Islands for analysis, while the other set, and 18 "other" soil samples, are in storage at the DAHP. Samples collected for trace element analysis were packed and shipped, along with human remains from the site, to Dr Sandford at the University of North Carolina. Only the human remains in Burial 15, too fragmentary to recover, were retained unexcavated in their ceramic bowl at the DAHP (Figure 1.9).

In 1995, before the lab work had been completed, Hurricane Marilyn struck the island of St Thomas and the lab was destroyed. Soaked boxes of materials and scattered bags of samples were rescued by Jeremy Lazelle, who re-sorted and re-boxed the collection, saving the majority of it. However, a few field bags, some original field records and drawings of post holes and other features were lost.

Analyses

Except for charred plant remains which will be curated at the University of Missouri in Columbia, and radiocarbon samples that are destroyed during analysis, materials that were sent off the island to be analyzed by experts will be returned to the DAHP, where they will be housed with unanalyzed samples awaiting further study.

Despite generous contributions and grant awards from the National Endowment for the Humanities (NEH) and the Virgin Islands Government, funding was not available to cover the cost of analysis of all samples recovered from good contexts at the site. The project was extremely fortunate that a number of local citizens, scientists and other professionals with special expertise provided analytical assistance without charge.

FINDINGS

Summary tabulation for the site

Of the approximately 2.20 hectares Tutu site the primary occupation area, middens and central open space comprised about 2.00 hectares. For the site as a whole, 41 excavation units, 13 test units, 21 shovel tests, 34 site features, 37 burial pits, 1 isolated ceramic bowl, 1 possible cooking area, 1 pit and 904 stains were excavated by hand; and 8 trenches were mechanically excavated. Twelve site profiles were recorded. Most hand-excavated units (EUs) were either 1 m^2 or 2 m^2, which tended to be less than 40 cm deep in northeastern, northern and northwestern portions of the site and up to 120 cm deep west and southwest of Soil Mound No. 4. Test units were between 30 cm^2 and 50 cm^2 and about 40 cm deep. Machine excavated trenches comprised about 202 m^2 of the site's surface, from which about 300 m^3 of soil were removed. Hand-excavated units and features comprised about 300 m^2 or 1.50 percent of the surface of the site proper. Soil mounds obscured about 20 percent of the site and another 30 percent of the site was archaeologically machine scraped to expose features.

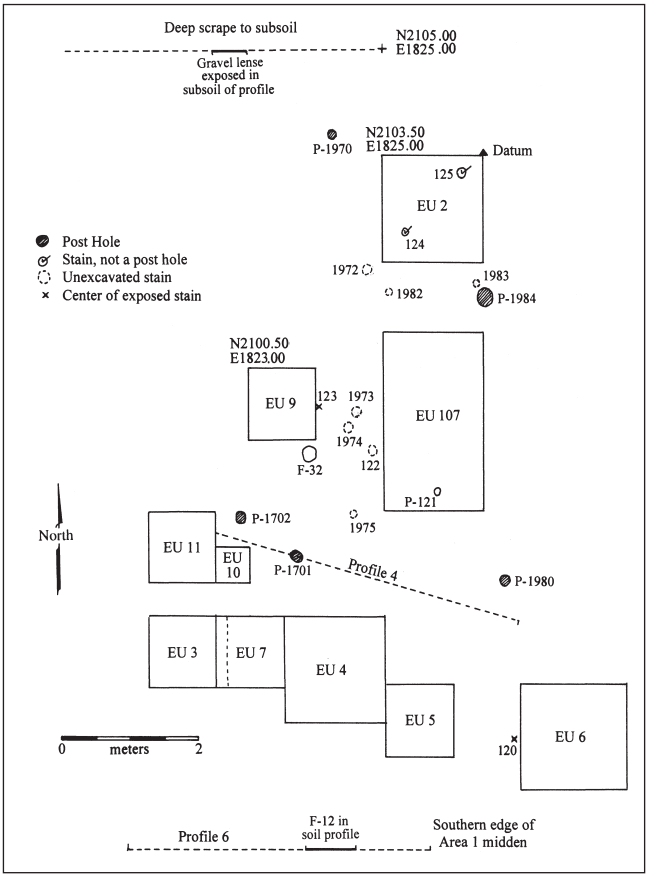


Figure 1.10 Plan view of excavation units and features in the midden portion of Area 1 (recorded by Elizabeth Righter, graphic by Julie Smith).

Volumes and weights of analyzed materials recovered from well-controlled contexts within proveniences of excellent integrity are provided in specific analytical chapters, while unanalyzed materials recovered from proveniences of less integrity were weighed, measured and tabulated by lab assistants, Jeremy Lazelle and Ann Heartburg. These records are on file at the DAHP.

EUs and tests: stratigraphy and midden characteristics

The following section is an overview of stratigraphy exposed in excavation units and trenches, and of midden characteristics and general contents in a chronological context. Detailed analyses of charred plant remains, phytoliths and faunal material recovered from stratigraphic contexts are presented in Chapters 2–4; ceramic items and flaked stone materials are presented in Chapters 5, 6 and 11; and other artifacts from midden contexts are briefly described in later sections of this chapter.

Area 1 EUs

In Area 1, 7 data recovery units were excavated in the richest part of the midden, and 3 units in thinner deposits to the north (Figure 1.10). Deposits at the eastern limit of the midden were about 10 cm thick and had been truncated by pre-1990 machine scraping on the site. In units that extended across the midden from EU 6 in a westerly and northwesterly direction (EUs 5, 4, 7, 3, 10 and 11), deposits became progressively thicker and less truncated toward the west and northwest, reaching a maximum thickness of between 20 cm and 25 cm (Figures 1.11–1.13). In EUs 3, 10 and 11, stratigraphic differentiation within the midden was recognized on the basis of subtle changes in soil texture, and in artifact size and abundance.

In general, Area 1 midden was observed in an extremely compacted dark brown clay loam which ranged in color between Munsell 10YR3/2 very dark greyish brown and 7.5YR3/4 dark brown. Horizontal strata, when present within the midden, appeared to consist of disposal episodes localized within the midden and extensive midden-wide horizontal differentiation was not evident. The midden rested on dark reddish brown to yellowish red clay and gravel (Munsell color, 2.5YR3/6 to 5YR4/6). Clusters of unmodified rocks observed on the floor of the midden in some units were interpreted as land clearing residue thrown into the area.

On the southern edge of the midden, Feature 12, a midden remnant exposed in Profile 6 (Figure 1.14) established the southern limit of the Area 1 midden. Profile 4 (Figure 1.15) marked the northern limit of the thickest midden deposits.

Between Profile 4 and the east–west line of excavation units to the south, midden was removed by shovel. Collar and rim fragments of one large circular pot (Chapter 5, Figure 5.2e) were present in dispersed locations in the shovelled midden area. In Profile 4, P-1701 originated below the upper midden in Stratum I (Figure 1.15). Pockets of red clay, perhaps indicative of localized prehistoric disturbance, also were observed in the recorded profile. Similar disturbances, however, were not observed in excavated units and the context of samples from the Area 1 midden was considered to be excellent.

North of Profile 4, the midden remnant was thin, with ceramic sherds, charcoal pieces, crab claws and turtle bone exposed on its surface. This thin midden remnant terminated at N2103.50/1825E (Figure 1.10). In a separate area north of the Area 1 midden, pieces of a red-painted inverted bell-shaped vessel were excavated in an isolated context (Figures 1.7a–d) at N2110/1826.50E. This was interpreted as either a cache or a single disposal episode, perhaps fallen from a storage rack (Roe & Siegel 1982: 105; Siegel, 1990a; Schinkel, 1992: 186). In test units opened north of this find, a single thin stratum of midden, about 10 cm thick, was present in clay loam beneath grass and disturbed Level A topsoil. Underlying the midden was sterile clay. The midden which was traced in a series of small test units disappeared within a 6 m radius of the central units. The midden level was not dated.

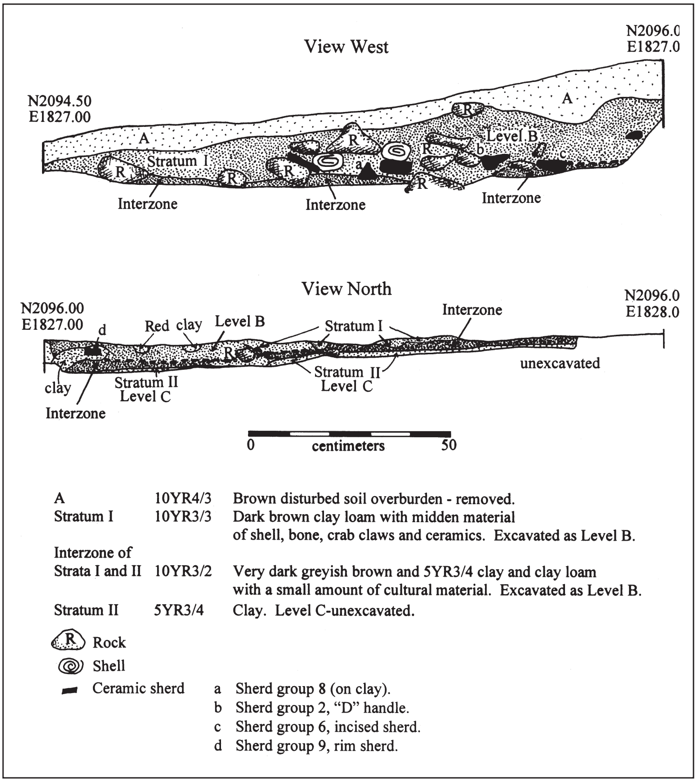


Figure 1.11 Stratigraphic profiles of west and north walls of EU 6, Area 1 (recorded in the field by Emily Lundberg, graphic by Julie Smith).

Interpretation of the range of radiocarbon dates returned on carbon samples from the Area 1 midden is discussed in a later section of this chapter. No late occupation midden was found in the Area 1 excavation units or in overlying residual soil furrows, which apparently were the result of secondary pre-1990 re-scraping of the exposed Saladoid midden surface. Chican Ostionoid material was found, however, in post holes and in scraped soil east of the Area 1 midden, and it is possible that, if later refuse originally overlay the Area 1 midden, it was scraped away when topsoil was removed prior to 1990.

Area 4 EUs

In Area 4, shell plaques (gorgets) and green stone insets were exposed on the surface of midden deposits that had been exposed by light pre-1990 surficial scraping. Preforms and unfinished artifacts were included among this material.

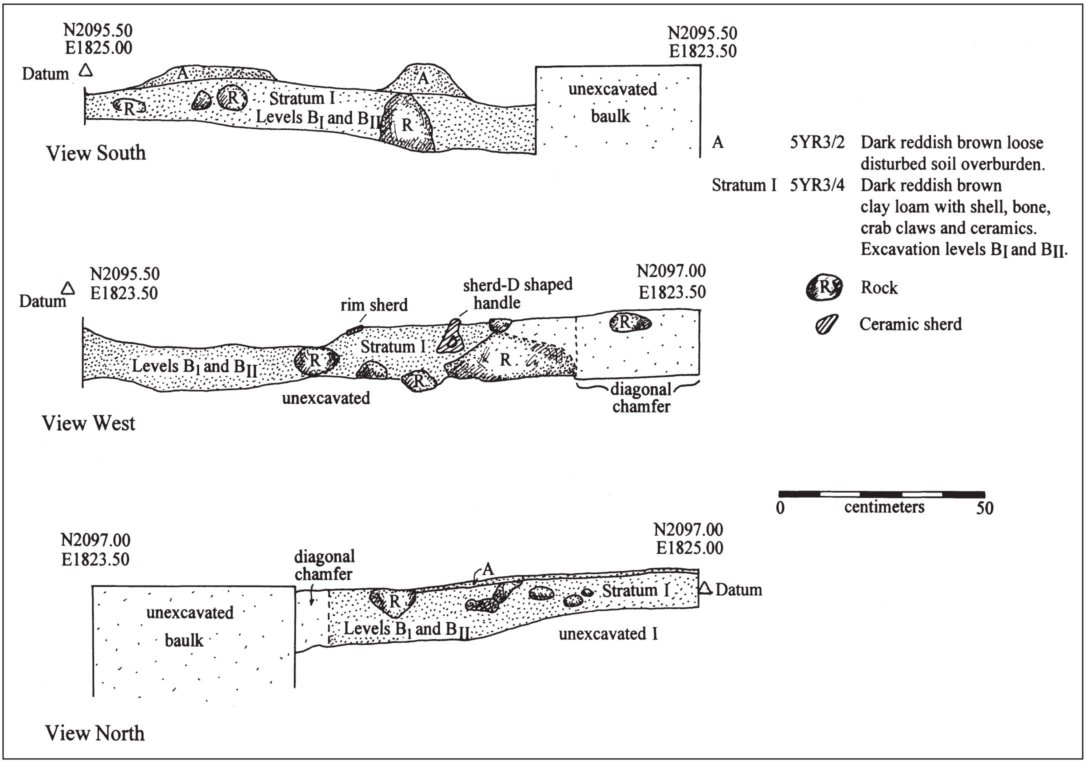


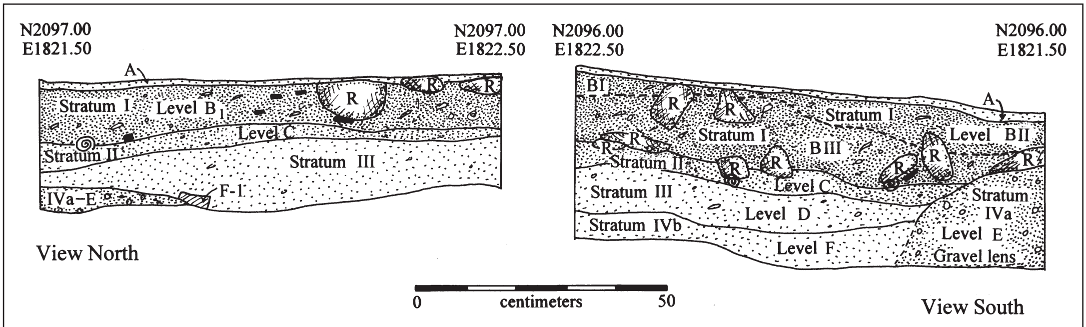
Figure 1.12 Stratigraphic profiles of south, west and north walls of EU 4, Area 1 (recorded in the field by Elizabeth Righter, graphic by Julie Smith).

Midden exposed in 5 EUs of Area 4 was variable in thickness, and consisted of lenses or layers of densely packed food remains and artifacts separated by thin deposits of clay loam, either naturally or intentionally placed on the midden. Layering was probably related to discrete episodes of disposal.

Upper levels of N2087/1952E (EU 31) were permeated with charcoal that returned an historic date (Figure 1.16). Since the artifact assemblage is consistent with that of the remaining undisturbed midden, it is likely that a tree stump was burned in place, affecting radiocarbon dates, but not the midden. Under charcoal-permeated levels, in Level BIIC, two almost complete bowls were inverted in a midden of densely packed crab claw and other cultural material (Figures 1.17a and b, and Chapter 5: Figures 5.8a and b). Under one of the pots was a coprolite.

Carbon samples from Level BIIC, and Level D of adjacent unit N2090/1948E, returned overlapping date ranges of between cal. AD 265 and cal. AD 660 (2-sigma, Beta 50066, 54646). These date ranges exceed, by 60 years, Rouse's general termination date for the Cedrosan Saladoid ceramic subseries (Rouse, 1992: 107). The unit terminated in sterile red clay.

A 2 m unit (EU 30) was situated at N2082/1940E, just below the edge of the slope of Area 4. Contrary to expectations, this unit yielded almost no cultural material, and indicated that the major portion of midden deposits was not below the edge of the slope, but was in the area sampled, further downhill and to the north. This distribution and findings in N2112.50/1937.50E, in turn, indicated that structures investigated in the scraped portion of Area 4 probably were not the source of this midden remnant. A more likely source was structures, the remains of which were exposed but not investigated in Area 4N, and structures in uninvestigated areas buried under Soil Mound No. 6.



A	10YR4/2	Brown disturbed soil overburden.
Stratum I	10YR3/3	Dark brown clay loam midden containing ceramic sherds, shell bone, and crab claws. Levels BI, BII and BIII.
Stratum II	10YR3/4	Dark yellowish brown clay and clay loam with some gravel, shell bits, charcoal, and midden drift from Stratum I.
Stratum III	5YR4/6	Yellowish red clay with a small amount of cultural material- shells and bone bits.
Stratum IVa	7.5YR3/4	Dark brown silty loam with 5YR4/6 yellowish red gravel and 10YR3/3 dark brown worm casts. Also contains charcoal, shell bits and a ceramic sherd.
Stratum IVb	5YR4/6	Soft yellowish red clay.

/ Ceramic sherd
◎ Shell
R Rock

Figure 1.13 Stratigraphic profiles of north and south walls of EU 3, Area 1 (recorded in the field by Elizabeth Righter, graphic by Julie Smith).

Shell gorgets were collected from the scraped surface of N2090/1948E (EU 28), excavated initially by Dr Emily Lundberg and completed by Dr David Anderson with the assistance of graduate student, Jim Allison. A drilled shell plaque or gorget, a perforated mother-of-pearl shell disc, and several incised and red-painted ceramic sherds, were recovered from Levels A and B of the unit (Munsell color, 10YR4/3 dark brown clay loam). Disturbances resulting from machine scraping were observed in Level A. These affected Zone 1 of underlying Level B, from which crab claws, charred plant material and ceramic sherds were recovered. Three features which were pockets of material essentially similar to the rest of the midden, but concentrated in sometimes ashy soil of slightly different color and texture, were excavated successively in Levels B, C and D. A large thick sherd of an inverted bell-shaped, white-on-red painted pot, with a white-painted design in an "H" shape (Chapter 5: Figure 5.9c), a large piece of an angular utilitarian pot with an attached handle, and a third sherd, a large portion of a utilitarian pot (Chapter 5: Figure 5.9f), were recovered from Feature 3 which originated at the base of Level D. Other large ceramic sherds also were present in Feature 3 and in the southern portion of Level D, which terminated in orange clay (Munsell color, 5YR4/6). Cross-mending sherds of one vessel recovered from Levels B, C and D of N2090/1948E (Chapter 5: Figures 5.13a, 5.14b) provided further evidence of the homogeneous nature of the Area 4 midden.

Recovered samples from two other units, N2089/1947E and 2112.50/1937.50E, which contained material similar to that recovered in other Area 4 midden units, were not analyzed.

Lundberg (Chapter 5) finds that ceramics of the Area 4 midden are a good example of a local style contemporaneous with the Cuevas style of Puerto Rico. In the Virgin Islands, this might be called the Tutu aspect of the Coral Bay style.

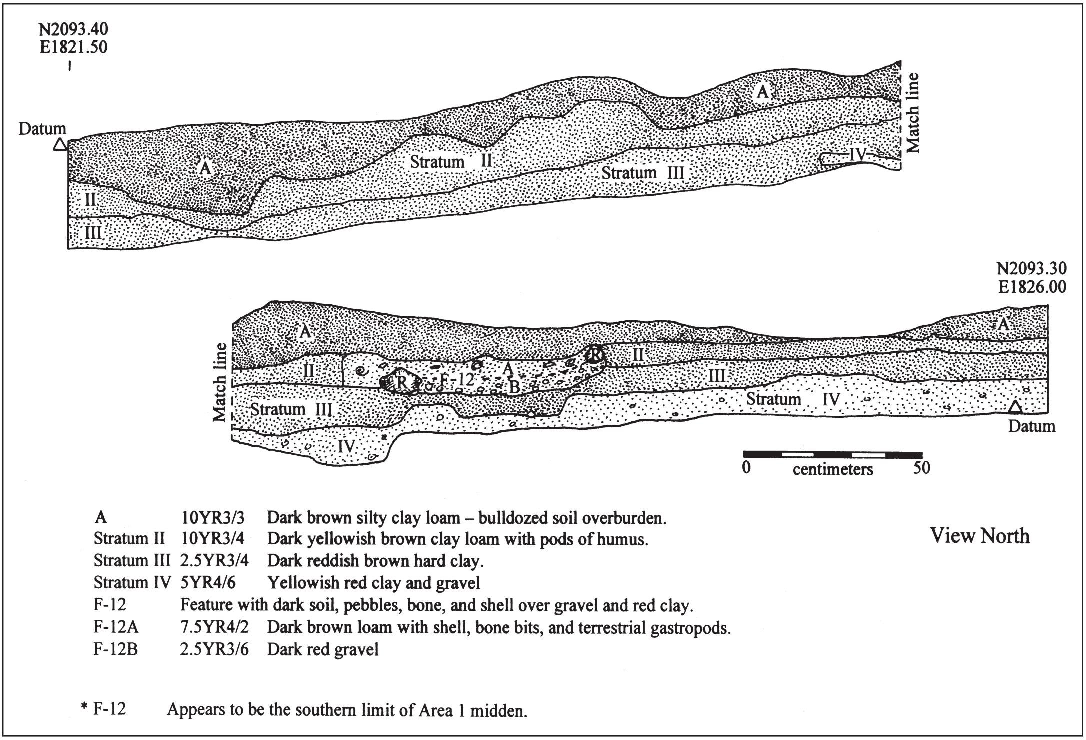


Figure 1.14 View north of Profile 6, Area 1, showing Feature 12 (recorded by Elizabeth Righter, graphic by Julie Smith).

No traces of material related to the post-Saladoid occupation of the site were found on the ground surface or in other excavation units of Area 4, and, if later deposits had been present, they were entirely removed by heavy equipment. Because artifacts recovered from the surface, from burned midden layers with charcoal of historic date, and from the undisturbed midden were consistently similar, it is virtually certain that the midden is homogeneous and representative of the time period for the Tutu site.

Area 8 EUs

Initial light machine scraping exposed two surficial midden scatters in Area 8: one in the southwestern section, where 5 excavation units, including a baulk, were opened; and one about 7 m to the east, where a single 2m^2 unit was excavated (Figures 1.7a, 1.18). The Area 8 southwestern midden contained only material related to the early occupation of the Tutu site and differed in character from the midden to the east. Unaltered rocks attributed to land clearing were not present at the base of any of the units.

The southwestern midden was thin, between 10 cm and 15 cm thick, and exhibited little internal structure. Midden in N2115.50/1837.50E (Figure 1.19, EU 16) consisted of dense lenses of clay loam, crab claws, potsherds, shell and bone in unstructured very dark greyish brown silty loam with tiny gravel bits (Munsell color, 10YR3/3). Feature 27 (see Figure 1.17c) (discussed below) was embedded in the midden, at about N2115/1838.50E, and sections of a red-painted pot were recovered from Level E of N2115/1839E, a 1 m subdivision of the unit. The midden terminated in hard red clay devoid of cultural material.

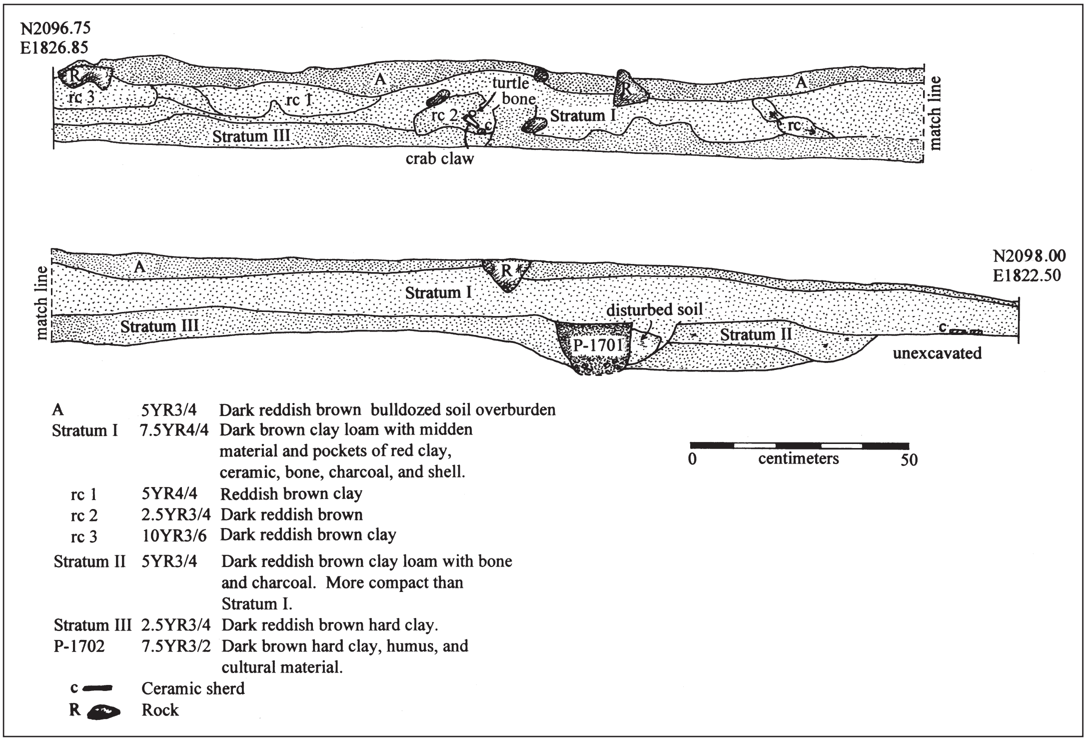


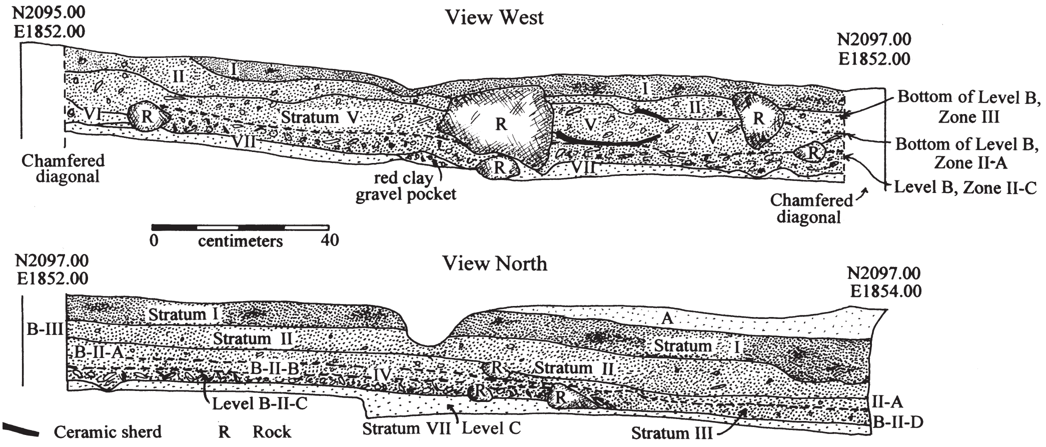
Figure 1.15 View south of Profile 4, Area 1 (recorded by Elizabeth Righter, graphic by Julie Smith).

Level B in N2113/1840E (EU 15) in the southwestern midden was a densely packed layer of artifacts, crab claws, bone and shell, from among which sherds of a red-painted pot also were recovered. The only date for the midden, between cal. AD 390 and cal. AD 630 (2-sigma, Beta 65473), was returned on a charcoal sample from this level. Dates and ceramic styles of the southwestern midden correspond with those for Lundberg's Assemblage 2 (Chapter 5).

A hearth, Feature 33, a pit, and three post holes (Figure 1.18) were exposed in a dark brown silty loam in Level B of N2116/1840E (EU 18)(Munsell color, 7.5YR3/4). This level terminated in bedrock.

Midden Level B in partially excavated N2111/1839E (EU 14) (Figure 1.7a) yielded several fragments of a ceramic pot.

In the eastern section of Area 8, lightly scraped topsoil remnants were in place, and four stratigraphic levels were present in N2117/1849E (EU 19). Levels A and B contained late Ostionoid series ceramic sherds and faunal material of both the early and late occupations. Two post holes, Feature 6 and 10, first appeared in Level B. Features 1 through 4 originated in Zones I and II, exposed at the base of Level B, and Features 5, 7, 8 and 9 originated in Level D. These features and Feature 4 extended into bedrock. Depths to bedrock varied within the unit and depths to which post holes had been excavated into bedrock varied between 8 cm and 63 cm. It was the excavator's opinion that Features 8 and 9 (Figure 1.18) may have been post holes of a circular structure partially exposed in the unit. Because of funding considerations, faunal material from this unit was weighed and measured by volume, but not analyzed.



A	10YR3/3	Dark brown disturbed soil overburden.
Stratum I	7.5YR3/2	Dark brown clay loam with 7.5YR2/2 black, charcoal – no distinct bottom.
Stratum II	7.5YR3/4	Brown clay loam with midden material. Excavated partially as Level B, Zone III and BII, Zone A.
Stratum III	7.5YR3/4	Dark brown clay with ceramic sherds and slight amounts of some other cultural materials. Level B-II-D. Excavated within Stratum III and IV.
Stratum IV	7.5YR3/4	Brown clay loam with midden. Not distinct from Stratum II. Level B-II-B. Excavated within Stratum IV. Densely packed midden at the base of Stratum IV. Crab claws, almost no soil.
Stratum V	7.5YR3/4	Brown clay loam, dense midden and crab claws. No other distinction from Stratum II. Level B-II-C. Excavated within Stratum V. Densely packed midden at the base of Stratum V.
Stratum VI	5YR4/6	Red clay with shells.
Stratum VII	5YR4/6	Red clay with no cultural material.

Figure 1.16 Stratigraphic profiles of west and north walls of EU 31, Area 4 (recorded in the field by Emily Lundberg, graphic by Julie Smith).

Area 9N EUs

In N2075/1810E, under a thin layer of disturbed overburden which was removed as Level A, a shallow midden about 15 cm thick was excavated as Levels B and B^2, by Mark Swanson and Margaret and Phil Caesar (Figure 1.20). The midden consisted of a moderately dense deposit of cultural material, including ceramic sherds and lithic tools, in dark brown clay loam. Charcoal recovered from Level B^2 returned 2-sigma date ranges of between cal. AD 415 and cal. AD 630 (Beta 65472). Both Wing (Chapter 4) and Lundberg (Chapter 5) observed characteristics of the material that questioned its integrity as a homogeneous deposit, and the date may apply only to a selected portion of the midden.

Four units, which included Burial 1 and Feature 7, also were opened in Area 9N (Figures 1.7a–d). Level A consisted of disturbed reddish brown clay and clay loam with artifacts of both early and late occupations in mixed contexts. A large round quartz bead was recovered from this level. Excavation of Level B was not completed and, because of funding limitations, samples recovered from these levels and from excavated fill of Features 7 and 9 were not analyzed.

Area 9W EUs

Primary midden deposits were present in the upper approximately 40 cm of N2044/1837E in Area 9W. Midden Levels D and F were separated by a stratum of relatively sterile clay which included tiny bits of unweathered andesite bedrock. As in the Area 4 midden, the nature of the andesite chips suggested that the soil had been excavated from a clean deposit on the site and intentionally placed over the midden,

Figure 1.17a Partial bowl exposed at base of EU 31, Level BII, Area 4 (photograph by Emily Lundberg).

Figure 1.17b Complete bowl upside down at base of EU 31, Level BII, Area 4 (photograph by Emily Lundberg).

Figure 1.17c Remains of buried *Chelonia mydas* (F-27) in situ, as exposed in EU 16, Area 8 (photograph by Elizabeth Righter).

Figure 1.17d Sherds of large inverted bell-shaped ceramic vessel in Burial 4/7, Area 13 (photograph by Emily Lundberg). View south.

perhaps to reduce odor and vermin. The midden consisted of a very dense soft "mash" of crab claw and shell residue, charcoal, lithic material, bone and artifacts in almost no soil (Figures 1.21, 1.22). Carbon samples collected from Levels D, F and I, in the upper midden, which contained ceramics representative of a late phase of the Saladoid series (see Chapter 5), had a maximum date range of between cal. AD 420 and cal. AD 885 (2-sigma, Beta 62569). These dates did not overlap with dates of between about 160 BC and AD 400 for the Hacienda Grande style of Puerto Rico, as defined by Rouse & Alegría (1990: 57).

Below upper midden layers, which ended at the base of Level J or Stratum VIII, the character of the midden changed. Between Stratum IX and the bottom of the excavation unit (at about 78 cm below damtum (cmbd) stratigraphy was characterized by thick levels of clay and gravel, with interspersed discontinuous very thin bands of cultural refuse particles and midden trails. These bands, which were of varying thicknesses, had the appearance of material suspended in soils that had washed in during episodes of flooding. Confirming this scenario, because of their weathered

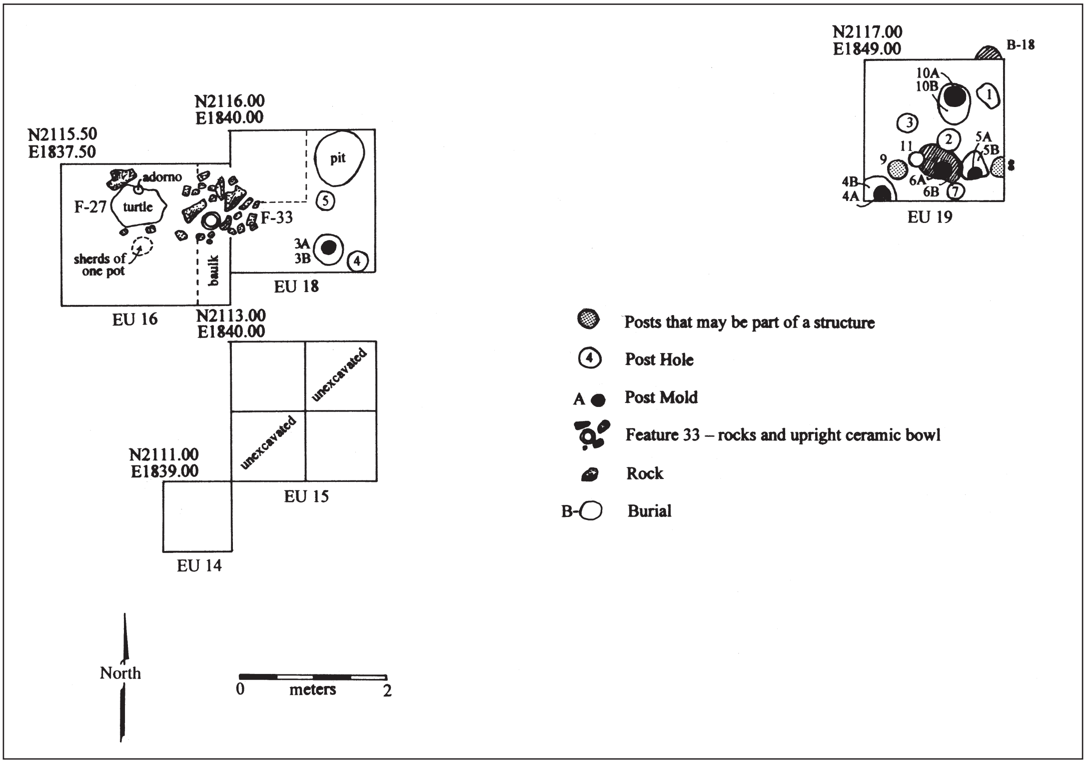


Figure 1.18 Plan view of excavation units in Area 8 (recorded by Elizabeth Righter, graphic by Julie Smith).

condition, Dr Wing (personal communication) was unable to analyze most of the faunal specimens collected from lower levels of the unit.

Stratigraphy recorded in profiled walls of Trench 10 mirrored that of N2044/1837E. Intepretation of stratigraphy in the two units indicated that sources of the stratified materials were to the north and/or northeast. A dramatic change in the character of the strata after deposition of Stratum IX,suggests a corresponding change in land use at this source. A likely scenario is that lower levels of N2044/1837E and Trench 10 accumulated as soil eroded from an exposed uphill surface that was regularly swept and kept relatively clean of cultural debris. This may have been a plaza or an exposed "yard" associated with a structure. Upper midden levels in the units, on the other hand, contained large debris, such as whole crab claws and large ceramic sherds, indicative of primary midden which originated from a nearby source. The episodic nature of the deposits and the inclusion of greenstone inlays and preforms, annular-based red-slipped ceramic sherds, beads, celts and finely crafted ornaments suggest "ritual disposal", and indicate that the midden may have resulted from periodic public feasting on the plaza and ceremonialism associated with burial rituals and ancestor worship (Siegel, 1989, 1992). The midden also may have originated from one or more domestic structures present north or north northwest of Trench 10 and N2044/1837E. If Features 7, 9 and 34 are dripline remnants (Siegel, 1990a), they pre-date the interment of Skeleton 1 and the structures that they represent may be candidates for sources of the primary midden. An additional source of upper levels of N2044/1837E and Trench 10 may have been feasting on the plaza.

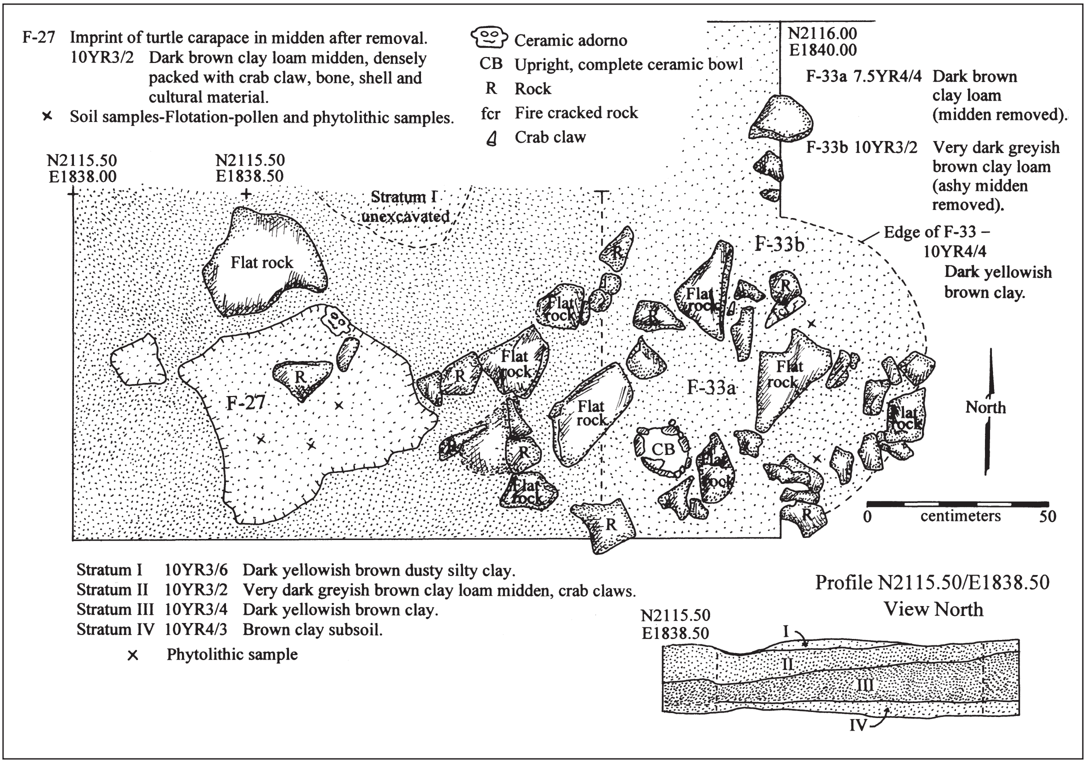


Figure 1.19 Plan view of Feature 27 (a buried *Chelonia mydas*) in relationship to midden Feature 33 (a hearth), and an upright small red slipped bowl, Area 8 (recorded in the field by Elizabeth Righter, graphic by Julie Smith).

The Area 9S middens

A rich midden layer, distinguished from other middens of the site by its very dark color and greasy consistency, was present at the top of Trench 9. *Cittarium pica* shells and ceramic sherds of the Chican Ostionoid series were noticeable in a dense mixture of shell, charcoal, bone and other cultural material in very little soil (Munsell color, 10YR3/2 very dark greyish brown silt). The presence of *Manatus trichecus* rib bones on the ground surface and in Trench 9 fill suggested that the greasiness of the midden was the result of manatee roasting. In all aspects, this midden level, identified as Level C/E in Trench 9, was continuous with midden found at the tops of EUs N2033.50/1843.50E; N2037/1842E; and N2037/1836E, and presumably shared a similar chronological position.

Beneath the upper midden level of Trench 9 was a thick deposit of consolidated clay loam and fine gravel (Munsell color, 7.5YR3/4 dark brown) which overlay unconsolidated variously thick layers of clay and gravel interspersed with discontinuous layers or lenses of midden. At the base of the stratigraphic column was another clearly defined midden level (Munsell color, 10YR3/2 very dark greyish brown clay loam) which lay on sterile reddish brown clay on either side of a large field rock, apparently cleared from the site. Stylistically, ceramic sherds recovered from the lowest midden level are similar to those of the Cedrosan Saladoid subseries. A large calcite crystal was recovered from the bottom of the trench. Ceramics retrieved from profile walls, with associated charcoal, were not dated, but will remain in storage for future study.

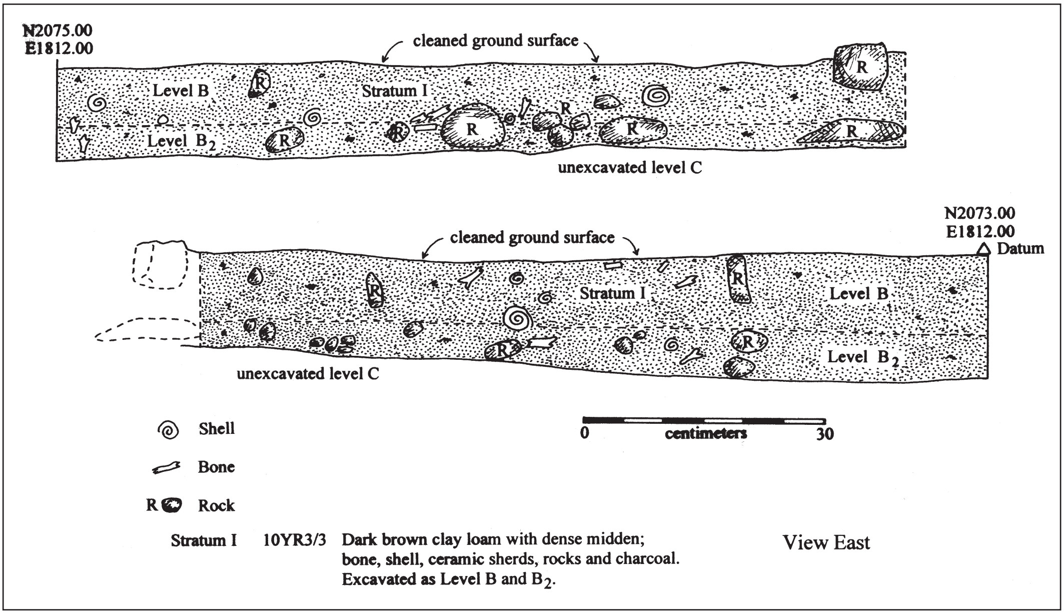
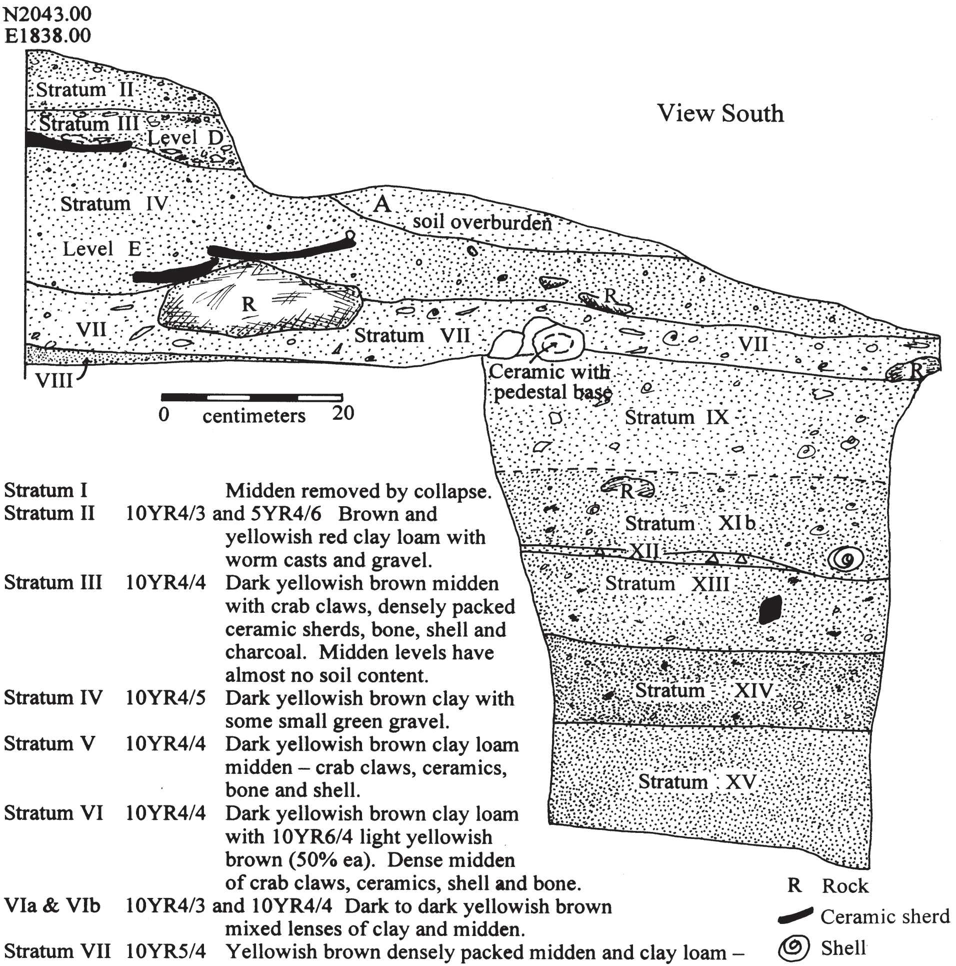


Figure 1.20 Stratigraphic profile of east wall of EU 33, Area 9N (recorded by Mark Swanson, graphic by Julie Smith).

Stratigraphy in units opened to the north and south of Trench 9 was similar to that of Trench 9 with slight variations. In unit N2037/1842E (EU 25) north of the trench, the upper midden (Levels B and C) was missing in the northern half of the unit and was an undisturbed level (Level B, 6 cm thick) in the southwestern portion (Figure 1.23). As in Trench 9, the midden was very dark brown and greasy with faunal remains that were visually different from those of the Saladoid middens at the site. The midden was clearly distinguishable from an underlying thick level of relatively sterile consolidated clay and fine gravel (Level D). Levels E and F, under this stratum, contained crab claws, Cedrosan Saladoid ceramic sherds, bone and charcoal, increasing in abundance in Level F. Beneath Level E, alternating layers of clay, gravel and midden trails resembled lower strata in N2044/1837E.

In EU 25, a 50 cm by 100 cm unit appended to the south side of EU 27, only the upper midden levels were excavated. The late midden stratum was slightly thicker in this unit, and, unlike other units of Area 9S, its surface had not been touched by previous scraping in the general area. In the southwest corner, the midden was divided by a lens of sterile clay. To avoid any chance of disturbance, samples were collected from the top and bottom of the clearly undisturbed portion only. Two sets of 2-sigma date ranges, between cal. AD 1250 and cal. AD 1535 and between cal. AD 1545 and cal. AD 1635 (Beta 51354), were returned for the top of the midden, and ranges of between cal. AD 1035 and cal. AD 1435 (Beta 51355) were obtained for samples from its base.

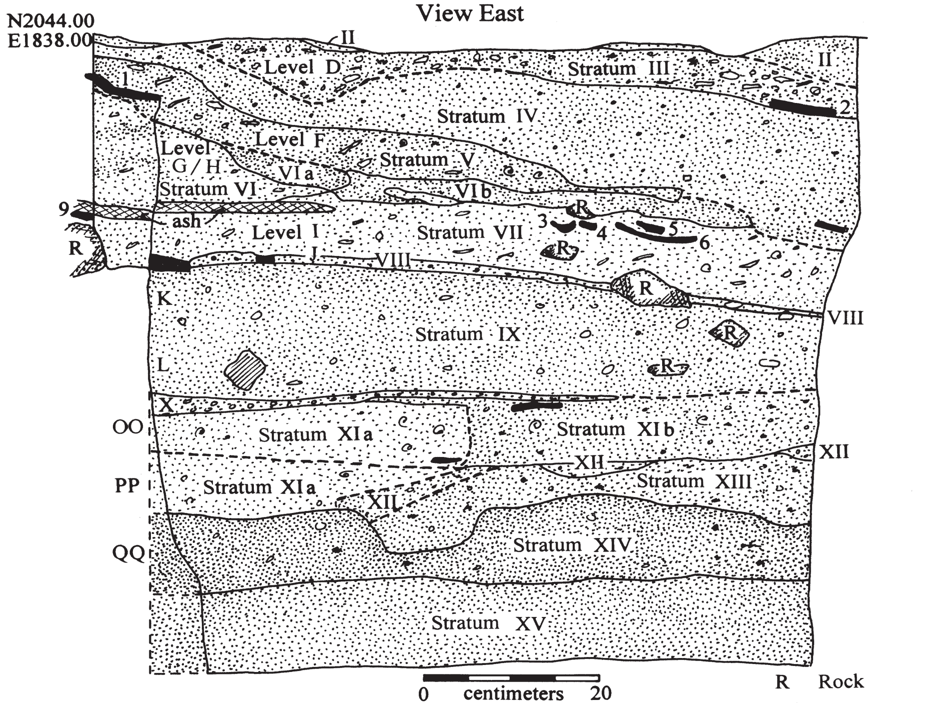
In EU 27, located approximately 1 m south of Trench 9, recent overburden overlay a midden layer similar to that at the top of other Area 9S units. This Level B (Figure 1.24) was removed by Josh Kehrburg in several flotation samples. Because the amount of disturbance to the surface of the midden in this area was difficult to determine, only Levels B^1 and C were considered suitable for collection of samples and analysis of remains. Ostionoid material in this level seemed to be in original context, in a very thin (5 cm) layer of mottled reddish brown, "dusty," and soft soil. Underlying levels, excavated as Levels C, C^1, C^2 and DI, were one stratum, the equivalent of Level D in EU 25 and Trench 9. Levels E and F in this unit also contained cultural material, but in less abundance than in EU 25. Underlying strata resembled those of other units and contained Saladoid material.



Stratum I		Midden removed by collapse.
Stratum II	10YR4/3 and 5YR4/6	Brown and yellowish red clay loam with worm casts and gravel.
Stratum III	10YR4/4	Dark yellowish brown midden with crab claws, densely packed ceramic sherds, bone, shell and charcoal. Midden levels have almost no soil content.
Stratum IV	10YR4/5	Dark yellowish brown clay with some small green gravel.
Stratum V	10YR4/4	Dark yellowish brown clay loam midden – crab claws, ceramics, bone and shell.
Stratum VI	10YR4/4	Dark yellowish brown clay loam with 10YR6/4 light yellowish brown (50% ea). Dense midden of crab claws, ceramics, shell and bone.
VIa & VIb	10YR4/3 and 10YR4/4	Dark to dark yellowish brown mixed lenses of clay and midden.
Stratum VII	10YR5/4	Yellowish brown densely packed midden and clay loam – crab claws, ceramics and shell.
Stratum VIII	10YR4/4 to 7.5YR4/4	Dark brown clay loam with fine gravel.
Stratum IX	7.5YR4/4 to 4/6	Dark brown to strong brown clay with gravel, pebbles and scattered cultural material.
Stratum X	7.5YR4/4	Dark brown pebble lens.
Stratum XIa	7.5YR4/6	Strong brown angular gravel with sparse midden, angular pebbles and shell.
Stratum XIb	7.5YR4/4	Dark brown silty clay and gravel with some shell, pebbles, charcoal and midden.
Stratum XII	7.5YR4/4	Dark brown clay with shells, charcoal and gravel.
Stratum XIII	7.5YR4/4	Dark brown clay and midden with gravel and charcoal.
Stratum XIV	7.5YR3/4	Dark brown clay with some gravel, charcoal flecks and midden trails.
Stratum XV	2.5YR3/6	Dark red clay (compact).

Figure 1.21 Stratigraphic profile of south wall of EU 1, showing details of soil types and cultural material in unit strata, Area 9W (recorded by Emily Lundberg, graphic by Julie Smith).

Interpretation of the stratigraphy in Area 9W and Area 9S units indicates that, when the site was settled, grade on the southwestern edge of the site was between 55 cm and 80 cm lower than in 1990. As a result of soil erosion, refuse disposal, and soil accumulation, slopes and swales inthe southwestern portion of the site gradually filled in. When the late prehistoric occupation began, grade was the same height as or higher than when the site was discovered in 1990. In this section



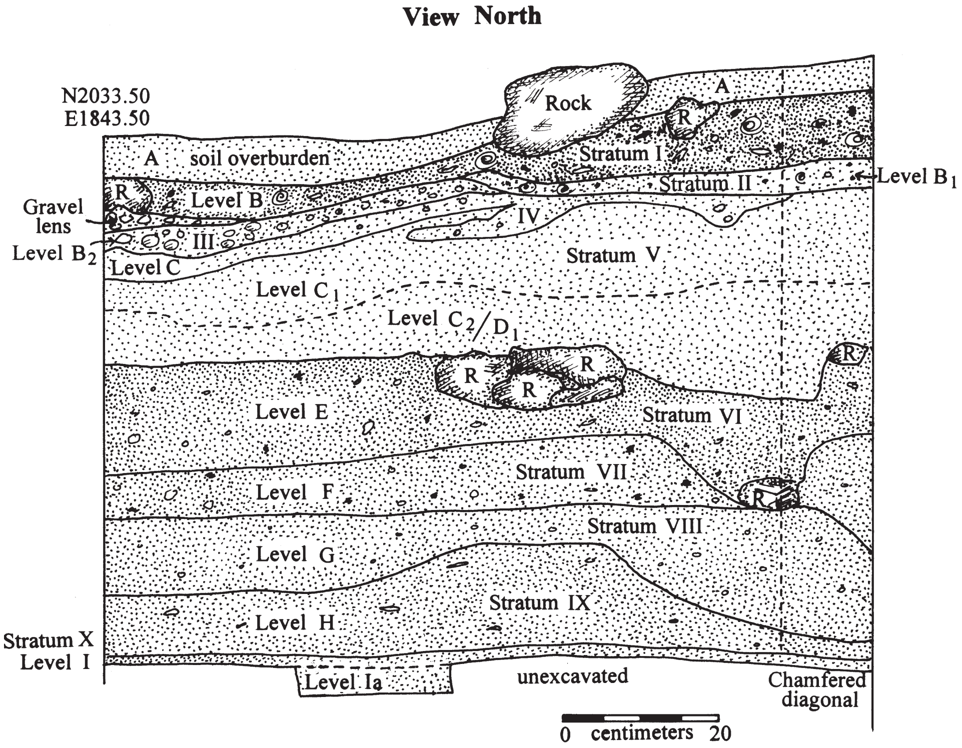
Stratum I		Midden removed by collapse.
Stratum II	10YR4/3 and 5YR4/6	Brown and yellowish red clay loam with worm casts and gravel.
Stratum III	10YR4/4	Dark yellowish brown midden with crab claws, densely packed ceramic sherds, bone, shell and charcoal. Midden levels have almost no soil content.
Stratum IV	10YR4/5	Dark yellowish brown clay with some small green gravel.
Stratum V	10YR4/4	Dark yellowish brown clay loam midden – crab claws, ceramics bone and shell.
Stratum VI	10YR4/4	Dark yellowish brown clay loam with 10YR6/4 light yellowish brown (50% ea). Dense midden of crab claws, ceramics, shell and bone.
VIa & VIb	10YR4/3 and 10YR4/4	Dark to dark yellowish brown mixed lenses of clay and midden.
Stratum VII	10YR5/4	Yellowish brown densely packed midden and clay loam – crab claws, ceramics and shell.
Stratum VIII	10YR4/4 to 7.5YR4/4	Dark brown clay loam with fine gravel.
Stratum IX	7.5YR4/4 to 4/6	Dark brown to strong brown clay with gravel, pebbles and scattered cultural material.
Stratum X	7.5YR4/4	Dark brown pebble lens.
Stratum XIa	7.5YR4/6	Strong brown angular gravel with sparse midden, angular pebbles and shell.
Stratum XIb	7.5YR4/4	Dark brown silty clay and gravel with some shell, pebbles, charcoal and midden.
Stratum XII	7.5YR4/4	Dark brown clay with shells, charcoal and gravel.
Stratum XIII	7.5YR4/4	Dark brown clay and midden with gravel and charcoal.
Stratum XIV	7.5YR3/4	Dark brown clay with some gravel, charcoal flecks and midden trails.
Stratum XV	2.5YR3/6	Dark red clay (compact).

Figure 1.22 Stratigraphic profile of east wall of EU 1, showing details of soil types and cultural material in unit strata, Area 9W (recorded by Emily Lundberg, graphic by Julie Smith).

of the site, therefore, where the early prehistoric settlers found swales and slopes, the later inhabitants found flat or mounded terrain.

The Area 13 midden

The top of a post hole, 11 cm in diameter, and 3 sherd clusters were exposed in Level A of a 2 m^2 unit, N2025/1855E (EU 35), opened in Area 13,where Rock 1 and a round grinding stone were



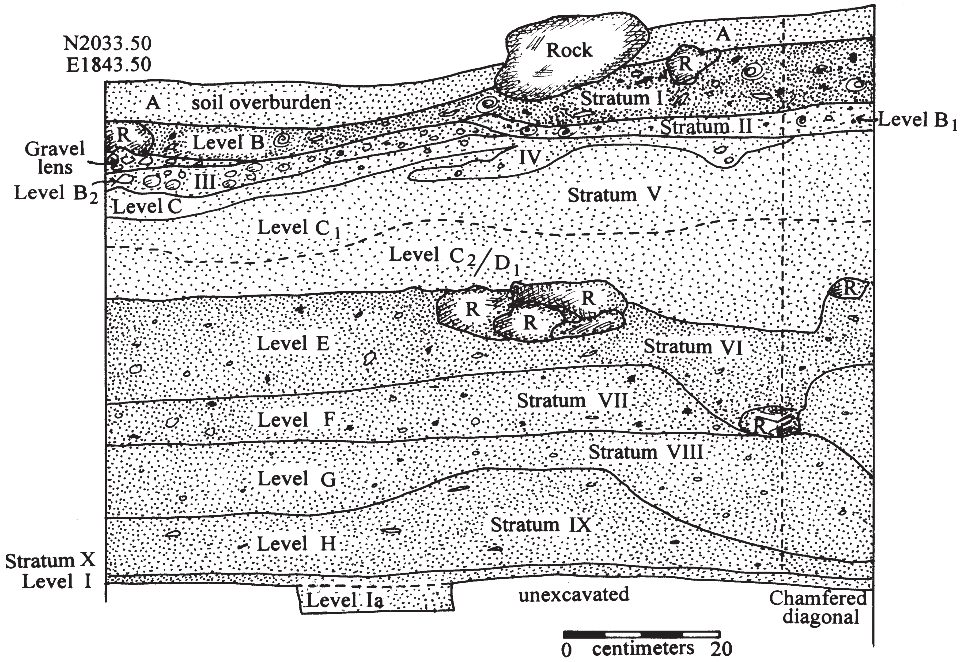
A	7.5YR4/3	Dark brown silty soil
Stratum I	10YR2/2	Very dark brown silt with densely packed midden. Shell (Cittarium pica), ceramic sherds, bone, ash and charcoal.
Stratum II	7.5YR4/4	Dark brown clay with dense midden.
Stratum III	7.5YR4/3	Dark brown gravel.
Stratum IV	7.5YR4/3	Dark brown clay loam with gravel and bits of cultural material.
Stratum V	7.5YR4/3	Dark brown compact clay loam. Sparse cultural material. Includes excavation levels C_1, C_2 and D_1.
Stratum VI	7.5YR3/4	Dark brown clay, gravel and rocks. Unconsolidated fill with cultural material.
Stratum VII	5YR3/4	Dark reddish brown clay and gravel; cultural material and charcoal.
Stratum VIII	5YR3/4	Dark reddish brown clay, small gravel and sparse cultural material.
Stratum IX	5YR3/4	Dark reddish brown loose gravel and clay; ceramics and midden.
Stratum X	7.5YR3/4	Dark brown loam with midden.
Stratum XI	5YR3/4	Dark reddish brown clay. No cultural material.

Figure 1.23 Stratigraphic profiles of east wall of EU 25 and its extension EU 26, showing details of soil types and cultural material in unit strata, Area 9S (recorded by Elizabeth Righter and Josh Kehrburg).

recovered from the ground surface. Level B consisted of hard redeposited silty clay (Munsell color, 7.5YR3/2) which was about 7 cm thick and largely devoid of cultural material. Partially excavated Level C consisted of midden similar to that in a lower level of Trench 1 and at the base of Trench 9.

A 1m^2 unit was opened at N2030/1857.50E (EU 37) on the north edge of Trench 1, adjacent to a large surficial rock which had been re-located with heavy equipment. Excavation of this unit, and the unit at N2025/1855E, wasnot completed and recovered material was not analyzed.

Tutu Archaeological Village
Profile of EU 27: N2033.50/E1843.50
View North



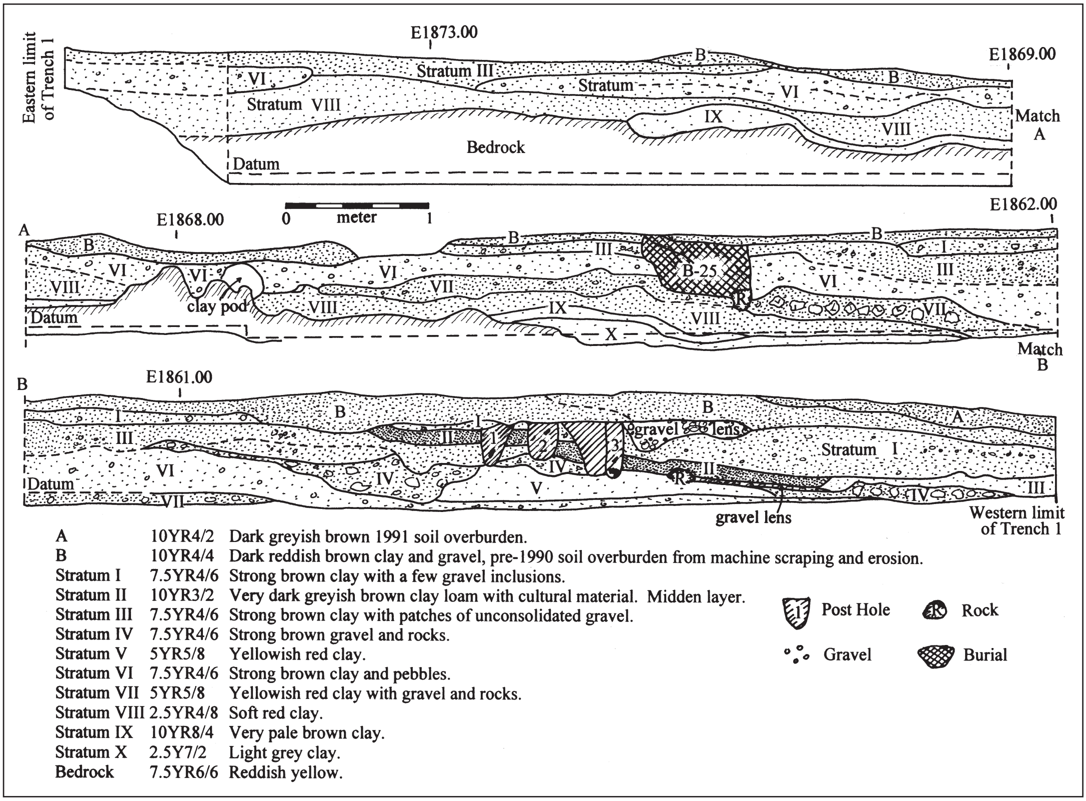
A	7.5YR4/3	Dark brown silty soil
Stratum I	10YR2/2	Very dark brown silt with densely packed midden. Shell (Cittarium pica), ceramic sherds, bone, ash and charcoal.
Stratum II	7.5YR4/4	Dark brown clay with dense midden.
Stratum III	7.5YR4/3	Dark brown gravel.
Stratum IV	7.5YR4/3	Dark brown clay loam with gravel and bits of cultural material.
Stratum V	7.5YR4/3	Dark brown compact clay loam. Sparse cultural material. Includes excavation levels C$_1$, C$_2$ and D$_1$.
Stratum VI	7.5YR3/4	Dark brown clay, gravel and rocks. Unconsolidated fill with cultural material.
Stratum VII	5YR3/4	Dark reddish brown clay and gravel; cultural material and charcoal.
Stratum VIII	5YR3/4	Dark reddish brown clay, small gravel and sparse cultural material.
Stratum IX	5YR3/4	Dark reddish brown loose gravel and clay; ceramics and midden.
Stratum X	7.5YR3/4	Dark brown loam with midden.
Stratum XI	5YR3/4	Dark reddish brown clay. No cultural material.

Figure 1.24 Stratigraphic profile of north wall of EU 27, showing details of soil types and cultural material in unit strata, Area 9S (recorded by Elizabeth Righter, graphic by Julie Smith).

Trenches 1–10

Trench 1

In the vicinity of Trench 1, pre-1990 grade had sloped slightly between the east and west ends of the trench (Figure 1.25). Scraping for mall preparation had removed about 14 cm of soil, truncating upper portions of Burial 25, three post holes, and a buried midden layer which originated



A	10YR4/2	Dark greyish brown 1991 soil overburden.
B	10YR4/4	Dark reddish brown clay and gravel, pre-1990 soil overburden from machine scraping and erosion.
Stratum I	7.5YR4/6	Strong brown clay with a few gravel inclusions.
Stratum II	10YR3/2	Very dark greyish brown clay loam with cultural material. Midden layer.
Stratum III	7.5YR4/6	Strong brown clay with patches of unconsolidated gravel.
Stratum IV	7.5YR4/6	Strong brown gravel and rocks.
Stratum V	5YR5/8	Yellowish red clay.
Stratum VI	7.5YR4/6	Strong brown clay and pebbles.
Stratum VII	5YR5/8	Yellowish red clay with gravel and rocks.
Stratum VIII	2.5YR4/8	Soft red clay.
Stratum IX	10YR8/4	Very pale brown clay.
Stratum X	2.5Y7/2	Light grey clay.
Bedrock	7.5YR6/6	Reddish yellow.

Figure 1.25 Stratigraphic profile of Trench 1, showing post holes and pit of Burial 25 exposed on south wall, Area 13 (recorded by Elizabeth Righter and Robert Pederson, graphic by Julie Smith).

at grid-point 1859.80E and sloped to the west. This midden layer, which included Saladoid series ceramic sherds, declined about 55 cm over a horizontal distance of 3 m.

In the western portion of the trench, between 10 cm and 25 cm of soil had been redeposited over the truncated features, of which the lower portions remained buried and undamaged in the soil. P-3 in Trench 1 had a 2-sigma date range of between cal. AD 1020 and cal. AD 1245 (Beta 111453), indicating that it was a late occupation feature. In the eastern half of the trench, several horizontal levels of clay and clay with gravel overlay bedrock and no cultural material was evident. The truncated top of Burial 25 was present between grid-points 1864.75E and 1864E. The burial pit, about 40 cm deep, penetrated layers of gravel and clay that sloped to the west.

Stratigraphy at the western end of Trench 1 confirmed evidence in Trench 9 that, during the early occupation of the site, midden was deposited on grade that was lower than that found in 1990 and had sloped more steeply to the west. Over time soil, probably eroding from an open area to the east, had accumulated over the sloping midden, raising elevation and creating the flat terrain on which later occupants built structures and buried their dead.

Trench 2

In Trench 2, strata sloped slightly from east to west. Bulldozer marks were present at the top of a layer of dark brown clay loam (Munsell color, 7.5YR3/4), about 10 cm thick, that underlay backdirt from trench excavation. Under the clay was a stratum of brownish red clay (5YR4/4),

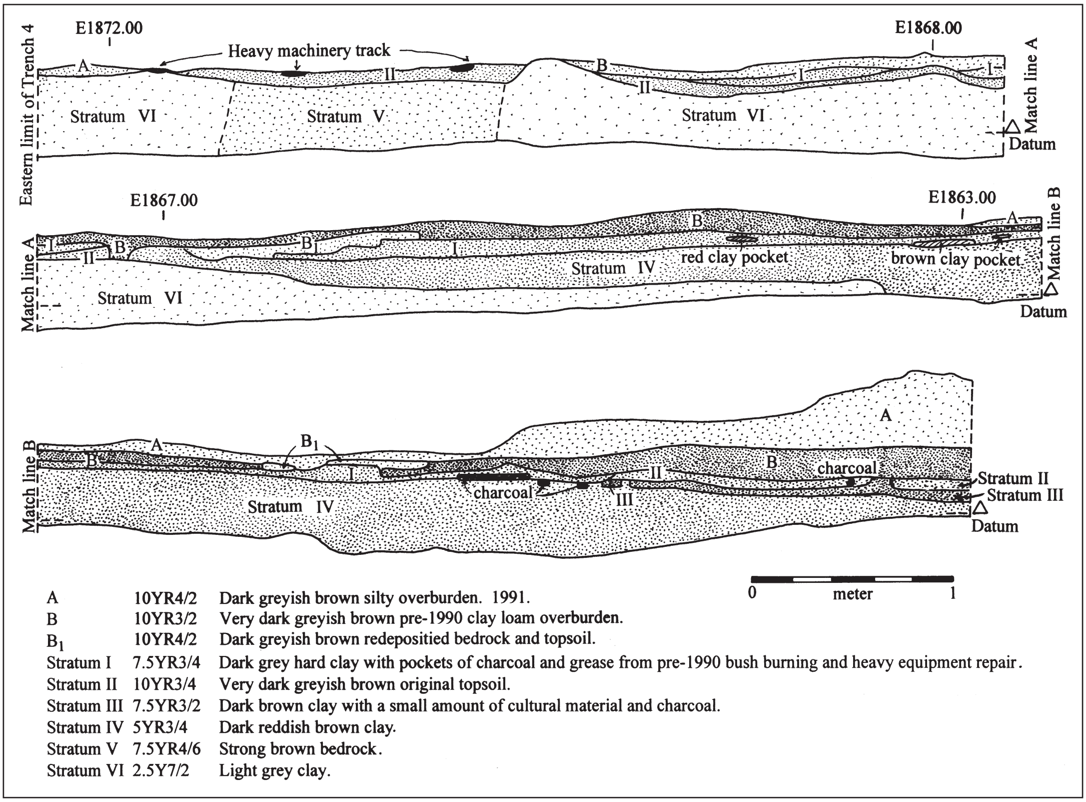


Figure 1.26 Stratigraphic profile of south wall of Trench 4, Area 5 (recorded by Elizabeth Righter, graphic by Julie Smith).

about 20 cm thick, with lenses of unconsolidated large gravel, which overlay a sterile yellowish red clay (Munsell color, 5YR4/6). Bedrock was present at about 60 cm below the 1991 grade. In Trench 2, there were no buried midden level or post holes.

Trench 3

The surface of Trench 3 sloped to the west for a grade difference of 50 cm. Underlying strata reflected this declination. Patches of very dark greasy soil with abundant charcoal, at the top of the uppermost stratum, documented pre-1990 tree burning and repair of mechanical equipment. Underlying this stratum, which was between 10 cm and 20 cm thick, was a stratum of dark red clay (Munsell color, 2.5YR3/6) mixed with rocks that overlay bedrock. No buried cultural deposits or features were observed in trench wall profiles.

Trench 4

Wall profiles of Trench 4 also revealed evidence of tree stump burning and mechanical repairs that took place on the ground surface prior to 1990. Westward from 1860E, Stratum III was a thin level of dark brown clay (Munsell color, 7.5YR3/2) with inclusions of charcoal and cultural material of unknown affiliation (Figure 1.26). Under this level, dark reddish brown clay rested on bedrock. No features were exposed in trench walls.

Trench 5

In the vicinity of Trench 5, grade was 45 cm lower than grade at the eastern end of Trench 1. Strata in the trench were horizontally layered. A superficial level of disturbed dark reddish brown topsoil (Munsell color, 5YR2/3 and 3/3) overlay light yellowish brown and dark red weathered bedrock (Munsell color, 2.5Y6/3 and 2.5YR3/6). A tree root system intruded on the north wall, but no other disturbances or features were present in Trench 5.

Trench 6

In Trench 6, white subsoil (Munsell color, 5Y8/1) and an olive-colored bedrock (Munsell color, 5Y4/3) were exposed under a discontinuous thin layer of dark grey topsoil (Munsell color, 5Y4/1). No features or cultural material were observed in the western portion of Trench 6; but in the portion east of the field tent, the pit of Burial 26 originated on the surface and intruded 22 cm into subsoil and bedrock. Two post holes were present, one on either side of the trench, about 1 m to the east of Burial 26.

Trench 7

Grade was relatively flat along the horizontal distance of Trench 7, which was opened at the southern end of Area 7 where subsoil had been exposed by pre-1990 machine scraping (Figures 1.7a–d). Sterile clay (Munsell color, 5YR7/1 light grey) was exposed beneath a discontinuous layer of very dark brown topsoil (Munsell color, 10YR2/2). The clay layer graded into light olive brown bedrock (Munsell color, 2.5Y5/4) which was exposed at between 64 cm and 82 cm below grade in the western and eastern ends of the trench respectively. Four post holes were exposed in Trench 7 profiles, three on the south wall and one on the north.

Comparison of grade before and after scraping for mall development indicated that the scraping had not been sufficient to remove features that might have been present in Trenches 2–5. It was concluded that the area had been an unoccupied open space during prehistoric occupation of the site.

Trench 8

Trench 8 was excavated in an area where topsoil had been scraped from the surface, exposing sterile red clay (Munsell color, 2.5YR4/8) and fine gravel at elevation 55.57 m amsl. The absence of cultural material and features in the soils and walls of Trench 8 indicated that it was outside the western limit of the site.

Trenches 9 and 10

Soil profiles and findings resulting from excavation of these trenches were discussed in a previous section (see pp. 46–48).

Interpretation of radiometric dates

There were 92 radiometric dates returned for the Tutu site (Figures 1.27a–d). Of these, 65 were botanical remains: 21 dated charred plant, 43 charred wood and 1 dated uncharred wood sample. Of these, 20 dates were from excavation units (Table 1.3), 1 from a hearth and 44 from post holes (Chapter 12). There were 27 AMS dates obtained on bone collagen of human skeletons recovered from the Tutu burials (Table 1.4). Error ranges for 'Accelerator Mass Spectrometry' (AMS) dates were between ±30 years and ±90 years, while, for post wood and charred plant remains, they were between ±50 and ±140 years. Each sample was individually calibrated by Beta Analytic Inc. to yield a 2-sigma date range. This provides a 95 percent probability that an event occurred anywhere within that range. At 1-sigma the range is narrower, but there is only a 68 percent chance of an event having taken place within that time range.

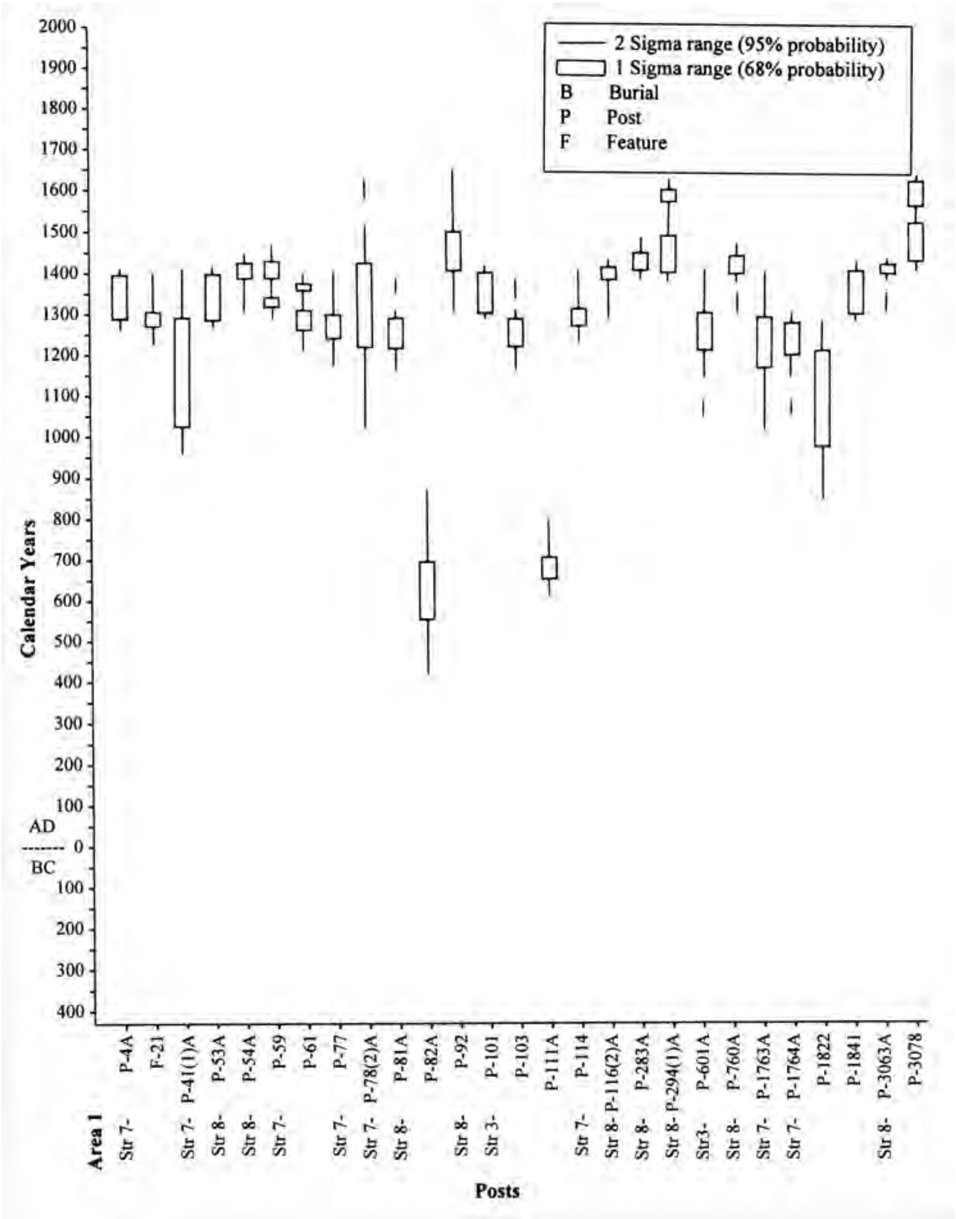


Figure 1.27a–d Time chart showing 1-sigma and 2-sigma AMS date ranges obtained on bone collagen from human remains; and date ranges obtained from radiometric analysis of charred plant and wood samples from excavation units and features of the Tutu site (graphic by Julie Smith, from drawing by Elizabeth Righter).

Beta Analytic Inc. automatically corrects $^{13}C/^{12}C$ ratios for AMS dates, and the $^{13}C/^{12}C$ ratios of carbon samples recovered from excavation units at Tutu also were corrected by Beta Analytic. According to Dr Ron Hatfield (personal communication, 3 April 1998), the precision and accuracy of corrected radiometric dates and AMS dates on bone collagen are the same and the results of the

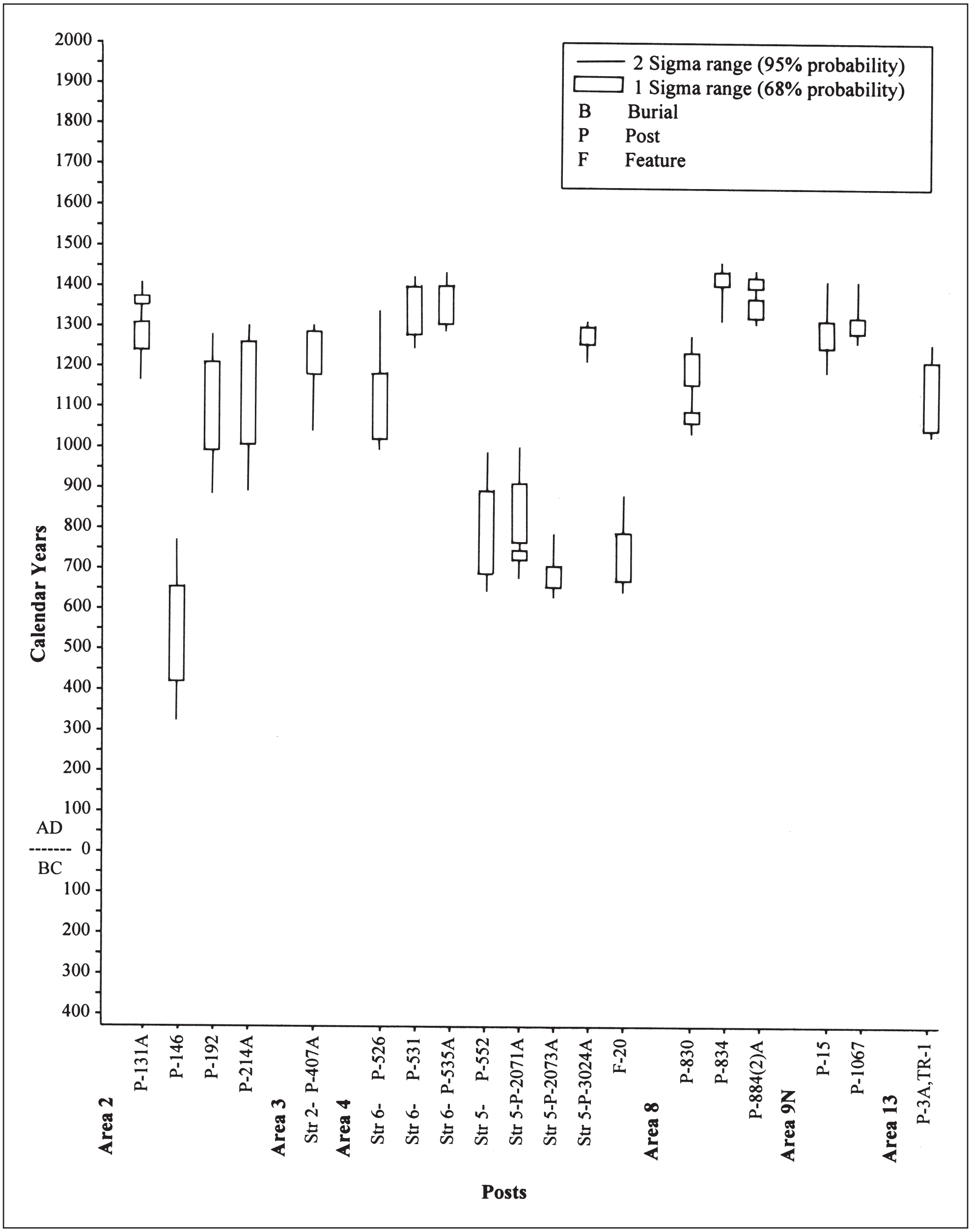


Figure 1.27b

two dating methods are totally comparable. Because $^{13}C/^{12}C$ ratio correction must be requested at additional cost, however, and because it was doubted that the result would justify this extra cost, $^{13}C/^{12}C$ ratio correction was not requested for dates obtained on carbonized wood and wood samples recovered from Tutu post holes, and a standard of –25 was used by Beta Analytic Inc.

Samples collected for radiometric dating are subject to natural variation and cultural manipulation (for example, dogs or other rooting animals may disturb midden levels; or old post wood may

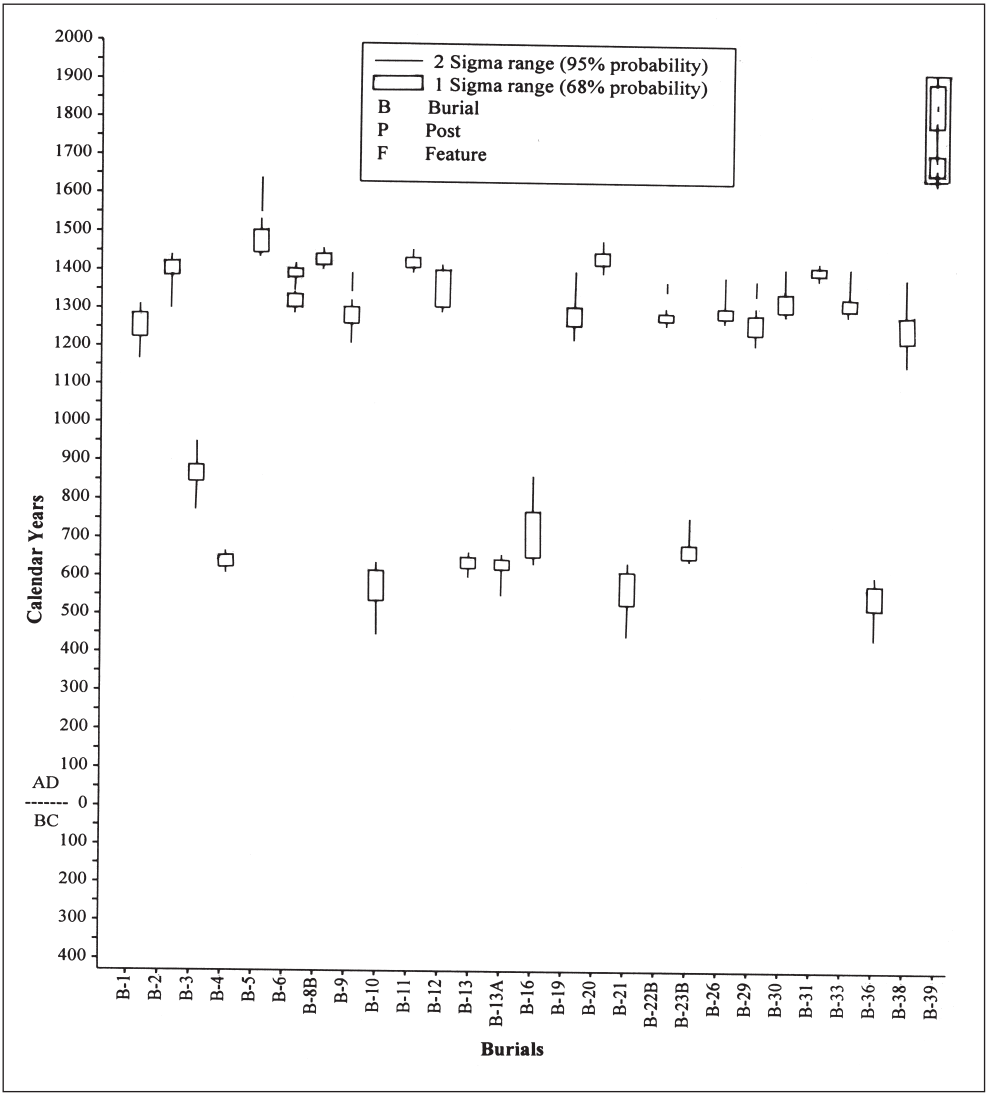


Figure 1.27c

be re-used in later structures). In addition, at Tutu, AMS dates returned on bone collagen generally had tighter ranges than radiometric dates on carbonized plant remains. Thus, interpretation of some dates required evaluation in terms of other evidence from the site; and, in general, the dates obtained at Tutu can be considered only one among a number of interpretive tools.

With that in mind, radiometric dates for the site are interpreted to obtain an estimated time of original site settlement and to provide time frames for the two major occupations of the site, their subdivisions, and an apparent gap in the chronology.

Beginning 2-sigma date ranges for Level B of the Area 1 midden are the earliest for the site, but a large error factor and long 2-sigma date ranges for the midden make it difficult to establish a firm date for settlement of the site. An early date recovered from a gravel lens in N2097.00/1821.50E, Level E (Figures 1.13, 1.27b; Table 1.3) is anomalous with other dates, and apparently dates a

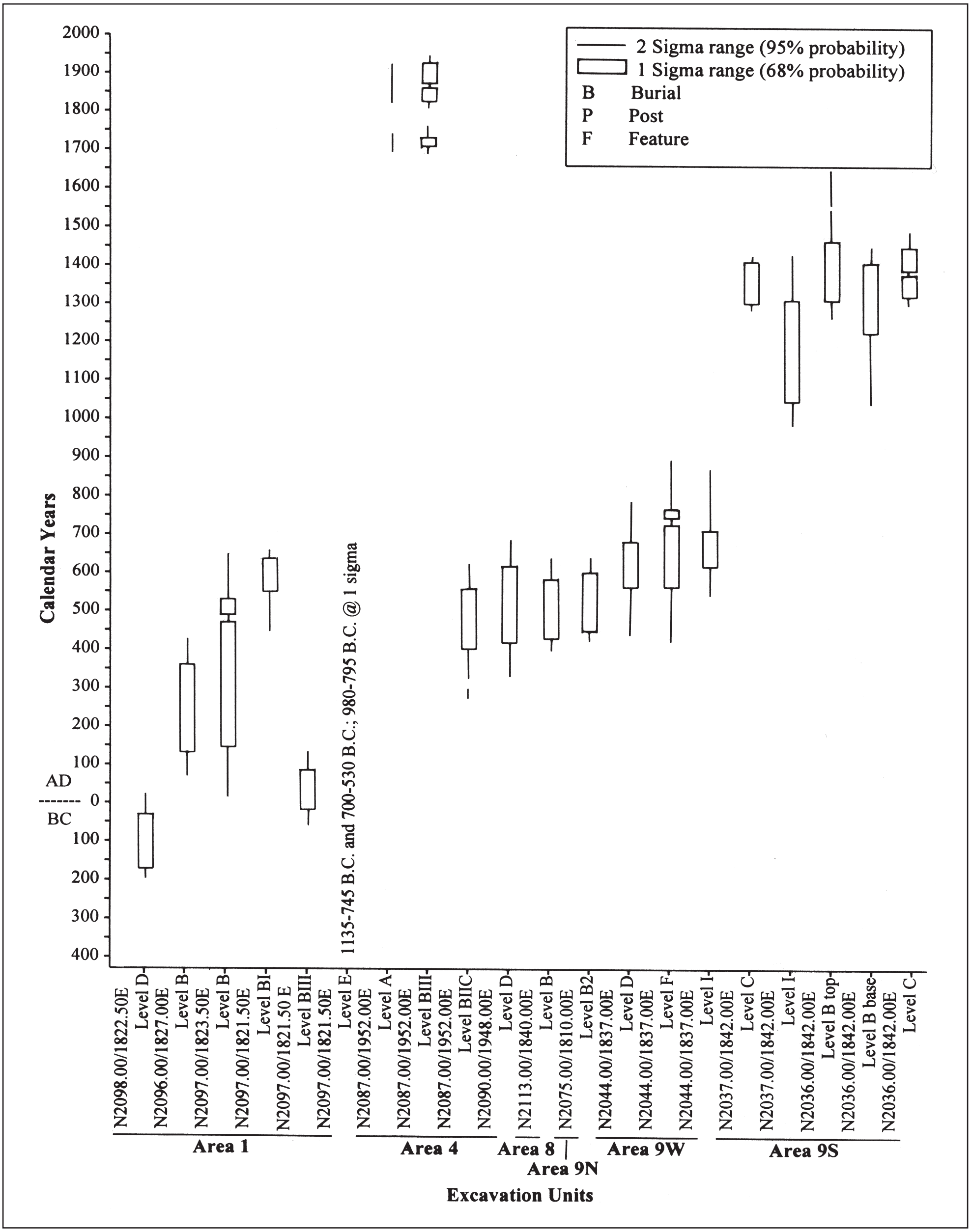


Figure 1.27d

natural gravel level. A date from Level D in N2098.00/1822.50E, taken from the very bottom of the midden, also is suspected of being too early, possibly dating a natural stratum beneath. Two other samples from the Area 1 midden (Beta 111462, 108888) returned 2-sigma dates with ranges that begin at cal. 60 BC and cal. AD 15 respectively. These dates are less easy to dismiss. For example, features such as P-1701, which originated under upper midden levels, and P-614 which originated under upper levels of Profile 5, hint at an initial localized small settlement in Area 1 or

Table 1.3 Radiometric and Accelerator Mass Spectrometry (AMS)[a] dates obtained from carbon samples extracted from midden contexts of the Tutu site

Beta no.	*Grid coordinate and level*	*Calibrated age 2-sigma or 95% probability*	*Calibrated age 1-sigma or 68% probability*
Area 1			
108917	N2098.00/1822.50E Level D	200 BC–AD 25	175 BC–35 BC
65474	N2096/1827E Level B	AD 65–420	AD 130–350
108888	N2097.00/1823.50E Level B	AD 15–635	AD 145–465 AD 475–515
108889	N2097.00/1821.50E Level BI	AD 440–650	AD 540–630
111462	N2097.00/1821.50E Level BIII	60 BC–AD 130	20 BC–AD 85
111459	N2097.00/1821.50E Level E (gravel lens interface)	1135 BC–745 BC 700 BC–530 BC	980 BC–795 BC
Area 4			
65470	N2087/1952E Level A	AD 1680–1755 AD 1815–1925	No sigma date
65471	N2087/1952E Level BIII	AD 1680–1755 AD 1805–1940	AD 1700–20 AD 1820–55
50066	N2087/1952E Level BIIC	AD 265–90 AD 320–615	AD 395–550
54646	N2090/1948E Level D	AD 330–660	AD 415–615
Area 8			
65473	N2113/1840E Level B	AD 390–630	AD 425–575
Area 9N			
65472	N2075/1810E Level B_2	AD 415–630	AD 440–590
Area 9W			
62568	N2044/1837E Level D	AD 435–780	AD 560–675
62569	N2044/1837E Level F	AD 420–885	AD 560–720 AD 735–60
62570	N2044/1837E Level I	AD 535–865	AD 615–705

(continued on next page)

Table 1.3 (cont.)

Beta no.	*Grid coordinate and level*	*Calibrated age 2-sigma or 95% probability*	*Calibrated age 1-sigma or 68% probability*
Area 9S			
111461	N2037/1842E Level C	AD 1275–1410	AD 1290–1395
48742	N2037/1842E Level I	AD 980–1420	AD 1040–1300
51354	N2036/1842E Level B – top	AD 1250–1535 AD 1545–1635	AD 1295–1450
51355	N2036/1842E Level B – base	AD 1035–1435	AD 1220–1395
111452	N2036/1842E Level C	AD 1285–1470	AD 1310–65 AD 1375–1435

Note
a Dates include analysis of $^{13}C/^{12}C$ ratios.

its vicinity. Of the 9 stone and shell artifact types associated with the Hacienda Grande style of Puerto Rico, 7 dated to between 160 BC and AD 400 by Rouse & Alegría (1990: 57) were recovered from Level B of the Tutu Area 1 midden, also lending support for an early component in Area 1.

On the other hand, Lundberg (Chapter 5) finds that ceramics identified in her Assemblage 1 from the Area 1 midden share attributes with mid-phases of Hacienda Grande (equivalent of the Virgin Islands' mid-Prosperity style, but not early Prosperity), and possibly with beginning phases of the Coral Bay–Longford style (as proposed, the Coral Bay–Longford style is viewed as two styles: an earlier Coral Bay style and a later Longfordian style, Lundberg & Righter, 1997; Lundberg, Chapter 5) in the Virgin Islands.

No burials were found in or under the Area 1 midden; the nearest identified burial, Burial 30 in Area 9N, was dated to the later occupation of the site. Screening of dirt retained in soil piles overlying the Area 1 midden, however, recovered a small number of human bone fragments and teeth, indicating that previous scraping may have disturbed unknown burials somewhere in the vicinity of the Area 1 midden.

Two-sigma date ranges for Level B in EUs 6 and 4 overlap between cal. AD 65 and cal. AD 420 (Beta 108888, 65474) and provide reasonable date ranges for ceramics and some artifacts in the Area 1 midden. While there may indeed have been an earlier habitation in an uninvestigated portion of the site near Area 1, available evidence reconciles best with 2-sigma date ranges for charcoal samples from Level B of EUs 6 and 4; and AD 65 is acceptable as an early date for settlement of the site.

Date ranges for Assemblage 2, recovered from upper portions of the Tutu Area 1 midden and from the Areas 4, 8 and 9N middens, correspond well with those for the Cuevas ceramic style of the late Saladoid series in Puerto Rico. Assemblage 2 is equated with the Coral Bay style of the Virgin Islands (Chapter 5).

Although dates for the Cedrosan Saladoid subseries in Puerto Rico and the Virgin Islands have not been extended beyond AD 630 (Rouse, 1992: Figure 14; Rouse & Alegría, 1990: 55), at Tutu, ceramics indicative of a later phase of the Saladoid series were recovered from N2044/1837E in Area 9W, in

Table 1.4 AMS dates[a] from bone collagen samples extracted from human skeletal material recovered from the Tutu site

Beta no.	*Burial no.*	*C^{14} age BP*[b]	*^{13}C/^{12}C ratio*	*Conv. C^{14} age BP*[c]	*Calibrated age 2-sigma or 95% probability*	*Calibrated age 1-sigma or 68% probability*	*Intercept*[d]
73390	B-1	640±60	–17.2‰	770±60	AD 1170–1310	AD 1230–1290	AD 1270
109070	B-2	450±50	–18.8‰	550±50	AD 1305–1445	AD 1395–1425	AD 1410
83010	B-3	1090±30	–19.4‰	1180±30	AD 785–960	AD 855–890	AD 880
83001	B-4	1330±30	–20.7‰	1400±30	AD 620–675	AD 640–65	AD 650
88344	B-5	300±40	–18.6‰	400±40	AD 1435–1535	AD 1450–1505	AD 1470
109071	B-6	480±50	–19.5‰	570±50	AD 1300–1435	AD 1315–45	AD 1405
						AD 1390–1420	
83007	B-8B	340±30	–16.9‰	470±30	AD 1420–1460	AD 1425–50	AD 1435
73391	B-9	580±60	–16.1‰	730±60	AD 1210–1320	AD 1260–1300	AD 1280
					AD 1340–90		
88345	B-10	1390±40	–17.7‰	1510±40	AD 450–640	AD 540–615	AD 575
88346	B-11	390±40	–16.9‰	520±40	AD 1395–1450	AD 1410–35	AD 1420
83008	B-12	540±30	–19.8‰	620±30	AD 1295–1410	AD 1305–1400	AD 1315
83009	B-13	1300±30	–17.6‰	1420±30	AD 605–65	AD 630–55	AD 645
83006	B-13A	1280±40	–15.3‰	1440±40	AD 560–665	AD 605–650	AD 635
73392	B-16	1190±60	–17.7‰	1310±60	AD 640–870	AD 660–780	AD 690
73393	B-19	600±60	–17.5‰	720±60	AD 1220–1400	AD 1260–1300	AD 1290
109072	B-20	380±50	–18.3‰	480±50	AD 1400–85	AD 1420–50	AD 1435
83011	B-21	1390±40	–17.5‰	1510±40	AD 450–640	AD 540–615	AD 575
83005	B-22B	600±30	–18.3‰	700±30	AD 1275–1310	AD 1285–1300	AD 1290
					AD 1365–75		
83000	B-23B	1230±30	–19.3‰	1330±30	AD 655–770	AD 665–95	AD 680
88347	B-26	560±40	–18.8‰	660±40	AD 1280–1400	AD 1290–1315	AD 1300
73394	B-29	630±60	–18.2‰	740±60	AD 1220–1320	AD 1250–1300	AD 1280
					AD 1350–90		
88348	B-30	470±40	–17.7‰	590±40	AD 1300–1425	AD 1310–55	AD 1400
						AD 1385–1410	AD 1390
83004	B-31	500±30	–22.4‰	540±30	AD 1395–1435	AD 1405–25	AD 1415
88349	B-33	460±40	–17.1‰	580±40	AD 1300–1425	AD 1315–45	AD 1400
						AD 1390–1415	
83003	B-36	1390±30	–16.6‰	1530±30	AD 450–615	AD 535–90	AD 555
73395	B-38	590±90	–16.1‰	740±80	AD 1170–1400	AD 1240–1300	AD 1280
83002	B-39	80±30	–18.9‰	180±30	AD 1660–1700	AD 1670–1950	AD 1675
					AD 1720–1820	AD 1685–1740	AD 1770
					AD 1855–60	AD 1810–1930	AD 1800
					AD 1920–50		AD 1940

Notes

a Dates include analyses of ^{13}C/^{12}C ratios.

b BP is "years before present" with the present being at AD 1950.

c Conventional (Conv.) C^{14} age is the result after applying ^{13}C/^{12}C corrections to the measured age.

d Intercept is the point where the conventional radiocarbon age intersects the calibrated calendar time scale.

contexts dated to between cal. AD 420 and cal. AD 885 (2-sigma, Beta 62569). Date ranges for Burials 3 and 23B, which contain Saladoid series ceramics, also have maximum 2-sigma range between cal. AD 655 and cal. AD 960 (2-sigma, Beta 83010, 83000). Although statistical error may contribute somewhat to extension of the date range for the early occupation at Tutu, it is apparent that ceramics consistent with a late phase of the Saladoid series and associated artifacts such as green stones persisted at Tutu, unaffected by new influences, for several generations after AD 630. Extension of the late Saladoid series into the tenth century after Christ also has been reported at the Anse des Peres site on St Martin (Hamburg, Nippenburg, Nokkert & Brokke, 1995); and Hofman (1993: 1) puts ending dates for the Saladoid series in the northern Lesser Antilles at between AD 600 and AD 850. There is a growing body of evidence, therefore, to support the suggestion that late Saladoid styles at some sites in the Virgin Islands and the northern Lesser Antilles may extend as much as 250 years beyond the terminal dates of AD 600 suggested by Rouse (Hamburg *et al.*, 1995; Chapter 5, this volume; Lundberg & Righter, 1997; Vescelius, 1979). Siegel (1992: 114) has proposed extension of dates for the late Saladoid Cuevas style in Puerto Rico to AD 700.

At the Tutu site, radiometric dates and negative ceramic evidence suggest a gap in the record between about AD 900 and AD 1150. When 1-sigma ranges are used, the gap is present between AD 900 and AD 1200, which coincides with a lack of early Ostionoid, or the Magens Bay/Salt River I and II ceramic styles, in the wide range of features excavated throughout the Tutu site. At 1-sigma, there are no dated burials between cal. AD 900 and cal. AD 1225. Evidence for a period of abandonment also may be indicated in the stratigraphic profiles of units southwest of Soil Mound No. 4. Such evidence cannot be taken as entirely conclusive, however, since parts of the site were uninvestigated and the late Ostionoid midden remnant on the site was small and localized. As a result of large error factors, 2-sigma date ranges for some house posts extend into the “gap,” but, when these posts are included with other posts of their affiliated structures (Chapter 12), they are removed from this period.

Two-sigma radiometric dates for upper midden in the southwestern units, and for the majority of burials and posts of identified structures, fall within a period between AD 1150 and AD 1500; and it is apparent that the site was well populated during all or most of this time. While date ranges for Burials 5 and 8B, 11, 20 and 31 begin at AD 1395 or afterwards, dates for only one of these burials extend beyond AD 1500 and it is likely that the site was abandoned prior to that time. Post hole dates, and the absence of any fifteenth- or sixteenth-century European trade goods, tend to substantiate this finding.

Available evidence from the Tutu site, therefore, indicates two major periods of occupation: one with 2-sigma date ranges between about AD 65 and AD 950, and another between about AD 1150 and AD 1500. Although the early occupation is better represented in middens, the later period is better represented in features. Recognizing that a majority of midden from the late period is missing, the evidence suggests that the later occupation of the site was continuous and populous.

Site features

There were 34 site features identified either in excavation units, soil profiles or exposed surfaces of the site (Figure 1.7a–d). Most site features proved to be either post holes, burials, hearths and kilns (discussed elsewhere in this chapter), or non-cultural stains and soil anomalies that yielded no phytoliths or information useful to interpretation of the site. The remainder are briefly described in numerical sequence below.

Features 1 and 2, two small pockets of faunal bone, about 20 cm x 18 cm in plan and 10 cm deep, were exposed on the surface of the scraped subsoil of Area 3. The presence of these filled pockets in subsoil suggests that the area (a possible burial yard discussed in Chapter 12) was exposed to subsoil when the material was deposited.

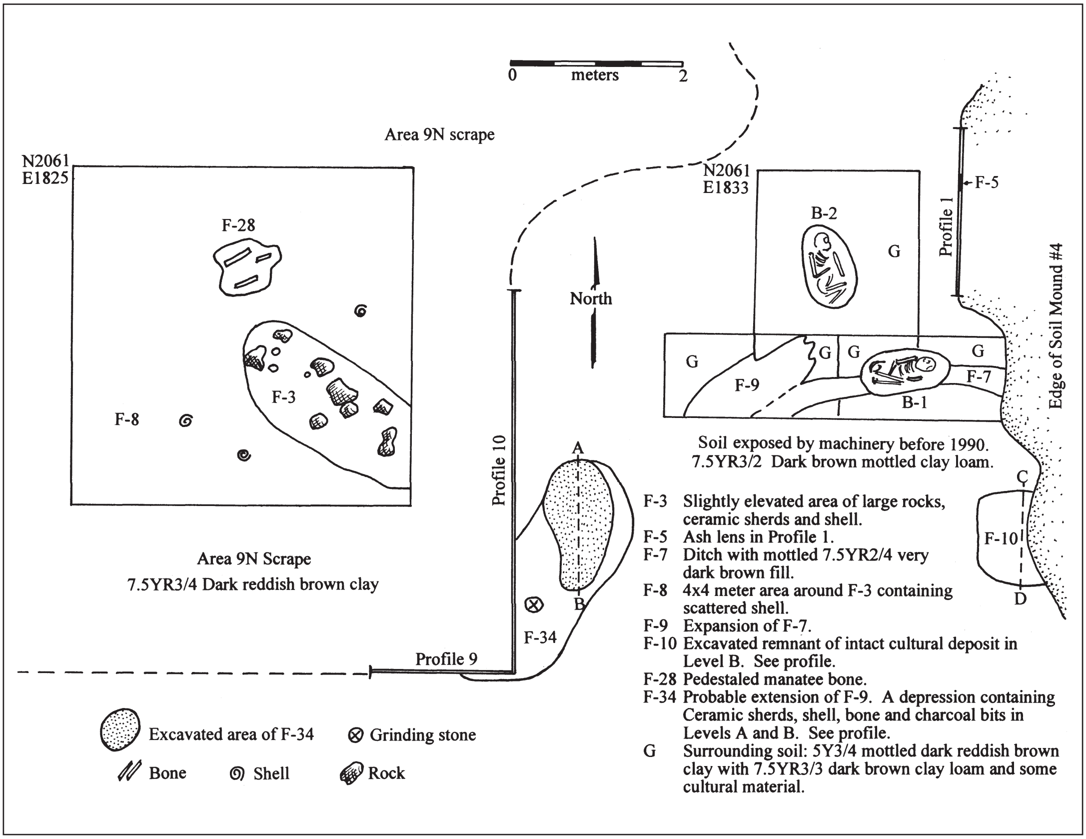


Figure 1.28 Plan view of a portion of Area 9N, showing Features 7, 9 and 34 in relationship to Burials 1 and 2, along with Features 3, 8, 10 and 28 (recorded by Elizabeth Righter and Emily Lundberg, graphic by Julie Smith).

Features 7 and 9 (and 34 which is discussed below) in Area 9N (Figure 1.28) perhaps were a type of archaeological evidence that rarely survives in prehistoric habitation areas (Siegel, 1990a: 403). Feature 7 was a shallow trough or ditch, about 15 cm deep, exposed in N2059/1832E, through N2059/1835E. The fill of the feature was disturbed clay loam distinguished from surrounding soils only by the presence of charcoal flecks. Burial 1 was an interment in this trough, but the burial pit extended only 8 cm into the trough fill, demonstrating that the burial took place after the ditch was filled. The burial pit fill was the same as that in Feature 7 and it also contained charcoal flecks. Dates for the burial (between cal. AD 1170 and cal. AD 1310, 2-sigma, Beta 73390) provide a *terminus ante quem* for Feature 7.

An explanation for this feature might be found in Roe & Siegel's (1982: 116) description of house drainage channels. The authors observe that, when a new house is erected in a Shipibo village, a shallow channel is scraped around the perimeter to aid drainage. Subsequently, downpours of rain turn the channel into a wide gutter that leaves the house sitting on a platform of earth elevated between 10 cm and 30 cm above the surrounding surface. The mounded area survives only if the site is abandoned. Otherwise, to provide a level space for a new house, succeeding generations cut down the old platform and fill the "inevitable flanking runoff gullies" with its remains. Siegel (1990a: 405) also has observed that gullies or driplines can be expected to form naturally where water pours from a thatched roof. These descriptions fit the archaeological evidence found in Feature 7 which most likely was an excavated water channel or dripline of a structure situated to the south of the feature.

Site Feature 9, which was not investigated, appeared to have resulted from overflow of the trough of Feature 7.

Feature 10 was an in-place soil remnant that escaped pre-1990 machine scraping. The wedge-shaped feature consisted of mottled soil, charred wood fragments and cultural material, including potsherds of the Saladoid series, which extended to 14 cm below datum on its northern end. Underlying soil was a dark brown clay loam (Munsell color, 7.5YR3/4) devoid of cultural material. No further identification was made of this feature.

Feature 12 was a small midden lens, the southernmost extent of the Area 1 midden, exposed in Profile 6.

In the southeastern portion of N2115.50/1838E were the remains of Feature 27, a complete *Chelonia mydas (*green turtle) buried in a midden of crab claws, bone, shell, ceramic sherds and other refuse (Figures 1.17c and 1. 29). The carapace was upturned and there was no evidence of the plastron, head, or claws. Rafe Bulon, Biologist for the Virgin Islands Fish and Wildlife Agency, who viewed the remains, indicated that the animal was lying on its back with the head oriented to the east. Major bones were present, although not articulated, inside the shell. Several large flat rocks surrounded the feature, which was buried at between 15 cm and 19 cm below an interim datum at grade. Under the northeastern edge of the turtle shell was a red-painted Cedrosan Saladoid adorno, a *trompe l'oeil* anthropomorphic figure (Figure 1.29a) that apparently had been a lug on a large pot. Excavation of a baulk between N2115.50–N2116/1839.50E and N2116/1840E revealed that the flat rocks surrounding the turtle extended in an eastward direction to join the rocks of a hearth, Feature 33. Resting atop rocks of this hearth was a small red-painted pot with inverted rim, rounded shoulders and a small flat base.

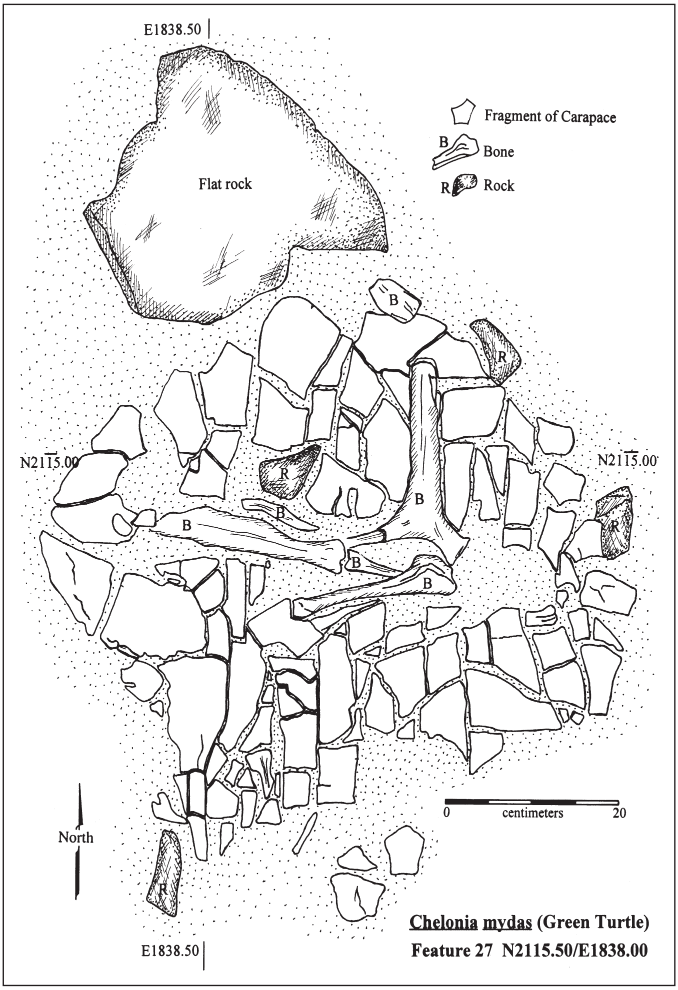


Figure 1.29 Detailed drawing of carapace and bones of Feature 27, a *Chelonia mydas* buried in midden of EU 16, Area 8 (drawn and recorded by Elizabeth Righter, reproduced as a graphic by Julie Smith).

A turtle burial in a midden at the Golden Rock site on St Eustatius (van der Klift, 1992: 75) and turtle bones associated with pottery vessels and a half-circle of hearths at the Tanki Flip site on Aruba (Rostain & Versteeg, 1997: 333) were identified by excavators as caches indicative of symbolic behavior. Versteeg (personal

Figure 1.29a Adorno recovered from under the carapace of a *Chelonia mydas* (Feature 27) buried in midden of Area 8 (photograph by Elizabeth Righter).

communication, July 1995) also sees the turtle burials as signs of continuity from the Saladoid to the later pre-contact period.

With this in mind, the scenario at Tutu is subject to several interpretations. The Tutu turtle burial/hearth complex may have been an intentionally constructed feature with symbolic meaning; for example, flat rocks surrounding the eastern portion of the turtle may be interpreted as a primitive "altar" and the round ceramic bowl may have contained "offerings." On the other hand, a purely practical interpretation fits the evidence as well. The turtle was securely buried in a midden, with refuse above, under and around it, suggesting the discarded remains of a food item. The turtle may have been cooked and consumed (the carapace acting as a communal bowl) and its major bones deposited back into the shell. Flat stones north and east of the turtle may have been used during food preparation and may have supported vessels, such as the vessel found east of the turtle remains, related to food preparation, cooking and eating.

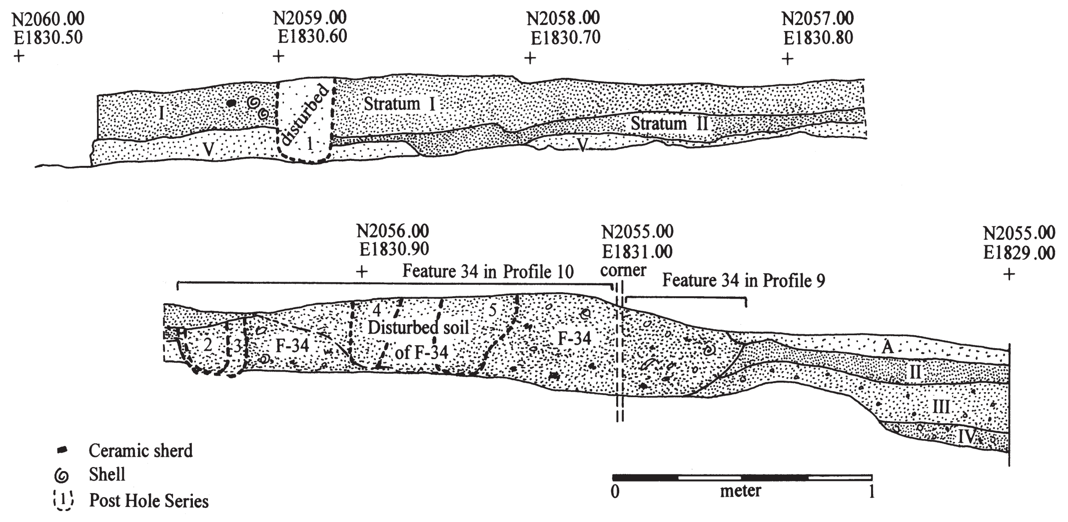
It is apparent that the turtle was a significant animal in the lives of the Tutu inhabitants (as evidenced by a recovered turtle fetish, discussed later), both symbolically and as a source of food. The turtle shell was prized as a container and it is puzzling, if the turtle was a food item, that its shell would have been buried. In a third scenario, the turtle may have been brought to the site for food, but for some reason was not edible and the dead turtle, with its spoiled meat, was tossed out in the midden west of the hearth where dogs or other rooting animals may have disturbed the extremities.

Feature 28 proved to be a purely superficial cluster of *Trichechus manatus* (manatee) bones; and Feature 29 was a stain, about 25 cm deep, which contained an isolated cluster of undecorated potsherds. The cluster was not believed to have been an intentionally deposited cache, but may have been a group of utilitarian vessels that fell from a storage rack, broke, and were abandoned in place where they become incorporated into the archaeological record (Roe & Siegel, 1982: 105).

Feature 32 was an isolated surficial cluster of bone and ceramics exposed in Area 1.

Feature 34 (Figure 1.30) was either a separate feature or an extension of Features 7 and 9 in Area 9N. On the ground surface, the stain of Feature 34 extended, in a semi-circular pattern, east from Profile 10 and south from Profile 9, but a link with Feature 7 was not visible. Since the western portion of Feature 34 had been removed by machine scraping, the full dimensions of the feature are not known.

Like Feature 7, charcoal flecks occurred in the Feature 34 fill. In Profile 10 (Figure 1.30), the feature appeared to be ditch-like, but the top of Feature 34 may have been mounded. In Profile 10 also, the



A	10YR3/3	Dark brown disturbed soil overburden.
Stratum I	10YR3/6	Dark yellowish brown clay with sparse cultural material.
Stratum II	7.5YR3/4	Dark brown clay.
Stratum III	7.5YR4/4	Dark brown clay and gravel.
Stratum IV	5YR3/4	Dark reddish brown gravel and clay.
Stratum V	2.5Y5/4	Light olive brown subsoil.
Feature 34	Mixed soils and midden with ceramics, shell (Cittarium pica), charcoal and bone. Soils include 10YR3/3 dark brown clay, 7.5YR3/4 dark reddish brown clay, 10YR4/3 brown and 10YR3/6 dark yellowish brown clay.	

Figure 1.30 Views east and south showing Feature 34 and post holes exposed in Profiles 10 and 9, Area 9N (recorded by Elizabeth Righter, graphic by Julie Smith).

tops of post holes 4 and 5, and the top of Feature 34 east of post holes 2 and 3, appear to have been truncated by machine scraping. Post holes 2 and 3 originated below Stratum 1 and penetrated the bottom of the feature, indicating that, like post holes 4 and 5, the features had been constructed after Feature 34 had been filled. Post hole 1, which penetrated Stratum 1, was a later post.

The bottom of Feature 34 sloped gradually from 30 cm below datum on its north end to 40 cm below datum where it met Profile 9 on its southern end. The slope in Profile 9 indicated that the base of the entire feature inclined to the southwest. The sloping base of Feature 34 and the direction of the feature's arc suggest that Feature 34 may have been a wide water channel or dripline of a structure situated to the northwest.

Hearths

Five stone hearths and one possible cooking area were identified in three areas of the Tutu site. These features were first assigned feature numbers (Figures 1.7a–d) and later given the designation "H" (Chapter 12). It is likely that other exterior and interior hearths were destroyed either by post-depositional processes, such as farming and grazing, or by machine scraping.

Feature 16 (72H) was an elliptically shaped hearth, 47 cm wide, 84 cm long and 16 cm deep on the eastern edge of Area 1(Figure 1.31). Four fire-cracked rocks, 144 g of marine shells, bone and crab claw fragments, and 106 g of ceramic sherds, were recovered from the sandy clay loam matrix of the feature. There was abundant charcoal throughout, and patches of burned clay also occurred

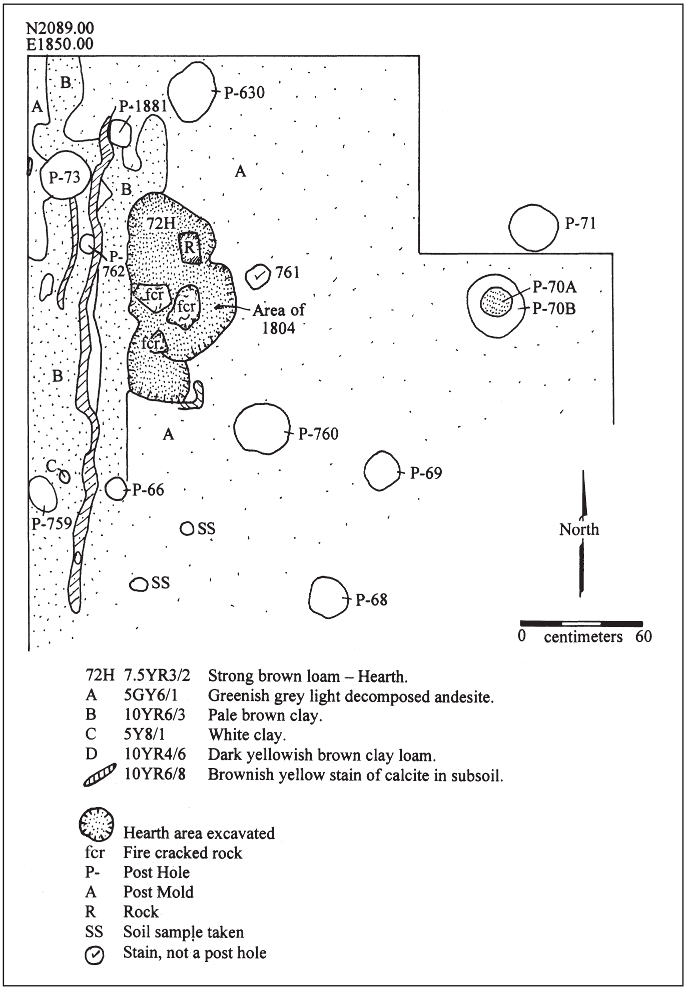


Figure 1.31 Plan view of hearth, Feature 16 (72H), and surrounding post holes and stains, Area 1 (recorded by Elizabeth Righter, graphic by Julie Smith).

in the matrix. In the andesite subsoil (Munsell color, 2.5Y7/1) at the base of the feature, stains of two post holes, P-72(1) and P-72(2), appeared. These post holes were excavated to their bases at 52 cm below the scraped surface. Feature 16 appeared to be associated with Structure 7 in Area 1 (see Chapter 12).

Feature 759H, 64 cm long and 86 cm wide, was located in close proximity to Feature 16. Numerous fire-cracked rocks, 17 g of faunal material and 156 g of ceramic sherds were recovered from the feature which was 24 cm deep. Soils were dark brown clay loam (Munsell color, 2.5Y dark olive brown). Ceramic sherds were not among those analyzed by Dr Lundberg and no date was obtained for the feature. Feature 759H, situated about 1.25 m inside the eastern wall of Structure 8, may have been used by occupants of that structure. The hearth was too close to the exterior wall of Structure 7 to have been used by occupants of Structure 7 (Chapter 12).

Feature 21 was exposed among a cluster of features northwest of Structure 7 and west of Structure 8 (Figures 1.7a–d, 1.32). Several fire-cracked rocks, including a possible "fire-dog" to support cassava griddles (personal communication, Jeff Walker) were recovered from Feature 21, which was roughly triangular in plan, 70 cm wide at the base, 64 cm long and 23 cm deep. Soil of the feature was dark brown clay loam (Munsell color, 10YR3/3 dark brown) from which abundant charcoal, 183 g of faunal material and 87 g of ceramic material were recovered. At the base of the feature, wedged beneath a rock, was an unusual red-painted adorno (Figure 5.26c), which apparently represented a frog and was similar in style to others of the Cedrosan Saladoid subseries. Located 1.50 m outside the exterior wall of Structure 8, Feature 21 was probably used by the structure's occupants. It was too close to the wall of Structure 7 to have been a working hearth of that structure.

The proximity of the hearth to the early occupation Burial 15 (Figure 1.32) initially was puzzling. In the case of Burial 15 and Feature 21 at the Tutu site, however, the relationship must have been accidental. Charcoal from Feature 21 returned a date of between cal. AD 1225 and cal. AD 1400 (2-sigma, Beta 112966), overlapping with dates for Structures 7 and 8, and indicating that the hearth was in use long after the human interment, which, fortunately, had escaped

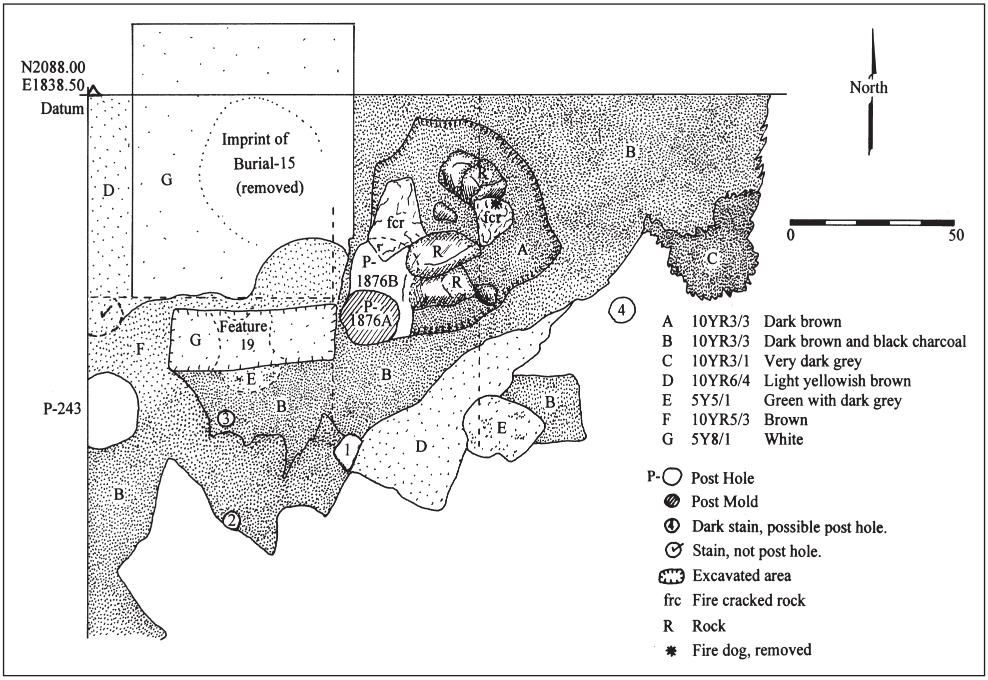


Figure 1.32 Plan view of hearth, Feature 21, in relationship to Burial 15 and adjacent features, Area 1 (recorded by Elizabeth Righter, graphic by Julie Smith).

damage during later occupations of the area. There is no ceremonial or other known connection between the two features. This finding emphasizes the importance of obtaining radiocarbon dates for features that are spatially close but may not, in fact, be related.

Feature 33 was exposed on the western edge of N2116/1840 E and extended into the baulk on the east side of N 2115.50/1839.50E (Figure 1.19). The elliptical rock formation measured 120 cm in an east–west direction and 90 cm in a north–south direction, with its base at 21 cm below the interim datum point at the corner of N2116/1840E. In the center of the rock cluster were dense concentrations of burned faunal bone, crab claws, seashells and a few ceramic sherds in a dark brown silty loam (Munsell color, 10YR3/3). From this area, 143 g of faunal material and 28 g of ceramic sherds were recovered. In spite of a limited amount of charcoal, the feature was identified by the excavator as a hearth. The flat rocks associated with the hearth extended to Feature 27.

Feature 3 (see Figure 1.28) was a concentration of fire-cracked rock and crushed *Cittarium pica* shell, and Feature 8 was a scatter of similar material around it. After investigation, Features 3 and 8 were identified as remains of a hearth, the upper portions of which had been removed and scattered by pre-1990 machine scraping. The remnant hearth base was 2.20 m long, 50 cm wide and 10 cm deep. Feature 3H may have been inside a structure represented by Feature 34, or on the exterior of another structure in the area. Feature 28, which consisted of an isolated cluster of manatee bones exposed by machine scraping, may have been debris associated with the hearth.

Area 9S cooking area

Along the south edge of Trench 9, a semi-circular unit was opened (Figure 1.7c). In this unit the upper midden , Level C/E, was exposed and excavated. A flat rock 30 cm long, 18 cm wide and 10 cm thick was uncovered, along with several other rocks in a matrix of very dark greasy clay loam

(Munsell color, 10YR3/2 very dark grey), charcoal, ash and faunal material, indicating continuity with the late occupation midden exposed in adjacent units. *Trichechus manatus* (manatee) rib bones were among faunal remains recovered from this excavation, as well as from Trench 9 fill, as noted earlier. Although the configuration of rocks in the exposed midden on the south side of Trench 9 did not appear to be an intact hearth, the thick greasy residue suggests that manatee was cooked in or near this area.

Manatee rib remains were also found in Area 4, as well as in Areas 9N and 13. A manatee ear bone recovered from topsoil in Area 1 and manatee teeth recovered from P-92 of Area 1 and P-3003 in Area 4 testify to the fact that the head also was at the site. In a fashion similar to Eskimo and Aleut walrus consumption, the inhabitants of the Tutu site probably used all parts of the manatee for food and for other purposes (Moreau, 1985). The wide distribution of manatee remains on the site indicates that butchered animals were probably shared among households. The shallow warm waters of the Mangrove Lagoon at the mouth of Turpentine Run would have been ideal habitat for the animals, and it is likely that manatee provided a substantial portion of the marine animal protein consumed by Chican Ostionoid inhabitants of the Tutu site, sustaining the population comfortably.

Pottery kilns

Area 1, Feature 25

Feature 25 was an area 47 cm wide, 100 cm long and 22 cm deep with charcoal concentrated in its upper portion. Under the charcoal were pockets of bright reddish yellow very fine dry clayey soil (Munsell color, 5YR6/6 reddish yellow) that extended well into fissures in the bedrock. No individual stones or fire-cracked rocks were found in the feature. From the feature were recovered 110 g of faunal material and 56 g of ceramic sherds. Located northwest of Structure 8, Feature 25 was somewhat isolated from surrounding post holes and other features, a pattern different from that of the stone hearths of the site. The presence of burned soil in the feature, associated with fissures caused by extreme heat, suggested that this was the bottom of a pottery kiln, similar to those described by Versteeg (1997: 311) at the Tanki Flip site on Aruba.

Recovered artifacts

The following is a brief description of shell, bone and lithic artifacts recovered from the Tutu site, along with proveniences, chronological contexts and cultural meaning.

Shell tools and implements

Strombus gigas tools and implements include two finished celts (one of which was extremely weathered) and one probable celt preform (Figure 1.33b), an awl (Figure 1.34a, upper left), a cylindrical-shaped graver with a beveled end, a multipurpose tool with a graver on one end and, on the other, a worked edge used to pull or scrape a substance toward the user or push it away (Figure 33a, lower center), and a scraper preform fashioned from a conch node (Figure 1.33a, lower right). A tear-drop shaped *Strombus gigas* artifact recovered from a surface context is similar to a tool identified as a spatula at the Golden Rock site (van der Steen, 1992: 107); however, the object is not a spatula in the traditional sense of a vomit stick. Another *Strombus gigas* implement resembles the bone handle of a Colonial knife. Very smooth and highly polished, the object may be the handle for a hafted implement. Ten angular fractured fragments of *Strombus gigas* shell are probably by-products of tool or bead manufacture.

Five complete and two partial *Cypraea zebra* implements, frequently referred to as scrapers or “spoons” (van der Steen, 1992: 95), were recovered from four areas of the Tutu site (Figure 1.35a,

Figure 1.33a Left: Finished *Strombus gigas* celt; Center: weathered *Strombus gigas* celt; Right: *Strombus gigas* lip extracted for finishing as a celt preform (photography by Robert Coates).

Figure 1.33b Upper left: *Strombus gigas* awl; Upper two right: awls of fish brachiostegal spines. Central spine is fire-hardened; Lower: turtle bone plaque (photography by Robert Coates).

Figure 1.34a Upper left: turtle idol or fetish fashioned from *Strombus gigas* shell, recovered from EU 1, Level F; Upper center: bone "plug" recovered from P-117, Area 1; Upper right: natural "zemi" with water worn holes; Lower left: *Strombus gigas* shell plaque with three parallel incised lines; Lower center: multipurpose *Strombus gigas* node implement. One end is a sharp pointed tool, for incising soft material, perhaps leather hard pottery, and the other end is a scraper; Lower right: *Strombus gigas* node scraper preform (photography by Robert Coates).

Figure 1.34b Quartzite stone "palette" or grinding stone, with beveled edges and incised decoration, recovered from Level BIID of EU 31, Area 4 (photography by Robert Coates).

lower; Table 1.5). Of these, four complete and one partial implement were recovered from contexts dating between cal. AD 15 and cal. AD 660 (2-sigma, Beta 108888, 54646), and the other two artifacts are unprovenienced. The seven *Cypraea zebra* implements exhibit variation in shape and wear pattern, and apparently have a number of different functions. Four are apparently multipurpose.

Figure 1.35a Upper left: unmodified *Cypraea zebra* shell; Upper center and right: *Cypraea zebra* shells with dorsal portions removed; Lower row: implements from extracted dorsal portions of *Cypraea zebra* shells (photography by Robert Coates).

Figure 1.35b Left: triangular *Strombus gigas* zemi recovered from P-702, Area 2; Right: zemi fashioned from a *Strombus gigas* node. Teeth motif is alongside the node; "eyes" and incised lines are apparent on upper surface (photography by Robert Coates).

Van der Steen (1992: 95) suggests that such implements were used to scrape a wide variety of substances and objects, including soft organic material such as cassava and other root crops, and adds that the decalcination exhibited on some implement edges may result from contact with any of a number of acids found in plants. Scrapers or spoons also may have been used for such tasks as cleaning and rubbing calabash and other gourd-like fruits, peeling rinds and vines, scooping pulp from fruit, or rubbing and smoothing unfired clay objects. In Puerto Rico these implements are associated with the Hacienda Grande style (Rouse & Alegría, 1990: 53). On other islands they are found in both early and late Saladoid contexts (Hamburg *et al.*, 1995; Haviser, 1991: 650; Rouse & Alegría, 1990: 53; van der Steen, 1992: 95). One unmodified *Cypraea zebra* shell (Figure 1.35a upper left) and two modified *Cypraea zebra* shells, with dorsal portions cut out (Table 1.5; Figure 1.35a, upper two right) were recovered from unprovenienced contexts at Tutu. Slants on dorsal cavity ends correspond to those observed on the ends of three of the *Cypraea zebra* implements.

A finished *Strombus gigas* three-pointer or zemi, recovered from P-702, resembles a thick flat triangle (Figure 1.35b, left). The object, 2.60 cm long, 2.60 cm wide at the base and 1.40 cm thick, is white and polished all over, with shell structure barely visible at its base.

A second zemi, fashioned from a *Strombus gigas* node was found on the ground surface in Area 1 (Figure 1.35b, right). The motif is a face with an exposed teeth pattern etched around the edge of the node and extending over the apex. This motif, similar to that found on a shell inset from the Cedrosan Saladoid Main Street site on St Thomas (Hoffman, 1988), in mixed context at the Hacienda Grande site (Rouse & Alegría, 1990: Figure 12i), and on Taíno idols representing deities (Rouse, 1992: Figures 29c, 29d), is an example of continuity in design motif.

Five other artifacts are small *Strombus gigas* nodes recovered from the surface of Area 1. Three are ground and smoothed around the basal rim and two retain attached portions of body whorls. The five artifacts are similar to those recovered from the Salt River site on St Croix (Hatt, 1924: 39), El Bronce in Puerto Rico, and sites in Curaçao (deJosselin deJong, 1924: Figure 4). According to Robinson *et al.* (1985), such artifacts are seldom described in archaeological reports and consequently their interpretive value has been overlooked.

Table 1.5 Attributes and proveniences of *Cypraea zebra* multipurpose shell implements or "Spoons" recovered from the Tutu site

Excavation unit, level and area	*Tool shape*	*Locations of use wear; shapes of corners*	*Approx. % of shell worn away*	*Description of wear on utilized end*	*Description of other wear*	*Shell surface*
N2087/1952E Level BIIC Area 4	Roughly square	Wear on exterior of one end. End is slanted on one side where it meets a corner at an acute angle. This corner shows no wear. Tiny chips on utilized edge. Other adjoining corner is worn and rounded. Wear is evident on one side of the implement and on two other corners. Unutilized end of the implement is smooth but not worn.	33% at utilized end	Band of wear 5 mm wide on exterior, tapering to a sharp edge. Localized decalcination on interior of utilized edge.	Directly on shell edge	Worn on exterior along long axis of shell near utilized end. Multi-purpose implement.
N2087/1952E Level BIIC Area 4	Elliptical	Wear on interior of one end which is slanted. This side terminates in an obtuse-angled, unworn corner. Adjoining corner is rough and unworn. The remaining edges are very rough with shell structure evident.	16% at utilized end	Band of wear 1 mm wide with decalcination on interior of utilized end. Corners unutilized.	None; edges jagged	Surface very slightly worn near utilized end.
General surface	Ellipse with squared corners, spoon-shaped	One end is round with wear on the interior of the edge. Wear on interiors and exteriors of adjoining corners and on the interior of one other corner. Two sides are smooth. Corners are rounded. The end opposite the utilized end is broken.	2% at utilized end	Band of wear 2 mm wide on interior of utilized end and one adjoining corner. Wear on exterior of other adjoining corner which has a sharp edge.	Directly on shell edge	Surface slightly worn at one corner. Multi-purpose implement.
Midden rescue	Roughly rectangular	Worn on exterior of one end, with one chip on interior edge. Band of wear, 1.50 mm wide, on exterior edges of adjoining corners. Shell structure is visible on one side of the implement. The other side is broken. Other end also is broken, with wear on unbroken portion.	12% at utilized end	Band of wear 3 mm wide on exterior of utilized end, which has a sharp edge with fine chipping on one side of edge. No decalcination.	Directly on shell edge	Shell surface shows wear on utilized end and on one corner. Multi-purpose implement.

(continued on next page)

Table 1.5 (cont.)

Excavation unit, level and area	*Tool shape*	*Locations of use wear; shapes of corners*	*Approx. % of shell worn away*	*Description of wear on utilized end*	*Description of other wear*	*Shell surface*
N2097/ 1823.50E Level B Area 1	Tapered on one end; square on other	Wear directly on edge of one end, which is more worn on one side. This side joins an obtuse-angled, smooth-edged corner. That corner and one side are smooth. Other corner of utilized end is broken and that side is rough-cut. Tip of implement is broken.	24% at utilized end	Edge of utilized end is rounded, with no use wear evident on interior and exterior. No decalcination.	Directly on shell edge	No wear
Surface Area 9W	Tapered on one end and rounded on the other	Directly on edge of one end, which is even. Implement is broken longitudinally. Existing corner is chamfered and worn on interior edge. Existing side is smooth but uneven.	10% at utilized end	Very thin edge with no evidence of use wear or decalcination on exterior or interior.	Edge is smooth and uneven. Possibly ground and polished, but not utilized.	No wear
N2087/1952E Level BIIC Area 4	Broken	On exterior of one end and on edge of one side. Remainder of implement is absent.	n.a.	Band of use-wear, 1.50 mm wide on exterior of utilized end.	Directly on edge of one side	No wear
Trench 10 Fill Area 9N	Cowrie shell	Parent shell from which scraper was extracted. Dorsal side removed. Evidence of cutting visible on interior edge of hole. Hole is 6.20 mm × 3.80 mm. Top of interior columella broken off at posterior end.				
Area 1 Midden	Cowrie shell	Parent shell from which scraper had been extracted. Dorsal side removed. Evidence of cutting visible on interior edge of hole. Hole is 5 mm × 3.70 mm. Top of interior columella broken off at posterior end, but columella not removed.				

Finally, a large *Strombus gigas* node with six natural holes in it, a surface find, may have been selected for its natural attributes and used "as is" as a zemi (Figure 1.34a, upper right).

Shell ornaments, adornments and other objects

Six small thin perforated rectangular shell plaques, with drilled holes at either end, and one unperforated finished plaque, of *Strombus gigas* shell, were recovered from the Area 4 midden. No two plaques are exactly alike and the variation in detail reflects the individuality of each maker. The largest two plaques are 2.50 cm long and 1.40 cm wide, and the smallest is 1.70 cm long and 1.10 cm wide. Four facets on one side of the perforated plaques meet more or less at a point. Undersides of four plaques are concave ovals framed by flat ground edges; one is concave on the entirety of the base and the other is flat.

In most cases, holes are different sizes, not aligned with each other and not equidistant from plaque ends. In some cases, on a single artifact, one hole is drilled from one side and one from the other; but usually both holes are drilled from the same side. Plaques or gorgets drilled with holes at slight angles may have been joined to create a necklace or bracelet. A single plaque was unperforated, with beveled edges that created a flat rectangular surface on one side.

Similar plaques were recovered from, among other sites, the Aklis and Salt River sites on St Croix (Hayward & Cinquino, 1997a; Hatt, 1924: Figure 10) and the Maisabel site in Puerto Rico (Siegel, 1992; Figure 3.27b).

Of 38 modified *Oliva* sp. shells recovered from the Tutu site, 17 recovered from midden contexts in Areas 4 and 9N, and one from Burial 3, are from the early occupation of the site. One recovered from N2033.50/1843.50E, Level C, is from the late occupation. Nineteen lack context (Table 1.6).

Oliva sp. shell ornaments were identified as either tinklers (pendants), beads or other ornaments (Figure 1.36, a and b). A tinkler has a perforated notch or groove on its dorsal area near the siphonal notch. This allows the tinkler, also a pendant, to be suspended from a cord. Finished tinklers are hollow with interior walls removed and orifice rims ground smooth. In some cases, orifice rims are jagged and either the full spire, or the spire and a narrow portion of attached body whorl has been knocked off, suggesting that, in the manufacturing sequence, time is not invested in finishing the rim of a tinkler until the perforation has been successful. Artifacts that are tinklers in all respects, except orifice rim polishing, are interpreted as tinkler preforms; and hollow shells with polished rims and no perforation are considered to be complete artifacts of another purpose.

Notches in all but one of the tinklers are uniform in shape and width, reflecting the form of the tool used to create the groove, perhaps a fragment of *Acropera cervicornus* (personal communication, L. A. Carlson, University of Florida Museum of Natural History). On the single exception, a hole was punched in a circular ground area that was created by sawing.

Tinklers similar to those recovered from the Tutu site were observed by the author at a contemporary Zuni pueblo in New Mexico. Here, a dancer wore many strands of closely strung *Oliva* sp. shell tinklers looped diagonally across the chest, from one shoulder to an opposite position on the waist. As the dancer moved, the shells knocked against each other, creating several musical tones. It is likely that the cavity, created by removal of the inner shell wall, and the diameter of the orifice, determined the sound that each shell would make.

Beads are identified as unperforated shells with spires partially ground away or ground to retain a point one whorl above the suture line, so that the entire length of the artifact may be threaded (Robinson, Lundberg & Walker, 1985: 171). These beads are hollow, which perhaps facilitates threading, but also may indicate that, in some cases, beads were intended to produce sounds. Most orifice rims exhibit secondary damage on edge interiors.

Table 1.6 Attributes and proveniences of modified *Oliva* sp. and *Cypraecassis testiculus* shells recovered from the Tutu site*

Provenience unit and level	*Ornament type*	*Body modification*	*Hole width (mm)*	*SHM*	*Modif. tech.*	*SMA*	*SMA width (mm)*	*Int. rem.*	*MA*	*PH*	*Spire modification*	*Orifice diam. (mm)*	*Time period*	*n*	*Comments*
General surface															
General surface (*Cypraecassis testiculus*)	TPre	No						Yes			SS:H:UP:B	18	?	1	
General surface	TPre	No						Yes			SS:H:UP	9	?	1	
General surface	Bead	No						Yes			A:H:P	2.5	?	1	
Area 1															
Area 1 general surface	TPre	No						Yes			SS:H:UP	6	?	1	
Area 1 general surface	Bead	No						No			A	4	?	1	
Area 1 soil mound	TPre	No						Yes			SB:H:UP	9	?	1	Very thin
N2040/1840E: surface	Bead	No						Yes			S1:H:P	4	?	1	
N2100/1825E: surface	TPre	No						Yes			SS:H:UP	7	?	1	
N2097/1823.50E: surface	TPre	No						Yes			SS:H:P	9	Early?	1	
N2100/1830E: surface	Tinkler	Yes	4 diam.	C	Gr + P	C	10 diam.	Yes	EQ	RE	SB:H:UP	11	Early?		
N2135/1825E: soil mound	Tinkler	Yes	2.25 × 5	E	Gr + W	E	6 × 15	Yes	DR	PL	SB:H:UP	11	?	1	
N2098/1815–28: furrow	Tinkler	Yes	1.50 × 3	R	Gr + P?	E	6 × 12	Yes	Hor	PL	SB:H:UP	8	?	1	
N2096/1825E: furrow	Bead	No						Yes			S1:H:P	4	Early?	1	
P-234: surface	Tinkler	Yes	1 × 2.50	E	Gr + P	E	6 × 14	Yes	Hor	PL	SS:H:P	9	?	1	
P-234: surface	TPre	No						Yes			SB:H:UP	10	?	1	Fossil or corroded
Midden (*Cypraecassis testiculus*)	TPre	No						Yes			SS:H:UP	19	Early	1	
N2090/1984E: Level D	Bead	No						Yes			A:H:P	3	Early	1	
N2080/1952.50E: surface	TPre	No						Yes			SB:H:UP	15	Early?	1	
N2087/1952E: Level A	OOrn	No						Yes			SS:H:P	7	Early?	1	

(continued on next page)

Table 1.6 (cont.)

Provenience unit and level	*Ornament type*	*Body modification*	*Hole width (mm)*	*SHM*	*Modif. tech.*	*SMA*	*SMA width (mm)*	*Int. rem.*	*MA*	*PH*	*Spire modification*	*Orifice diam. (mm)*	*Time period*	*n*	*Comments*
N2087/1952E: Level A	Bead ?	No						Yes			SS:H:UP	3	Early?	1	Fossil shell
N2087/1952E: Level BIII	Tinkler	Yes	2 × ?	E	Gr + P	E	7 x ?	Yes	DL	??	SB:H:P:B	n.a.	Early?	1	Thin
N2087/1952E: Level BIIIA	TPre	No						Yes			SB:H:UP	8	Early?	1	
N2087/1952E: Level BII	TPre	No						Yes			SB:H:UP	9	Early?	1	
N2087/1952E: Level BII	Tinkler	Yes	Broken		Gr + P	E		Yes	H or	RE	SB:H:UP	n.a.	Early?	1	Flattened lip
N2085.04/1952.73E: Level BII	OOrn							Yes			SS:H:P	6	Early?	1	
2975-N2087/1952E: Level BIIA	TPre							Yes			SB:H:UP	7	Early?	1	
2984-N2097/1952E: Level BIIB	Bead	No						No			A	4	Early?	1	
1603-N2085/1950E: surface	Bead	No						No			A	3	?	1	
Midden recovery	Tinkler	Broken	Broken					Yes		PL	SS:H:P	n.a.	Early?	1	
Area 7															
Area 7 surface	TPre							Yes			SS:H:UP	Broken	?	1	
Area 8															
N2116/1840E: surface	Bead	No						Yes			S1:H:UP	5	Early?	1	Fossil shell, smooth on rim interior
Area 9N															
N2075/1810E: Level B	TPre	No						Yes			SS:H:P	6	Early?	1	
N2075/1810E: Level B_2	T/B?	No						Yes			SB:H:P	7	Early	1	

(continued on next page)

Table 1.6 (cont.)

Provenience unit and level	*Orna-ment type*	*Body modifi-cation*	*Hole width (mm)*	*SHM*	*Modif. tech.*	*SMA*	*SMA width (mm)*	*Int. rem.*	*MA*	*PH*	*Spire modification*	*Orifice diam. (mm)*	*Time period*	*n*	*Comments*
N2075/1810E: Level B_2	Bead	No						Yes			A:H:P	2.5	Early	1	
Area 9W															
Soil mound 3	TPre	No						Yes			SS:H:UP	7	?	1	
N2044/1837E: surface	Bead	No						Yes			A:H:P	3	?	1	
N2044/1837E: Level B	?	Lip Only						No					?		
Area 9S															
N2033.50/1843.50E: Level C	Tinkler	Yes	1 × 4	E	Gr	E	7 × 11	Yes	DR	RE	SR:P	10	Late	1	
Trench 9 Fill	T/B?	No						Yes			SS:CD:P	9	?	1	
N2040/1842.80E: Burial 3	Bead	No						No			A	4	Late	1	

Notes

*This table, modelled after Table 48 in Versteeg and Schinkel (1992), includes classification attributes developed by Robinson (1978).

n = number

Ornament type: TPre = tinkler preform OOrn = other ornament

Body modification: in the Tutu collection, a shell with body modification also exhibits a hole at the deepest point of the modification.

SHM = shape of hole in modified area (note that in some cases the hole seems to have opened when the area was ground, and been augmented by punching or pecking): E = roughly elliptical; R = roughly rectangular; C = circular.

Modif tech. = modification technique: P = punching; Gr = grinding (i.e. the hole seems to have been produced by grinding of the modified area); W = rim of hole is weathered or eroded obscuring manufacturing marks.

SMA = shape of modified area which includes the prepared area and the hole. C = circular; E = roughly elliptical.

Int. rem. = interior whorls almost completely removed. All tinklers, tinkler preforms and most beads exhibit this condition.

MA = major axis of modified area (orientation of the hole): Hor = horizontal; DR = diagonal upwards to the right side; DL = diagonal upwards to the left side; EQ = equiaxial.

PH = placement of hole: n.a. = shell broken; RE = right edge aligned with or slightly overlapping siphonal notch; PL = on palatal lip entirely at the left side of the siphonal notch.

Spire modification: A = apical whorl removed; S1 = spire removed one whorl above final suture; SS = spire removed at suture; CU = canal undamaged; CD = canal damaged; H = hollow; SB = spire removed together with a portion of the body whorl; SR = spire removed; P = orifice rim ground and polished; UP = orifice rim unpolished; B = shell broken, some diagonistic information may be lacking.

Orifice diam. = diameter of opening where spire was removed.

Because the sample is relatively small, the full range of completed *Oliva* sp. artifacts may not be represented, and preform identifications are considered tentative.

Two *Cypraecassis testiculus* tinkler preforms also were recovered from the site, one from an early context and one from the surface (Table 1.6).

Discoidal shell beads, inlays and other artifacts

Of 20 large discoidal artifacts, 18 were recovered from early contexts of the Tutu site and 2 from the surface (Table 1.7). Shell types were identified with the assistance of L. A. Carlson and William Keegan of the Florida Museum of Natural History. Of the large discoidal artifact, a mother-of-pearl perforated disc recovered from upper levels of the Area 4 midden may have been fashioned from *Isogonomon alatus* and one inlay may have been fashioned from an operculum of an *Astrea* sp. (personal communication, William Keegan). The majority of the remaining large discoidal artifacts were fashioned of *Spondyllus americanus*, *Strombus gigas* and *Conus* sp. shells. In Table 1.7, no shell type is listed in cases where shell type could not be determined without damaging the artifact. Shell fragments and preforms recovered from the site suggest on-site manufacture of shell artifacts (Carlson, 1993).

Tutu discoidal *Strombus gigas* beads and unperforated discs do not exhibit the edge notching that is found on the examples from Golden Rock and some Ostionoid period sites in the Caribbean islands (van der Steen, 1992: 110; personal communication, L. A. Carlson).

Of 46 tiny flat discoidal beads recovered from five areas of the Tutu site, 40 are from excavated contexts, 2 are from the site surface, 2 from post holes (Table 1.8) and 2 from site features. Shell

Figure 1.36a Upper left: unmodified *Oliva reticularis* shell; Upper right three: *Oliva* sp. shells with apices removed. These artifacts are beads; Lower left three: *Oliva* sp. shells with entire spires or spires and one adjacent whorl removed. Rims are jagged indicating unfinished tinklers; Lower right: *Oliva* sp. shell with spire removed and rim polished. Finished artifact that is not a tinkler (photography by Robert Coates).

Figure 1.36b Upper right and upper left: *Oliva* sp. shell tinklers, exhibiting notches "sawed" until perforated. Notches are on dorsal portions of shells near their siphonal notches; Upper center: stone bead with one longitudinal perforation, and another at a right angle, probably for insertion of decorative items such as feathers; Lower left: single example of *Oliva* sp. tinkler which is not notched but exhibits a circular ground area with a "punched" hole; Lower center: broken *Oliva* sp. tinkler; Lower right: *Oliva* sp. tinkler with jagged rim not yet polished (photography by Robert Coates).

Table 1.7 Attributes and proveniences of unperforated discs, discoidal and truncated beads and inlays recovered from the Tutu site

Provenience	*Area*	*Item and brief description*	*Color*	*Thickness in mm*	*Width in mm*	*Diameter of hole in mm*	*Period*	*n*	*Shell type*[a]
Unperforated discs/preforms									
N2050/1820E, surface	9N	Unperforated circular disc preform with separation marks and shell structure visible.	White	3	3 × 3.20	—	?	1	—
N2090/1948E, Level C	4	Unperforated discoidal preform partially smoothed.	Pink/orange	3	7	—	Early	1	*Spondyllus americanus*
Perforated discs/beads									
N2087/1952E, Level B	4	Perforated disc with very rough unsmoothed edges, similar to a blank. Shell structure visible. Bi-conically drilled central hole.	White	2 and 4	9 × 11	1	Early[b]	1	*Strombus gigas*
N2087/1952E, Level BIIA	4	Perforated disc with rough edges and shell structure evident. Burnt.	Grey	2.50	12 × 10	2 and 3	Early[b]	1	*Strombus gigas*
N2087/1952E, Level BIIC	4	Perforated discoidal bead with portions of smoothed edge removed, as if broken off in the smoothing process.	—	2	8 × 9	1.10 and 1.50	?	1	*Spondyllus americanus*
N2090/1948E, Level A	4	Perforated flat disc with partially smoothed faceted edges and shell structure visible.	—	3 × 4	12	2.10 and 1.50	Early[b]	1	*Spondyllus americanus*
N2090/1948E, Level A	4	Perforated disc, very slightly curvate. Smoothed faceted edges with shell structure visible. Shell lip ground flat and polished on incurving side of disc.	White	2 × 2.50	10	1.50 and 1.10	Early[b]	1	*Spondyllus americanus*
Midden rescue, Area 4	4	Perforated disc bead ground smooth on all surfaces, obscuring shell structure. Conically drilled from one side.	White	2	14	2.50 and 1.50	Early[b]	1	*Spondyllus americanus*
N2040/1837.50E, Level E, under B-3	9S	Half of a thin perforated discoidal bead, shell structure not visible.	White	1.10	8	2	Early?	1	*Spondyllus americanus*
Midden rescue, Area 4	4	Thin perforated disc bead, shell structure not visible.	White	1	15	1.9 and 2.1	Early?	1	—

(continued on next page)

Table 1.7 (cont.)

Provenience	*Area*	*Item and brief description*	*Color*	*Thickness in mm*	*Width in mm*	*Diameter of hole in mm*	*Period*	*n*	*Shell type*[a]
N2090/1948E, Level B	4	Large very thin perforated disc.	Irridescent	0.75	22	2	Early[b]	1	Mother-of-pearl
N2089/1947E, Level A	—	Small curvate bead with modified hole on exterior. Natural whorl hole on interior top of shell. Perhaps naturally broken from the rest of the shell and smoothed.	White	11	4	2	Early?	1	Conus
N2097/1823.50E, Level B	1	Small curvate bead. Portion of smoothed rim broken off in smoothing process.	—	4	8 × 14	2	Early	1	Conus
Area 1 midden, surface	1	Small curvate bead.	—	6	14	3	Early?	1	Conus
Truncated bead									
N2037/1842E, Level F	1	Small thick bead with smaller diameter at top than at base.	White	—	3 and 5	1.50	Early?	1	*Spondyllus americanus*
Inlays									
N2087/1952E, Level BIIA	4	Unperforated elliptical disc with smoothed faceted edges.	White	3	7 × 8.50	—	Early[b]	1	*Strombus gigas*
N2090/1948E, Level A	4	Unperforated disc preform with smooth faceted edges. Probably a complete artifact.	White	2 and 3	10	—	Early[b]	1	*Spondyllus americanus*
N2090/1948E, Level A	4	Unperforated disc preform, slightly curvate. Smoothed on edges, lip of incurving side round, flat and polished. Possibly a complete artifact.	White	2 and 3	10	—	?	1	*Spondyllus americanus*
N2087/1952E, Level BII	4	Unperforated disc with smoothed ground edges. Possible artifact.	White	2	9	—	Early[b]	1	—
Soil Mound 4	5	Smoothed disc bead, partially perforated on one side, which is flat and smooth. Undrilled side is smooth but uneven in thickness. Shell structure not evident.	White	2 and 3	17 × 18	3	Late?	1	*Astrea operculum*

Notes

[a] Shell types identified by Lisbeth Carlson and William Keegan, University of Florida, Museum of Natural History.

[b] Artifacts recovered from midden contexts of Area 4 are one component of the early occupation.

Table 1.8 Attributes and proveniences of small discoidal beads recovered from the Tutu and Main Street sites

Provenience	*Area*	*Color*	*Thickness (mm)*	*Bead diameter (mm)*	*Hole diameter (mm)*	*n*	*Shell type*[a]
Tutu							
N2087/1952E, Level BIII	4	White	1	3	<1	1	*Spondyllus*
N2087/1952E, Level BIII	4	Opaque white	1.5	4	2.5	1	*Strombus*
N2087/1952E, Level BIIIA	4	White	1	3	2	1	*Spondyllus*
N2087/1952E, Level BIIIB	4	Grey	2	6.5	2.1 and 2.5	1	*Strombus*
N2087/1952E, Level BIIIB	4	Opaque white	2	4	1.5	1	*Strombus*
N2087/1952E, Level BII	4	Dark grey	3	5	2 and 2.25	1	*Strombus*
N2087/1952E, Level BII	4	Dark grey	2	4.5	2.5	1	*Strombus*
N2087/1952E, Level BII	4	White	1	4	1	1	*Spondyllus*
N2087/1952E, Level BIIB[b]	4	White	2.1	4.5	2	1	*Strombus*
N2087/1952E, Level BIIB	4	Dark grey	1	4	1.5	1	*Chama*
N2087/1952E, Level BIIC	4	Pink	1	4	1	1	*Chama*
N2090/1948E, Level A	4	White	1	3.5	1.1	1	*Spondyllus*
N2090/1948E, Level B	4	Greyish white	3	3.75	1.5	1	*Strombus*
N2090/1948E, Level C	4	Dark grey	2.75	5	2.75	1	*Strombus*
N2089/1947E, Level C	4	Very dark grey	1.5	3	1.5	3	*Strombus*
N2089/1947E, Level C	4	Very dark grey	1	3.1	1	2	*Strombus*
N2089/1947E, Level C	4	Very dark grey	2	3	1	1	*Strombus*
N2089/1947E, Level D	4	Opaque white	1	3	2	1	*Strombus*
N2075/1810E, Level B	9N	White	1.5	4	1.1 and 1.25	1	*Spondyllus*
N2075/1810E, Level B	9N	Pink	1	4	1	1	*Chama*
N2075/1810E, Level B	9N	White	2	4.5	1.25 and 2	1	*Chama*
N2075/1810E, Level B2	9N	White	1.5	4.3	1.1	1	*Chama*
N2075/1810E, Level B2	9N	Pink	1	3	0.75	1	*Chama*
N2060/1825W, surface	9N	Greyish white	2.5	5	0.75	1	*Spondyllus*
N2044/1837E, surface	9W	White	2	4	1.1 and 2.1	1	*Spondyllus*
N2044/1837E, Level D	9W	Pink	1.1	3	0.75	1	*Chama*
N2044/1837E, Level F	9W	White	1.5	3.5	1.1 and 1.5	1	*Chama*
N2044/1837E, Level J	9W	White	0.9	3.75	2	1	*Spondyllus*
N2044/1837E, Level J	9W	Pink	1	3.5	1.1	1	*Chama*
N2044/1837E, Level Q	9W	White	2	4	0.9	1	*Chama*
N2037/1842E, Level E	9S	Opaque white	1	4	1.25	1	*Spondyllus*
N2096/1827E, Level B	1	Opaque white	1.5	3.9	1.1 and 1.5	1	*Strombus*
N2097/1821.50E, Level BI	1	White	1	4	1	2	*Spondyllus*
N2097/1822.50E, Level B	1	White	2 and 1	4 square	1.5	1	*Spondyllus*
N2097/1823.50E	1	White	2	5	1 and 1.9	1	*Spondyllus*
N2101/1825E	1	Yellow and white	1.5	4.5	1.1 and 1.2	1	*Spondyllus*

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Table 1.8 (cont.)

Provenience	*Area*	*Color*	*Thickness (mm)*	*Bead diameter (mm)*	*Hole diameter (mm)*	*n*	*Shell type*[a]
N2102/1825E, Level B	1	Very dark grey	1–1.25	4	1.1	1	*Strombus*
N2115.50/1837.50E, Level A	8	White	0.75	3.50	1	1	*Spondyllus*
P-82	1	Flat dull grey	1.5	4	1.9	1	*Chama*
P-2071	1	Opaque white	2	3	1.75	1	*Strombus*
F-10	1	White	1	4	0.9	1	*Chama*
F-34	1	White	1.25	4	1 and 1.25	1	*Spondyllus*
Total of small discoidal beads from the Tutu site						45	
Main Street							
Flot # 289		Pink	1.5	3	1	1	*Chama*
Flot # 289		Pink	0.9	3.25	1.1	1	*Chama*
Flot # 297		Pinkish white	0.9	4	0.9	1	*Chama*

Notes

a Shell identifications were made with the assistance of Lisbeth Carlson and William Keegan, University of Florida, Museum of Natural History.

types include *Strombus* sp., *Spondyllus americanus* and *Chama sarda* shells. Eight beads are of the "ring" type in which the diameter of the central hole is equal to or larger than one half the diameter of the entire bead (Serrand, 1997: 211). Of these ring beads, 6 are rounded on one or two sides, and 2 are rounded and slightly concave on one side and flat on the other. All of the small discoidal beads recovered from the Tutu site are from early contexts, beginning at cal. AD 15 (2-sigma, Beta 108888) in the Area 1 midden, and extending to cal. AD 885 (2-sigma, Beta 62569) in the upper midden of N2044/1837E.

No shell bead manufacturing tools, preforms or debitage related to production of these small beads were recovered from the Tutu site, and it is possible that the artifacts were obtained through exchange and/or trade.

In general, small discoidal shell beads from Cedrosan Saladoid contexts in the Caribbean are not well reported in the literature. At Tutu, the use of 0.159 cm (1/16 in.) mesh screen to process bulk soil samples and heavy fraction from a large number of flotation samples may account for recovery of the beads.

Other shell objects and ornaments

A *Strombus gigas* fetish or idol was recovered from Level F of N2044/1837E, dated to between cal. AD 420 and cal. AD 885 (2-sigma, Beta 62569). The artifact resembles a labret, but the characteristic side grooves are missing. One half of the object is round, 3.20 cm in diameter and between 3 cm and 5 cm thick, and the other half consists of a beveled projection between two grooves (Figure 1.33a, upper left). When viewed from the side, the object resembles a swimming turtle (personal communication, William Keegan, Florida Museum of Natural History).

A *Strombus gigas* shell plaque fragment with natural holes and three parallel incised lines (Figure 1.33a, lower left) was recovered from the site surface.

Coral and coral objects

Coral that was recovered from midden contexts of the Tutu site and sent to Dr Elizabeth Wing is quantified in tables of Chapter 4 but it was not identified by species or examined for signs of use. Coral from other contexts at the site was identified by Jeremy Lazelle with the assistance of Dr Stephen Prosterman, Marine Biologist at the MacLean Marine Science Center of the University of the Virgin Islands. Five major types of coral, *Acropera palmata* (n=198); *Acropera cervicornus* (n=21); *Diploria* (n=94); *Montastrea* (n=13); and *Dichocoenia stoikes* (n=1), were identified among the materials that were not analyzed by Dr Wing. No coral was recovered from burial fill.

The only positively identified coral artifacts were 6 pestles, 1 perforated disc possibly used as a weight, and 1 zemi of fossil coral. The surface of the zemi, recovered from the ground surface of the site, is highly polished. An off-center natural concavity in the base of the artifact causes it to list to one side when placed on a flat surface. The base of this object is 4.80 cm long and 3.80 cm wide at its widest point. Maximum artifact height is 4.50 cm.

Bone artifacts

Two brachiostegal fish rays, used as awls or punches, were recovered from lower midden levels of N2044/1837E (Figure 1.33b, upper two right). One awl had been fire-hardened and had a high sheen.

Enigmatic bone artifacts include an artifact that resembles a small plug, 280 mm long, 90 mm in cross-section at one end and pointed at the other, recovered from P-117 (Figure 1.34a, upper center). Another is a plaque of turtle bone, recovered from the Area 4 midden, with a rectangular cut-out smoothed stepped pattern on one edge. Other edges are rough (Figure 1.33b, lower).

A pendant fashioned from a *Monachus tropicalis* (monk seal) tooth was recovered from surface contexts at Tutu. Horizontal perforations at right angles to each other, on the broken end of the tooth near the root, indicate that the pendant, about 4.40 cm long, was suspended by a cord placed through one perforation with other items, perhaps feathers, placed in the other. The complete pendant may have resembled incised forms recovered from archaeological contexts in the Dominican Republic (Rimoli, 1984). While Timm, Salazar & Peterson (1997) limit the eastern extent of the seal's natural habitat to the Dominican Republic, Wing (personal communication) indicates that bones of the now extinct animals have been reported from a number of Caribbean islands, including the Virgin Islands and Lesser Antilles, and the seals must have been living in their waters. However, the presence of monk seal-tooth pendants at these sites, and a monk seal mandible recovered from the Golden Rock site in St Eustatius (van der Klift, 1992: 78), suggests that the animal had symbolic importance, and perhaps a widespread exchange or trade in monk seal teeth, and mandibles from which teeth could be extracted and fashioned into pendants, accounts for their presence on some sites.

Recovered from the Area 4 midden were 5 *Balistes* sp. (triggerfish) teeth, of which 1 is perforated and 1 is decorated with orange, yellow, dull green and blue stripes.

A large piece of burned *Trichechus manatus* (manatee) bone was recovered from the surface of Area 13. The charred upper surface of the bone is highly polished. Fine slice-marks, that penetrate the burned exterior surface of the bone, apparently are related to use of the bone as an artifact. Heavier cuts resulting from butchering also are present on the unburned underside of the artifact.

One (probably human) coprolite was recovered from under a ceramic bowl in N2087/1952E, Level BIIC. This Saladoid specimen awaits further analysis.

Lithic artifacts and artifact classes

In July of 1992, Dr Jeffrey Walker examined all available lithic artifacts from excavated as well as surface contexts of the site. He submitted his raw data for use in this volume. Except for lithic ornaments, adornments, inlays and other objects described below, lithic items examined by Jeff Walker are tabulated by artifact class in Table 1.9.

Flake and core tools from the site were analyzed by Dr Dave Davis. His results are reported in Chapter 12. During 1997, Jeremy Lazelle catalogued the entire collection, except for material that had been sent to Walker and Davis. Lithic tools and other cultural items identified by Lazelle are listed by artifact class in Table 1.10.

Presented below is a brief overview of the lithic items analyzed by Walker and the inventory catalogued by Lazelle. Detailed analysis of lithic materials recovered from the site remains to be completed.

Reduction techniques and artifact classes

Elsewhere, Walker (1985a: G3) has distinguished three lithic artifact categories representing three gross types of reduction: flaking, abrading and crumbling. These are not mutually exclusive techniques, and artifacts may exhibit evidence of more than one technique in their production. Artifacts produced by one method of reduction may, in turn, also be used to perform one or more types of reduction. Often two or more working edges may be present on one tool which also exhibits variation in wear on its edges (Walker, 1985a). Such tools were common in the Tutu collection and may be either multipurpose tools or the results of successive use by different workmen: most likely, the re-use of stone implements “found” by occupants of the site at various times. To Dr Walker, the re-use of durable stone items indicates a general scarcity of material suitable for tool production (1992: 1).

Flaking

At Tutu, the largest group of lithic artifacts is comprised of cores, shatter and flakes of local materials. Flaked stone technology and flaked stone artifacts are discussed in Chapter 11.

Abrading

Abrading includes grinding, rubbing, polishing, whetting, and direct and indirect drilling, which are used to produce artifact classes that include (among others) celts, ball belts, three-pointers, inlays and beads. Abrading that was an intentional process of tool manufacture should be distinguished from that which is a result of use-wear. For example, a bead may have been polished by intentional fine abrasion, while the drill hole also exhibits a polish that resulted from abrasion by the cord while the bead was worn (Walker, 1985a: G11). Some artifacts exhibit signs of abrasion and also are abraders.

Abrading tools

Among abrading stones analyzed by Jeff Walker are 4 grinding, smoothing and polishing stones, of which 2 can be identified as small stones for polishing or burnishing pottery. An additional 18 complete and 5 broken grinding stones, 41 complete and 7 fragmentary polishing stones and 1 smoothing stone were catalogued by Jeremy Lazelle (Table 1.10).

ADZES AND CELTS

Dr Walker notes that the Tutu celts and adzes indicate activities such as woodworking, canoe-building or forest clearing. Preparation of large house posts, especially those composed of dense hardwood, such as the *Guaiacum* (lignum vitae) center posts of Structure 2, surely would have necessitated an adequate woodworking kit.

According to Walker (1992), plano-convex adze and petaloid celt sequences in the Tutu collection demonstrate on-site production of tools. A narrow basalt plano-plano rectangular adze bit,

Table 1.9 Contexts and counts of artifact classes identified by Jeff Walker at the Tutu site

Area/Provenience	*Early (pre-950)*	*Late (post-1150)*	*Pet.*[a] *celt*	*Pet. celt bit*	*Pet. celt butt*	*Pet. celt flake*	*Plano conv.*[b] *adze*	*Adze*	*Edge-grinder*	*Pestle*	*Hammer-stone*	*Core*	*Modified cobble*	*Fire-cracked cobble fragment*	*Grinding stone*	*Smoother-polisher*	*Fire-cracked rock*	*Three-pointer*	*Ball belt*
Area 1[c]																			
Surface	—	—	—	—	2	—	2	—	1	—	—	—	—	—	—	1	—	1	—
Exc. unit	×[d]	—	1	—	—	2	—	1	—	—	—	—	—	—	—	—	1	—	—
Soil mound	—	—	—	—	—	1	—	—	—	—	—	2	—	—	—	—	—	—	—
P-53	—	×	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—
P-61	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
P-115	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
P-278	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	—
P-789(1)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
F-21 hearth	—	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—
Area 2																			
P-702	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Area 3																			
Surface	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—	—	—	—	1
P-410B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Area 4																			
Surface	—	—	1	—	—	—	2	—	—	—	1	—	—	—	—	1	—	—	—
Exc. unit	?	—	—	—	—	3	1	—	—	—	1	1	—	—	—	—	—	—	—
Exc. unit	×	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—
Area 5																			
Surface	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Area 8																			
Surface	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Exc. unit	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—

(continued on next page)

Table 1.9 (cont.)

Area/Provenience	*Early (pre-950)*	*Late (post-1150)*	*Pet.*[a] *celt*	*Pet. celt bit*	*Pet. celt butt*	*Pet. celt flake*	*Plano conv.*[b] *adze*	*Adze*	*Edge-grinder*	*Pestle*	*Hammer-stone*	*Core*	*Modified cobble*	*Fire-cracked cobble fragment*	*Grinding stone*	*Smoother-polisher*	*Fire-cracked rock*	*Three-pointer*	*Ball belt*
Area 9N[c]																			
Exc. unit	×	—	1	—	1	2	1	—	—	1	—	—	—	—	—	—	—	—	—
Area 9W																			
Surface	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Exc. unit	×	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Tr-10	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Soil mound 3	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	1
Area 9S																			
Surface	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—
Exc. unit	×	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Burial 3	×	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Tr-9	—	—	1	—	1	—	—	—	—	—	—	—	1	2	—	—	1	—	—
Totals			5	1	5	14	6	1	1	2	9	5	2	4	0	4	10	1	3

Notes

a Pet. = Petaloid

b conv. = Convex

c Two possible manioc grater teeth were recovered from early contexts of Area 1 and Area 9N. These are included among flakes discussed in Chapter 11 of this volume.

d Positive time period association.

Table 1.10 Unanalyzed lithic implements[a] and other utilized lithic objects recovered from the Tutu site

Tentative artifact class	*n*	*Weight range (g)*	*n early*	*n late*	*Comments*
Plano-convex rectangular adze, broken	2	33–53	—	—	
Adze, flake	1	6	—	—	
Axe?	2	371–980	—	—	
Petaloid celt, complete	1	104–459	—	—	
Petaloid celt, bit end	1	25	—	—	
Petaloid celt, butt end, undamaged	6	54–343	—	—	
Petaloid celt, butt end, damaged	3	130–166	1	—	One from P-411
Petaloid celt, mid-section	6	99–469	1	—	
Petaloid celt fragment	3	14–108	—	—	
Celt/chisel with flake scars	4	169–266	—	—	
Celt/chisel, broken	2	167–253	—	—	
Core[b]	3	228–1414	—	—	
Core, flake	3	253–343	—	1	
Edge-grinder, complete	2	151–261	—	—	
Edge-grinder, broken	3	34–97	—	—	
Graver for soft material	1	5	—	—	Pointed etching tool
Grinding stone, complete cobble	18	29–1563	1	—	
Grinding stone on broken cobble	5	79–804	—	—	
Hammerstone, complete	15	30–1949	—	—	
Hammerstone, broken	3	132–596	—	—	One from P-789 (1)
Mano, complete	13	868–2013	—	—	
Mano, fragment	4	97–276	—	1	One from P-1869
Metate fragment	1	435	—	—	
Pecking stone, complete[b]	5	35–46	—	—	
Pecking stone, fragment	2	69–116	—	—	
Pestle, complete, damaged	3	177–512	—	—	
Pestle, fragment	1	528	—	—	
Polishing stone, complete cobble	41	3–567	2	1	One with grooves from tool sharpening; one from P-590, surface; one from P-2073; one late and two early specimens are small round pebbles *c.* 3–5 g in weight
Polishing stone, fragment	7	7–137	—	—	From P-411
Possible ball belt fragment	1	1033	—	—	
Smoother	1	1075	—	—	
Three-pointer	1	185	—	—	Unfinished, broken

Notes

a Exclusive of beads, other ornaments and adornments and non-utilitarian lithic artifacts.

b These were omitted from samples sent to Dave Davis for analysis.

4.50 cm long, 1.50 cm thick and 1.70 cm wide, was recovered from Level D of N2098.50/1821.50E in the Area 1 midden, and 7 plano-convex adzes (including 2 rectangular specimens) and 1 adze flake were recovered from the Area 4 midden and from surface contexts. Composition of the adzes includes basalt, and a greenish grey andesite that is available at the site.

Five complete petaloid celts, 14 butt ends, 6 mid-sections, 2 bits and 12 flakes were recovered from the Tutu site. Of 5 complete petaloid celts, 2 are from early midden deposits and 3 are unprovenienced. Of 2 celt bits found at the site, 1 is a dark grey, beautifully polished artifact of hornblende gneiss, with concentric banding and a sharp edge, recovered from P-702. The celt bit, which exhibits no sign of use, is probably a ceremonial object. Also included in the Tutu celt inventory are 4 complete and 2 chisel-like celts.

Rectangular stone adzes are associated with the Hacienda Grande style of Puerto Rico where, along with petaloid celts, they continued into the late Saladoid period and are associated with the Cuevas ceramic style (Rouse & Alegría, 1990: 50–53). Adzes are found only in Saladoid contexts (Rainey, 1940: 107; Rouse, 1952: 358; Rouse & Alegría, 1990: 65; Siegel, 1992: 106), but ground stone celts were produced throughout the Ceramic Age.

PESTLES

Five broken stone pestles, 1 pestle fragment, and 6 whole and broken edge-grinders were recovered from early midden contexts, post holes or surface contexts of the Tutu site. Many of the broken pestles and celts bear flake scars and signs of re-use.

Artifacts created or affected by abrading

BALL BELTS

Three ball belt fragments were recovered from unprovenienced contexts of the Tutu site. Two are of the type described as "massive" and one is a "slender" fragment. All specimens are elliptical in cross-section. The massive ball belt fragment No. 195, recovered from the Area 3 ground surface, measures 5.80 cm by 9.50 cm in cross section and has an arc length of 6.50 cm. The object weighs 397 g. In cross-section, massive ball belt fragment No. 5018, recovered from Soil Mound No. 3 in Area 9S, has a width of 6 cm by 8 cm (Figure 1.37). The fragment has an arc length of 10 cm and weighs about 900 g. Its only decoration is a flat ridge, 1.50 cm wide and 0.03 cm high, which extends along one edge of the arc. Both massive ball belt fragments were manufactured by pecking and grinding of a hard granitic rock, of a type which can be found in the batholithic formations of Virgin Gorda and eastern Tortola.

The slender ball belt fragment, No. 5017, recovered from the surface of Area 5, is 3 cm by 3.80 cm in cross-section, and 5.80 cm long (Figure 1.38).

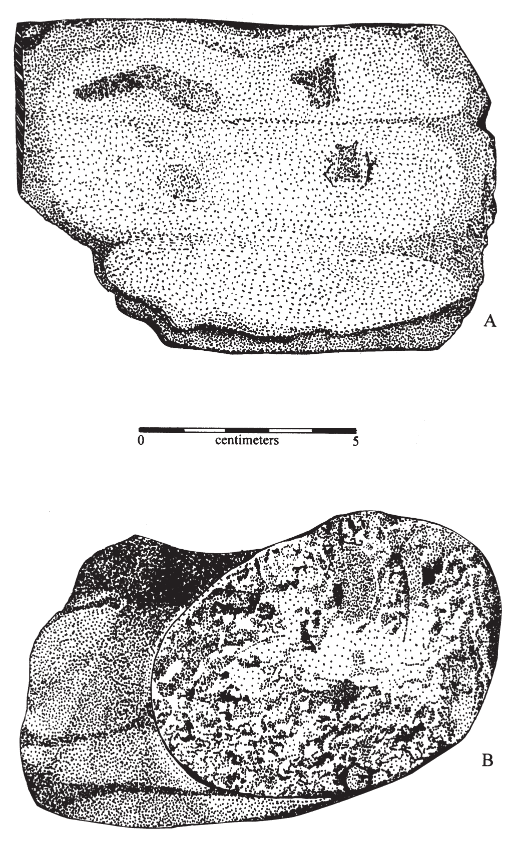


Figure 1.37 Two views of massive ball belt fragment No. 5018, recovered from Soil Mound No. 3, Area 9S (drawing by Sean Krigger).

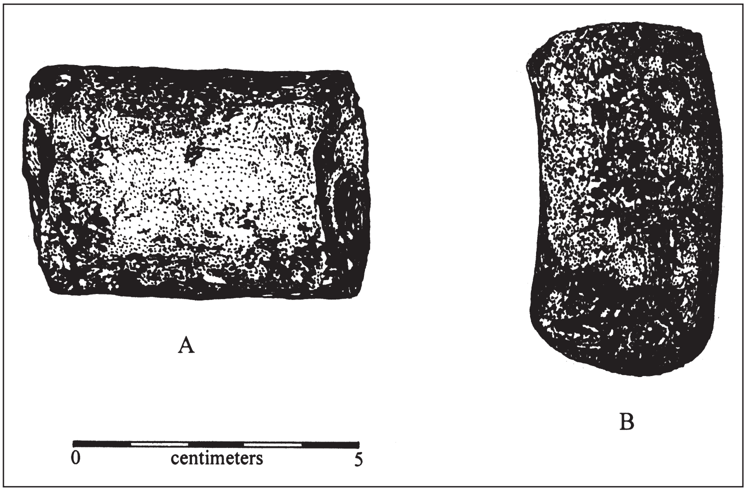


Figure 1.38 Two views of slender ball belt fragment No. 5017, recovered from the surface of Area 5 (drawing by Sean Krigger).

The fragment, which weighs 42.50 g, has a highly polished, smooth and undecorated surface. Post-breakage secondary battering and grinding wear are apparent on one fractured end of the belt fragment.

Ball belts are believed to be among the paraphernalia associated with a rubber ball game played by the Taíno Indians and described by eyewitnesses such as Fray Bartolomé de Las Casas and Gonzalo Fernandez de Oviedo (Alegría, 1983: 7–15). Archaeological remains of ball game courts or “bateys,” enclosed by stone alignments or earthen mounds, have been found in Cuba, Turks and Caicos, Hispaniola, Mona and Puerto Rico (Alegría, 1983). A single court also is known at Salt River, St Croix. In archaeological contexts, ball belts, zemis and elbow stones are associated with ball courts and seem to be related to ceremonial aspects. Ethnohistorical accounts provide no information about belts or any other type of protective gear worn during the game (Alegría, 1983: 15). However, small clay figurines, recovered from Nayarit, Mexico (Olsen, 1974: 206, 207, Figure 88), portray ball players with either white belt-like markings or slight protrusions above their hips, suggestive of protective belts about the waist. It is unknown whether the archaeologically recovered stone belts were actually worn by ball players or were purely ceremonial (Alegría, 1983: 150). Alegría suggests that straw or wooden belts might have been worn by the players, and, only during ceremonies associated with the game, were the stone replicas worn. (For a comprehensive discussion of the Caribbean rubber ball game, courts and associated paraphernalia, see Alegría, 1983.)

THREE-POINTERS

A three-pointed stone, recovered from a soil furrow in Area 1, is 3.80 cm in height and has a slightly convex diamond-shaped base 4.80 cm long and 3 cm wide at its widest point. The surface of the small “three-pointer” is uncharacteristically unpolished. It is a dull greyish green color, with small black streaks of hematite throughout, and a very thin band (1 mm thick) that encircles its midpoint. When suspended, the three-pointer is perfectly balanced and reacts to a magnet. The author is unaware of any other zemis of this type in the Caribbean islands. The stone most likely was selected for its magnetic qualities and may have been used by shamans in magico-religious rituals, similar to some described by Hatt (1924) and Ferdinand Columbus (Bourne, 1906: 5). Although its design is not suited to suspension, the magnetic responses of the stone are highly suggestive of use in non-ceremonial activities also, such as navigating or tracking celestial events.

An incomplete broken massive stone zemi, composed of a batholithic rock, was recovered from the fill of Trench 9. As found, the three-pointer is 11 cm long, 4.50 cm wide and 6 cm in height with a slightly concave base (Figure 1.39b, lower). The stone has been shaped by grinding, pecking and polishing and except for a section below the peak which is roughly pecked, is smooth all over. This pecking and fine etched lines on the artifact's surface suggest that further carving was intended. The unbroken end of the zemi shows signs of secondary battering and use as a hammerstone. While not recovered in a datable context, the Tutu stone zemi, when finished, would have been a massive elaborately carved type, comparable to an elaborately carved stone three-pointer recovered from the Trunk Bay site in a context after AD 1100 (personal communication Ken Wild, National Park Service Archaeologist on St John). The Tutu zemi demonstrates local skill in massive stone work, while the St John artifact also verifies the presence of carved massive stone zemis in the Virgin Islands during late Ostionoid times.

GREEN STONE PLAQUES, STONE BEADS, AND OTHER SMALL OBJECTS OF STONE

Eleven small stone plaques and preforms, composed of a variety of green lithic materials, including green chert, green quartzite and copper carbonate, were recovered from six areas of the Tutu site (Figure 1.40a). Seven of the plaques are finished artifacts, recovered from Areas 1, 4, 8, 9N and 9W. These are associated with Lundberg's ceramic Assemblages 1, 2 and 3 (Chapter 5), with date ranges between *c.* AD 65 and AD 885.

Of the 7 finished artifacts, 4 are fashioned from a deep green chert, and 2 from a pale green and light beige chert of poor quality. The artifacts are highly polished, plano-convex, and roughly trapezoidal in plan view, with one end narrower than the other. Of the finished objects, 1 was recovered from the surface of the exposed Area 1 midden, 4 were from the surface and Levels A and B of the Area 4 midden, and 1 was from Level D of N2116/1850E in Area 8. The bases of the stone plaques range in width between 1.10 cm and 2.25 cm. Lengths range between 1.25 cm and 2.40 cm, and maximum thicknesses range between 0.40 cm and 0.75 cm.

The remaining finished stone plaque is copper carbonate, elliptical in shape, flat on one side and rounded on the other. It was recovered from Level I of N2044/1837E, in a context dated to between cal. AD 535 and cal. AD 865 (2-sigma, Beta 62570). The artifact is 0.95 cm long, 1.90 cm wide and 0.40 cm thick.

Of 4 recovered preforms, 2 are emerald green quartzite, 1 recovered from Burial 3 fill and 1 from Level B of N2075/1810E. These two preforms are flat on one side with a raised ridge on the other, resembling a small prism. A third artifact, a chert preform, rounded on one side and only slightly flattened on the other, is 2.10 cm long, between 1.00 cm and 1.80 cm wide, and 1.00 cm thick. The fourth artifact, a copper carbonate preform from Level B of N2117/1849E, is elliptical in shape with rough edges. It is 1.40 cm long, 0.90 cm wide, and 0.40 cm thick.

The lowest and middle levels of the Hacienda Grande site in Puerto Rico yielded plaques composed of green stone, and semi-precious stones such as serpentine, jadeite and nephrite (Alegría, 1981; 13; Rouse & Alegría, 1990: 51, Figure 12A). Alegría interprets these as possible inlays for insertion in masks, adornos and other ceremonial paraphernalia composed of clay, stone, cotton, straw, bark and wood. In the Virgin Islands, small flat-bottomed polished green stones were reported from the Cinnamon Bay site, St John, in a context that dated to about AD 900 (personal communication, Ken Wild, National Park Service Archaeologist in St John). These objects, however, have not yet been catalogued or analyzed.

Green stone inlays were not recovered from Chican Ostionoid contexts at Tutu.

STONE BEADS, PREFORMS AND CRYSTALS

Eleven complete and 2 broken translucent cylindrical calcite beads were recovered from five areas of the Tutu site. Of these, 6 were from contexts dated to between cal. AD 265 and cal. AD 865 (2-sigma, Beta 50066, 62570); 1 was from Level PP of N2044/1837E, pre-dating the upper late Saladoid midden, and 1 was from P-703 in Area 2. The remaining beads were from undated midden levels or from surface contexts.

Figure 1.39a Upper: stone slab, used as a grinding stone, recovered from the surface of Area 13. The object exhibits a shiny polished surface, 20 cm x 23 cm (photography by Jeremy Lazelle).

The Tutu calcite beads are cylindrical in longitudinal section and either "short" or somewhere between short and "standard" in length (Watters & Scaglione, 1994: 229). Lengths vary considerably, while bead diameters are consistently between 4 mm and 6 mm. There is no observable direct relationship between size of bead and drill hole size. The beads are circular in transverse section, and, in longitudinal section, drill holes are almost uniform in diameter. A few drill hole edges exhibit signs of wear from the cord on which the beads were strung. Cylindrical surfaces are highly polished and smooth, and both ends are ground flat with marks of grinding still visible. Calcite bead ends do not exhibit slight indentations which would hint at drilling techniques. This suggests that a bead was drilled, bored, and finally ground or re-ground on the ends, to create a neat flat surface.

One large clear calcite crystal, ground on the ends (Figure 1.40b, second from left), was recovered from the bottom of Trench 9; and a hexagonal bead preform of opaque calcite was recovered from the Level A of N2087/1952E (Figure 1.40b, center). Eight quartz beads were recovered from four areas of the Tutu site. Beads are cylindrical and short (n=4); round (n=1); convex or barrel-shaped and long (n=2); and square (n=1) (Watters & Scaglione, 1994).

Two of the cylindrical quartz beads, one from the top 2 cm of the Area 1 midden, and the other from Burial 3 fill, resemble the cylindrical calcite beads from the site.

The two other cylindrical quartz beads, recovered from the Area 4 midden, are opaque white in color and wedged on the ends. According to L. A. Carlson (personal communication), the wedge shape is designed to facilitate curvature of a necklace and improves fit when it is worn around the neck.

Figure 1.39b Lower: massive stone zemi in process of manufacture, recovered from fill of Trench 9. Artifact apparently broke before it was completed and one end was re-used for hammering (photography by Jeremy Lazelle).

A large round bi-conically drilled and bored quartz bead, was recovered from mixed contexts in Level A of N2059/1833E (Figure 1.40b, far right). The edges of the bead (which is 180 mm in diameter and 110 mm thick) are dulled by grinding and fine pecking, and the remainder of the bead is smooth with a high polish. Marks of boring are visible on the interior of the drill hole. An almost identical bead was recovered from the Pearls site in Grenada (Cody, 1991b: Figure 2).

A long milky quartz bead (Figure 1.40b, second from right), which is slightly convex in longitudinal section and wedged on the ends, was recovered from the surface of Area 8 at Tutu; and a second long bead, which is convex or barrel-shaped in longitudinal section and composed of amethystine quartz (Figure 1.40b, far left), was recovered from Level BIIC of N2087/1952E, dated to between cal. AD 265 and cal. AD 615 (2-sigma, Beta 50066). The bead, which is polished on the exterior, is 113 mm long and 70 mm in diameter. Both ends of the bead are finely pecked and polished. The interior of the bore hole is smooth, suggesting that it was created by boring from either side with a stick and sand or grit (personal communication, L.A. Carlson, 30 October 1998).

A tiny bi-conically drilled square quartz micro-bead, 3.50 mm on a side and 1.10 mm thick, was recovered from Level B of N2097/1822.50E in Area 1.

Two white quartz discoidal artifacts, roughly circular in transverse section, were recovered from Level BIII of N2087/1952E in Area 4. One disc is unperforated with smoothed edges, and the other is partially perforated on one side. These may be an inlay and an inlay preform.

Figure 1.40a Upper left and right: green quartzite inlay preforms; Upper second from right: copper carbonate inlay; Remaining items: various green stone inlays (photography by Robert Coates).

A small clear unmodified quartz crystal was recovered from upper levels of the Area 4 midden.

A cylindrical stone bead with two perforations at right angles to each other (Figure 1.36b, upper center) was recovered from Level A of N2117/1850E. The bead was polished on both ends and apparently was designed to be strung on a cord with feathers or other decoration protruding from one of the perforations.

An elliptical discoidal bead, composed of a material resembling turquoise, but identified by Alan O'Hara as green chert, was recovered from the surface of the Area 1 midden at Tutu. The bead, which was 7.50 mm by 6 mm in width and 2 mm thick, was similar to a green stone bead recovered from the Hacienda Grande site (Rouse & Alegría, 1990: Figure 12D), and a bead described as "turquoise" that was recovered from the Cane Bay site on St Croix (Payne & Thomas, 1988: II–38). A circular discoidal bead preform, also of green chert, was recovered from Level BIIA of N2087/1952E of the Tutu site.

Figure 1.40b Left: amethystine convex or barrel-shaped bead; Second from left: calcite crystal recovered from the bottom of Trench 9; Center: calcite long bead preform; Second from right: convex wedged milky quartz bead; Right: large round quartz bead, pecked and polished on the exterior, recovered from Level A of N2059/1833E (photography by Robert Coates).

STONE SLAB

Among recovered abraded stone materials is a large stone slab which measures

66 cm by 60 cm in length and width, and is 12 cm thick (Figure 1.39a, upper). On one side of the slab is a shiny surface, 20 cm by 23 cm, that has been worn smooth by abrading. The other side of the slab is weathered, and there is a small grinding surface on that side also. On the surface of scraped soil, next to the slab, was a round ground stone ball, 14 cm in diameter.

GRINDING PALETTE

Another artifact in this category is a grinding palette, recovered from Level BII-D of N2087/1952E in the Area 4 midden (Figure 1.34b). The artifact, possibly a tray or seat palette composed of a non-local quartzite, is irregular in shape, approximately 19 cm long and 15.50 cm wide. Its thickness varies between 2 cm on the outer edges and 0.20 cm in the center. The upper surface of the artifact is smooth and polished with raised beveled edges and three decorative parallel engraved lines on two sides. The opposite two edges of the artifact are rough and unmodified. Two short lines, 3.50 cm long, extend diagonally across the smoothed surface of the artifact, against the grain of the stone. The underside of the artifact is flat and unaltered.

Crumbling

Crumbling techniques include battering, pecking, hammering and bashing. Wear, or the working edge, on crumbling tools is usually a flaked or naturally sharp edge, which, when dulled by use, is rejuvenated by the removal of a few flakes. Tool edge morphology changes as the use of the tool progresses. In the Tutu collection, it was not uncommon for one tool to have different stages and types of wear on several different edges. In some cases this might have resulted from re-use of a broken or defunct tool and in some cases the tool may have been multipurpose. For example, the abraded bit end of a broken celt might be re-used in a crumbling technique such as hammering. As with abrading, some tools are production tools and others are the object of crumbling production. Crumbling may also be a process in the production of an abraded tool.

Tools produced by crumbling

Typical tools modified by crumbling are hammerstones, chisels, gouges, pecking tools and anvils. A wide range of materials, sizes, shapes and weights was found among these tools (Table 1.10) and all classes but anvils were recovered from the Tutu site.

Fifteen complete and two fragmentary pecking stones, perhaps used in the production of ground stone artifacts, were analyzed by Dr Davis. Some of these unusual tools are listed in Table 1.9, and the remainder are described in Chapter 11.

Dr Walker observed that chopping and pounding tools were very common at the Tutu site, and often broken tools had been re-used for these functions. Dr Walker identified 9 hammerstones, and an additional 18 complete and broken hammerstones were catalogued by Jeremy Lazelle.

Other lithic items

Copper carbonate

Four large pieces of copper carbonate, 6 tiny chips identified by Alan O'Hara as "copper stains," and 2 pieces of parent rock containing copper stains, were recovered from five areas of the Tutu site. Four of these were recovered from excavated contexts dated to between cal. AD 265 and cal. AD 630 (2-sigma, Beta 50066, 65473). Larger pieces apparently were obtained to fashion inlays and the smaller chips are by-products of manufacture.

In addition to the "fire-dog" identified in Feature 21, 10 fire-cracked rocks and 4 cobbles altered by fire were recovered from surface contexts, hearths, post holes and excavation units of the Tutu site. Also recovered were 4 pieces of red ochre, 1 of which was found in Burial 11 and had ceremonial connotations.

Interpretation

General distribution of lithic materials used in artifact manufacture at Tutu

Dr O'Hara, gemologist, who examined the lithic artifacts from Tutu, provided a list of available lithic raw material sources at the Tutu site, on St Thomas, and on neighboring islands. The list is by no means exhaustive, and the presence of lithic resources is not necessarily an assurance that they were exploited by the Tutu inhabitants. In many cases, also, it is not possible to determine whether raw material was procured and brought to the site for artifact manufacture or whether finished objects were obtained in trade or exchange. However, on-site production of certain lithic items may be deduced from (1) the presence of artifacts and their raw lithic materials at the Tutu site and (2) the presence of artifacts in process of manufacture and related debitage.

Andesite, used in the manufacture of tools during all phases of Tutu occupation, was abundantly available at the Tutu site. Quartz and calcite also were readily available and raw crystals could have been obtained easily. There is good evidence for on-site manufacture of barrel-shaped and discoidal quartz and quartzite beads, but there is no evidence for similar manufacture of the calcite and clear quartz cylindrical beads, and it is possible that these were obtained by exchange or trade. Haviser (1991: 650) has noted that stone working areas were localized at the Hope Estate site, and, if such were the case at Tutu, residue of on-site manufacture may have been present in uninvestigated areas of the site or scraped away.

Raw materials from which Tutu lithic artifacts were manufactured also can be obtained elsewhere on the island of St Thomas. Basalt, noted by Walker as a material used in Tutu tool manufacture, is available in many areas of St Thomas and St John. Red jasper may be found at Caret Bay, as well as on the top of Crown Mountain and near Secret Harbor on St Thomas. The Secret Harbor source would have been the closest to the Tutu site. Green "chert" is available at Maile Bay and Caret Bay on the north side of St Thomas. While green stone plaques from the Tutu site were similar in appearance and probable function to inlays in green stone and semi-precious stone from Hacienda Grande and some other sites in the Greater and Lesser Antilles, the green stone artifacts from the Tutu site apparently were fashioned either from locally available materials, or from materials that could be found in the British Virgin Islands. It would appear that the color green was significant and that the Tutu green stone items (including, perhaps, polished green petaloid celts and a green chert bead and bead preform, discussed below) are what Cody (1991b: 592) has called "cultural jade."

Off-island lithic raw materials found at Tutu include green quartzite and copper carbonate, available at the Coppermine site on Virgin Gorda; batholithic granite found on Tortola and Virgin Gorda; and a grey to pinkish chert which outcrops at Ditlif Point on the south shore of St John. Other flint recovered from the Tutu site was identified as probably Antiguan flint (Jeff Walker, personal communication; Watters, 1997).

Lithic sources of early occupation artifacts at Tutu

A single amethystine quartz bead was recovered from Tutu. This bead is similar to those recovered from the Maisabel site in Puerto Rico (Siegel, 1992), La Hueca in Vieques, and the Trants site in Montserrat (Cody, 1991a), for which sources in Martinique, eastern Brazil, and possibly Grenada (suspected but not yet identified) have been hypothesized (Cody, 1991a). According to Alan O'Hara, amethyst and amethystine quartz occur naturally on Tortola, which would make this the only presently-identified source of amethyst and amethystine quartz in the northern Caribbean islands. The single amethystine quartz bead recovered from the Tutu site does not unequivocally demonstrate that the inhabitants of the Tutu site knew of or exploited the source in Tortola, however, and both geologic surveys and additional archaeological research on Tortola are warranted to determine whether the resource was being mined, processed into beads, or traded by prehistoric peoples.

As previously mentioned, green quartzite and copper carbonate discs were recovered, both as finished artifacts and in process of manufacture, from early occupation contexts at Tutu. These materials are present in surface contexts at the Copper Mine site on Virgin Gorda.

In the Caribbean islands, artifacts crafted of such lithic materials as nephrite, jade, jadeite, turquoise, serpentine and aventurine, found at one or more sites such as Pearls on Grenada (Cody, 1991a); Punta Candelero in Puerto Rico (Rodríguez, 1991a, 1991b; Rodríguez & Rivera, 1991); La Hueca in Vieques (Chanlatte Baik & Narganes Storde, 1983; Narganes Storde, 1995); Prosperity on St Croix (Vescelius & Robinson, 1979); and the Trants site in Montserrat (Watters & Scaglione, 1994), have led to hypothesis of a pan-Caribbean trade in semi-precious stones and exotic lithic materials and objects. Cody (1991a) has argued that manufacture and possession of artifacts of exotic stone were restricted, indicating centralization of power by elites, and Rouse (1992) has suggested that certain sites were ports of trade. If so, the Tutu site apparently was not among elite villages, although it is possible that the major Saladoid occupation at Tutu began after the semi-precious stone trade had begun to taper off (Boomert, 1987; Cody, 1991a; Rodríguez, 1991a; Vescelius & Robinson, 1979; Watters & Scaglione, 1994).

There are, however, many similarities between lithic artifact types recovered from the Cedrosan Saladoid occupation of the Tutu site (*c.* AD 65–660) and those recovered during roughly the same period from the Hacienda Grande, Punta Candelero and Maisabel sites in Puerto Rico (Rouse & Alegría, 1990: Rodríguez, 1991b: 308; Siegel, 1992) which suggest that inhabitants of these sites utilized a functionally comparable lithic toolkit, adorned themselves with similar-looking stone beads and used inlays in idols and other objects indicative of a similar belief system and ceremonial life. Raw materials used in production of some Tutu artifacts indicate differences in procurement practices and trading patterns. Some raw materials apparently were obtained from islands to the east and northeast, suggesting that either the Tutu inhabitants procured the materials themselves, or there was an interaction sphere for trade in lithic objects and/or raw materials, probably centered on Pillsbury Sound between St Thomas and St John, and Drakes Channel in the British Virgin Islands.

Lithic sources of artifacts from the late occupation at Tutu

Materials used in massive stone work produced by the late prehistoric inhabitants of the Tutu site were available on the east end of Tortola and on Virgin Gorda. This suggests continued exploitation of these resources or trade with these islands. Batholithic rock that contains nephlone and hornblende, the rock type of which Tutu ball belts and a broken massive stone zemi were manufactured, is found on Virgin Gorda and in eastern Tortola. Quarries on the south shore of St John also may have provided some raw lithic materials. Small late prehistoric sites identified on offshore cays, such as Rotto Cay in the Mangrove Lagoon and Lovango and Henley Cays in Pillsbury Sound between St Thomas and St John, suggest that use of the cays may have included stop-overs during voyages to obtain raw materials or to trade (Righter, 1995).

Present evidence, therefore, indicates that during both occupations of the Tutu site, the inhabitants obtained many raw lithic materials from the Tutu site itself, from the environs of St Thomas and from islands to the east and northeast, where an interaction sphere may have been centered.

Burials

Introductory overview

This section augments Chapter 7, which presents the bioarchaeology of the skeletons recovered from the Tutu site. Discussed briefly below are differences between burials of the early and late occupations at Tutu, in terms of age at death, orientation of skeletons, burial pit attributes and distribution of burials on the site.

If Burials 4 and 27 are included, 42 human skeletons were identified in 37 burial pits at the Tutu site. AMS dates were obtained from bone collagen of 27 specimens (Table 1.4). All adult skeletons (n=22), except Burial 40, were AMS dated. Bones of undated skeletons, such as newborns or stillborns, and other small infants, were too fragile to be suitable for extraction of bone collagen for dating. When two individuals were interred in one undisturbed pit, only one of the skeletons was dated. The chronological position of all but four of the Y2 Tutu skeletons (40, 41, 28A and 28B) could be established either by AMS dating, by associated vessel types, by stratigraphic context, or by association with AMS-dated burials. In the following discussion, counts by occupation period include only skeletons for which dates of interment are known or inferred (n=38).

Age at death: the early occupation

Because the sample of early occupation human remains at the Tutu site is small, age-at-death statistics may be skewed. Nevertheless, the Tutu figures compare very well with statistics from the Saladoid period Hope Estate cemetery in St Martin Estate (Richier & Bonnissent, 1995), and the early period at the Maisabel site in Puerto Rico (Budinoff, 1991; Seigel, 1992). Of the 14 early occupation human remains, the age of 1 was unidentified; 5 (or 36%) were infants less than 2 years old; 1 (or 7%) was between 18 and 25 years of age; and 8 (or 57%) were between 35 and 55 years of age at death. No skeletons fell into the age group between 1 and 17 years of age, which appears to indicate good health in that age group.

Age at death: the late occupation

Of the 24 late occupation deceased individuals, subadult deaths numbered 12 (or 50%), a substantial increase over the early period. In this group, individuals between the ages of 2 and 9 years numbered 6, or 50 percent of subadults and 25 percent of the total number of late occupation deaths. Two subadults and one adult (13% of total late occupation burials) were in the age group between 15 and 21 years of age; and, compared to the early occupation, a smaller number (11 or 46%) were between 35 and 55 years old. Age at death for adults generally mirrors that of the early occupation; but there is a substantial increase in deaths between the ages of 2 and 9 years and a decrease in the percentage that reached the ages of between 35 and 55 years. Age at death of recovered late occupation skeletons from the site most likely is representative of the entire deceased population.

Age, sex and relationship to middens: the early occupation

The 14 burials of the early occupation were located in Areas 1, 2, 5, 6, 9S and 13. Five burials were in an apparent cemetery in the central open space or plaza (in Areas 5 and 6) and the rest were in domestic areas of the site. Only one structure of the early occupation was identified and it was not associated with a burial of the same period. Therefore, although it is apparent that burials were in habitation areas, it is not known whether interments were inside or outside of structures. Except for Burial 3, an anomaly, burials did not occur in middens, and burial pit fill did not contain midden material. In some cases, overlying midden may have been removed by pre-1990 machine scraping, but in only one case, Burial 13, 13A, was it possible to deduce, from contents of adjacent post holes, that late occupation midden had overlain the early occupation burial.

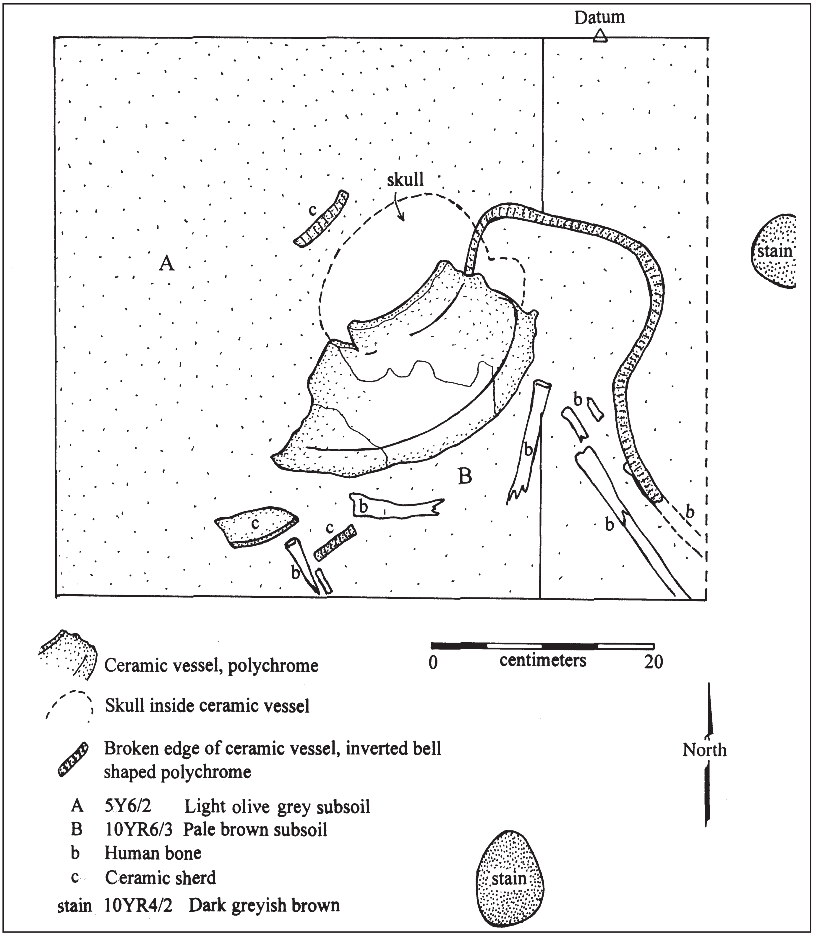


Figure 1.41 Plan view of Burial 21, showing inverted bell-shaped bowl that covered the head of the deceased (recorded by Elizabeth Righter, graphic by Julie Smith).

The small sample size and sexual imbalance in the early occupation burials preclude evaluation of sex as a determinant in burial location. The only obvious locational factor is burial of the single male skeleton in the center of the site with a decorative polychrome bowl inverted over his head (Figure 1. 41). His location may have had social or symbolic meaning. Placement of Burial 3 in the midden appears to have been a site anomaly which, again, may have been related to social factors (Kingsley, 1985). On the whole, during the early occupation of the site, rather than age, sex or relationship to middens, relationship to each other and to other site features, such as domiciles and the central open area/cemetery (probably also a plaza), accounted for the distribution of burials on the site.

Age, sex and relationship to middens: the late occupation

Twenty-four burials recovered from the Tutu site were dated to the late occupation, and 4 could not be assigned to either the early or late occupation.

Of the 24 dated late occupation burials, one was recovered from the central cemetery and the remainder were distributed on the site in habitation areas of Areas 1, 3, 4, 8, 9N and 13. Individuals of all ages were included in this distribution and there did not seem to be a relationship between age and location on the site. The same is true for distribution by sex. Groupings included both male and female adults with infant subadults (perhaps grandchildren or grand-nieces and -nephews) and burial groups were adjacent to structures. There was an increased representation of males (n=5 or 41%) in the deceased adult population during the late occupation at Tutu.

Midden deposits of the late occupation were located only in Area 9S. No dated late occupation burials were interred in or near the late occupation middens, and no burial pits contained midden material. Refuse in the pit fill of Burial 1 could not be described as primary midden. Like the early occupation, therefore, burials of the late occupation were not spatially distributed on the site according to age, sex or relationship to middens, but, rather, according to relationship with each other, with specific structures (domiciles) and with the central open space or plaza.

Orientation

At Tutu, the burial population for the early occupation is small, but a discernible difference can be seen between burial orientations of the early and late occupations. During the early occupation, orientation of the head appears to be random and there is a slight preference for facing to the west or northwest. During the late occupation, there is a marked preference for head orientation, of both adult and subadult skeletons, in a northerly direction. Facing direction is more or less random, with perhaps a slight preference for facing to the west, north or northwest. A subpattern was noted among burials of both occupations, when adults were buried next to or near subadults. In these cases, subadults were oriented to the east or southeast and adults were oriented in opposite directions.

During the late occupation of the site, therefore, a preference for orientation of the deceased's head in northerly direction is obvious and may indicate cultural behavior, and symbolic beliefs. However, in order to understand these patterns, more information is needed from large burial populations at other extensively investigated sites.

Burial pit attributes

The following list summarizes burial pit attributes observed at the Tutu site. Attributes 1–6 are further elaborated in the text following the list.

1 Burial fill at the Tutu site was noticeably clean. Of the 37 identified burial pits, 3 (8%) contained 94 percent of total faunal remains recovered from burial fill (Table 1.2).

2 Because burial fill was predominantly redeposited subsoil, tops of burials pits, especially in Area 1, were camouflaged by subsoil of similar color and mottling. In some cases, burial soils were so clean that archaeologists did not immediately identify their outlines in the scraped subsoil surface. This was especially true in areas where pit soil and subsoil were decomposed calcitic andesite.

3 When first exposed by machine scraping, Burials 8A, 8B, 10 and 22A, 22B appeared to be round post hole stains contrasting with the scraped subsoil.

4 Burials 8A, 8B and 11, in close proximity to Structure 8, and Burial 38, in close proximity to Structure 7, appeared to have been purposely sealed with caps of subsoil. Soil anomalies in Burials 21 and 31 suggested ritual behavior associated with burial ceremonies (Schinkel, 1992: 198).

5 Each of the early occupation skeletons dated between *c.* AD 450 and AD 675 was accompanied by either a single complete ceramic vessel, one or more complete vessels and parts of others, or portions of several vessels. Frequency of accompanying ceramic goods in Tutu burials diminished through time; and, in the late occupation, only two subadults (less than 8 years old) were each associated with all or part of a single ceramic vessel. Late occupation Burial 11 contained a piece of red ochre and, in Burial 8, a *Cittarium pica* shell appeared to have been intentionally placed near the lower mandible of Skeleton A.

6 A semi-circle of between three and four small round stains, or a line of two or three stains, was found in close proximity to Burials 8A, 8B, 11, 15, 16, 21, 26 and 38.

7 Several burials were associated with post holes. Burial 8A, 8B overlay a post hole, while a post hole penetrated the abdominal area of the skeleton in Burial 10. Burial 13, 13A was discovered when an adult femur was recovered from a post hole that had penetrated and disturbed the fill of Burial 13.

8 Bowls in which foetuses had been interred lay directly in and on subsoil with no fill beneath the bowls.

9 Digging stick marks sometimes were present on the sides and on the bottoms of burial pits, such as pits of Burials 16 and 38.

Burial fill, burial pit cavities and capped burials (1–4)

Except for ceramic goods intentionally placed with skeletons, burial pits were almost devoid of cultural material. Exceptions were Burial 27, disturbed by construction of P-1763; Burial 3, which was in a midden; and Burial 1, which was placed in a filled feature.

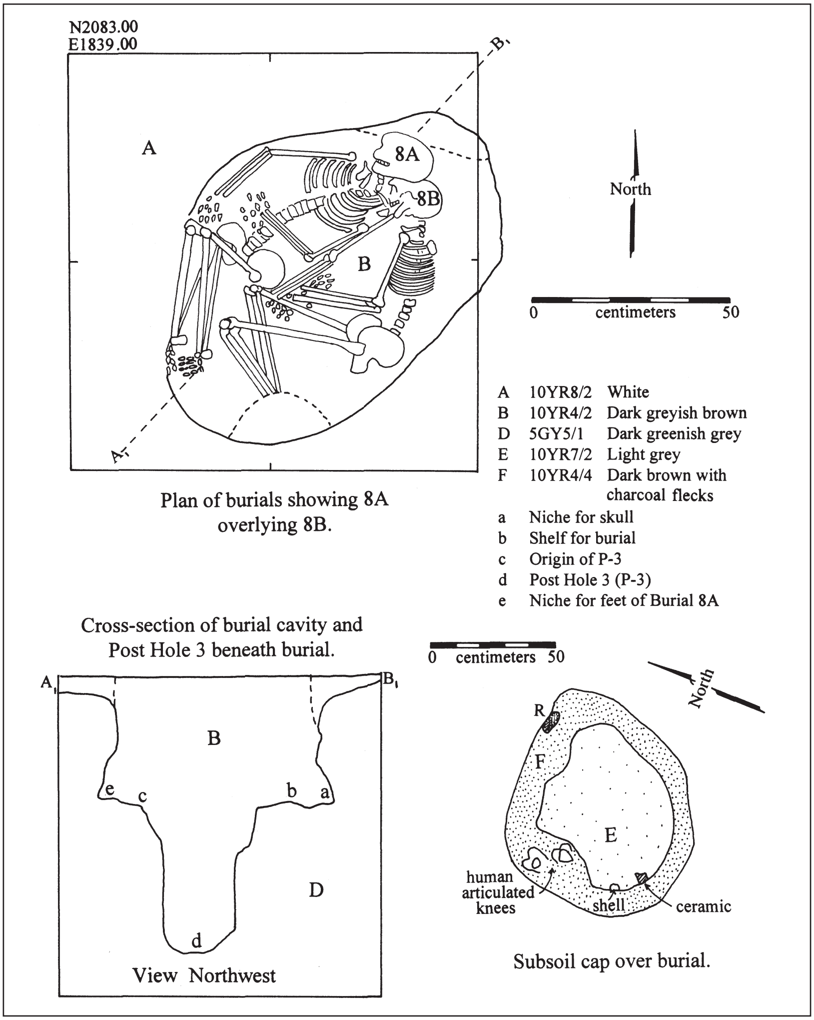
Some burial pits that appeared as large post holes on the scraped surface expanded either a few centimeters into subsoil or under subsoil caps. It appeared that prehistoric grave diggers had tunneled under subsoil to hollow out cavities or cysts for insertion of skeletons. Either one or two skeletons were then placed in these cavities. In the cases of Burials 8A, 8B and Burial 38, extremities such as feet and heads (Figures 1.42, 1.43) were tucked into the spaces cut out under subsoil.

Subsoil caps were present in pits of Burials 8A, 8B, 11 and 38 (Figures 1.42, 1.43, 1.44), all of which dated to the late occupation of the site. Despite subsoil caps, pits of Burials 8A, 8B and 11 first appeared as relatively dark stains. This is because darker soil had filled depressions caused by subsidence as human remains decayed underground, and, when the ground surface was scraped, dark humic soils, retained in depressions, contrasted with scraped subsoil. Accordingly, burial caps were not observed in Burials 8A, 8B and 11 until darker overlying soils had been removed. The cap of Burial 38, however, was exposed on the surface of subsoil, masking the burial. Skeleton 5 was just under the scraped surface, and, if a cap had been present, it may have been removed by scraping.

When first exposed, the pit of Burial 8A, 8B, initially opened and excavated by John Jamison of the National Park Service, appeared as an oval, 80 cm by 72 cm in size. After removal of 10 cm of overlying soil, a circular cap of subsoil (Munsell color, 10YR7/2 light grey) about 60 cm in diameter appeared in the center of the feature. The color and texture of this cap blended in with the surrounding subsoil (Figure 1.42) and were still present at 38 cm below datum (cmbd). Under the cap, the pit in which the skeletons were placed expanded to become an elongated cavity with its northeast and southwestern edges carved out under subsoil. The pit of Burial 8A, 8B extended only to 54 cmbd, at which point the skeletons were resting on an expanded shelf above a post hole.

The dark brown contrasting color and silty clay texture of Burial 11 fill (Munsell color, 7.5YR3/4) was easily recognized against a subsoil of decomposed andesite (Munsell color 5Y6/2 pinkish grey). As the excavation, by Rosa García, progressed, soil became mottled and lighter in color. According to the excavator, at 15 cm below the top of the feature, there was an area of hard greyish green subsoil, a subsoil cap, over the center of the skeleton.

Burial 38, excavated by Margo Schwadron of the National Park Service, also was capped with a wedge of subsoil, some of which had been removed. When the wedge was recognized, the west edge of the cap was retained in place covering the knees of the skeleton. The right foot of the skeleton was tucked into a cavity that had been created under subsoil on the southwestern end of the pit (Figure 1.43). Digging stick marks were visible on the edges and on the bottom of the pit and the pit soil was almost entirely sterile. Other caps may have been unobserved, or removed by scraping; however, caps were not observed in Burials 3, 6, 31, 12, 25, 29, 32A, 33 and 34, where



Plan of burials showing 8A overlying 8B.

Cross-section of burial cavity and Post Hole 3 beneath burial.

View Northwest

Subsoil cap over burial.

Figure 1.42 Burial 8A, 8B in plan and profile, showing also subsoil cap at surface of the burial pit and crypt hollowed out for the burial above a post hole, Area 1 (recorded by Pat Sternheimer, John Jamison and Elizabeth Righter, graphic by Julie Smith).

skeletons were well buried and undisturbed. Evidence indicates that capping was limited to late occupation burial pits, and to burial related to Structures 7 and 8 (Chapter 12). It is unknown whether the intent was to seal or conceal the graves, but the special treatment, including burial caps and clean fill, suggests attempts to preserve the human remains in the burial pits.

Burials with accompanying ceramic grave goods (5)

All burial pits of both adults and subadults, dated prior to AD 640, contained one or more complete or partial ceramic vessels.

Two-sigma date ranges for early occupation burials (prior to AD 960) fall into two general groups. An early group includes Burials 10, 21 and 36 which cluster at between cal. AD 450 and cal. AD 640 (2-sigma, Beta 88345, 83011, 83003) and Burials 4/7 and 13, 13A which date to

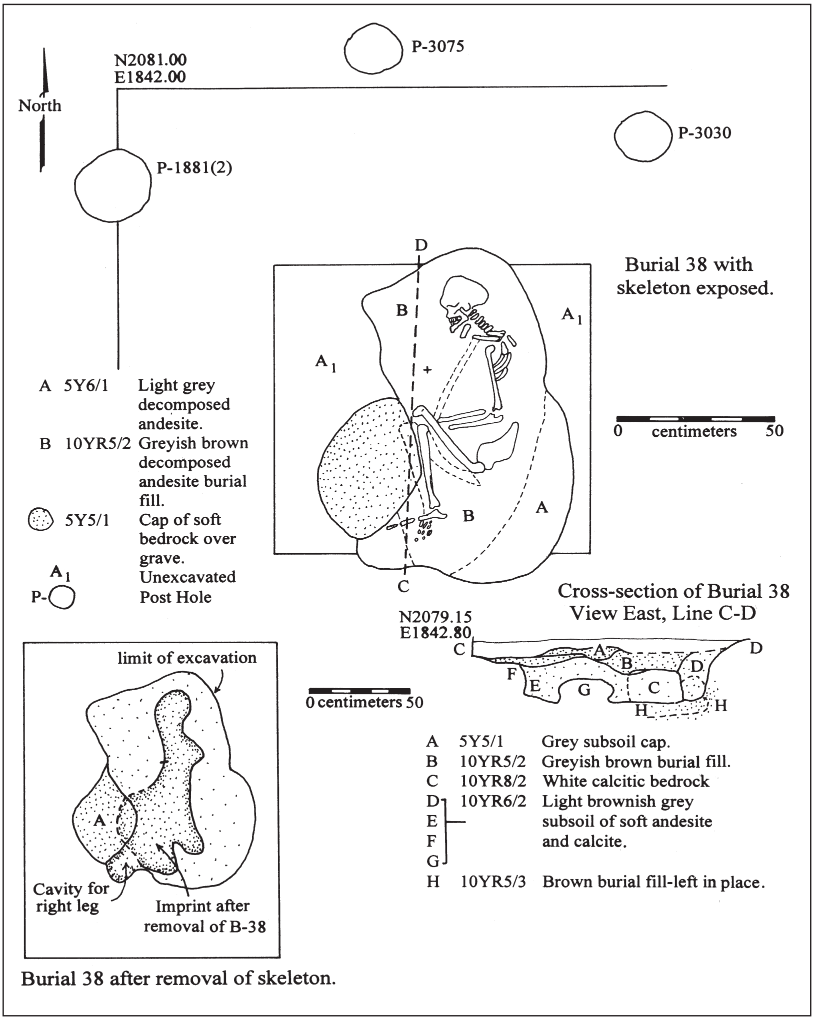


Figure 1.43 Plan and profile views of Burial 38, showing subsoil caps, crypt and cavity for feet (recorded by Margo Schwadron, graphic by Julie Smith).

between cal. AD 560 and cal. AD 675 (2-sigma, Beta 83001, 83009, 83006; Table 1.4). Dates for early Burials 10, 21 and 36 conform generally with dates assigned to the Cuevas ceramic style in Puerto Rico and the Coral Bay–Longford style in the Virgin Islands (Rouse & Alegría, 1990: Figure 15; Rouse, 1992; Figure 14), while date ranges for Burial 4/7 and Skeletons 13, 13A, extend perhaps 35 years beyond the Cuevas dates. Although Lundberg assigns ceramics accompanying Burial 4/7 (Figure 1.45), and one bowl in Burial 13, 13A, to her ceramic Assemblage 3, the relatively restricted 2-sigma date ranges for the two burials do not extend as far forward in time as the 2-sigma range for Assemblage 3 ceramics elsewhere on the site. For the purposes of comparative burial pattern analysis, therefore, the five early occupation burials which pre-date AD 665, and Burial 24, a tiny infant interred in an Assemblage 1 type bowl (Figure 1.46), will be treated as one group.

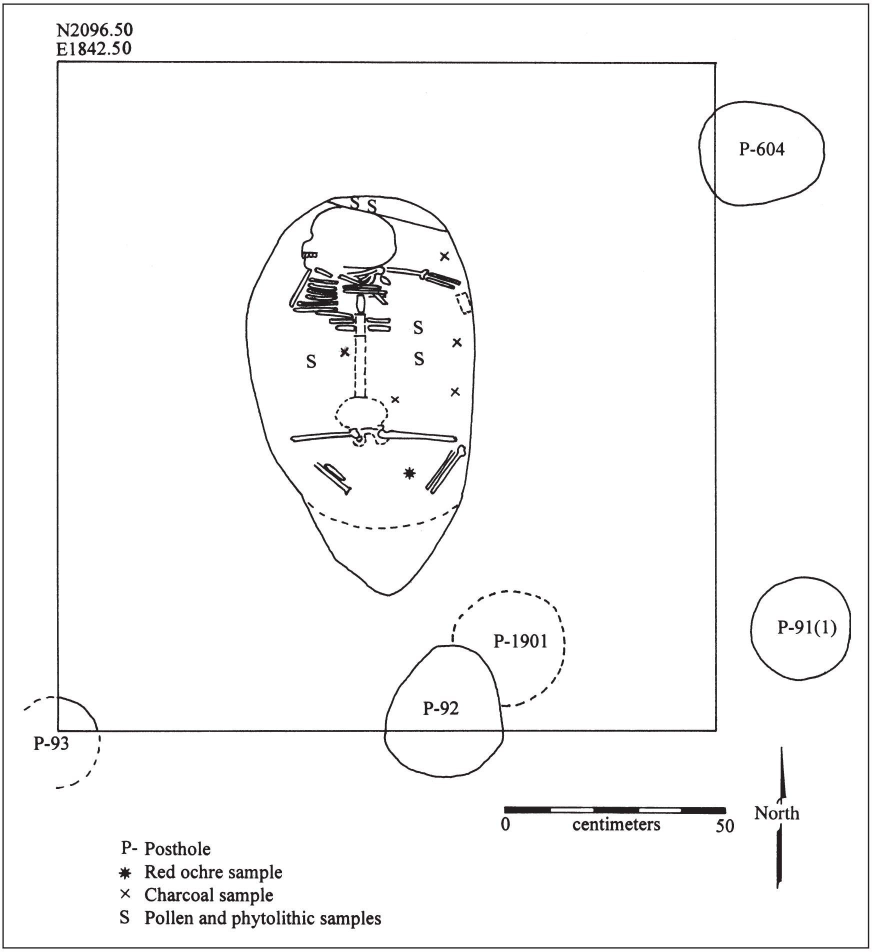


Figure 1.44 Plan of Burial 11, with subsoil cap removed (recorded by Pat Sternheimer, graphic by Julie Smith).

A second group of early occupation burials, Burials 3, 16 and 23B, which have date ranges between cal. AD 640 and cal. AD 960 (2-sigma, Beta 83010, 73392, 83000), seems to be chronologically distinct from the first group. Change in burial pattern is first evident in Burials 16, 23A and 23B, two adult females and a subadult buried in the central precinct. They are clustered in close proximity to each other, and as opposed to earlier burials, one adult and the infant burial do not contain pots. Burial 3 is an anomaly for the site, buried in late Saladoid midden west of the plaza. This skeleton appears to have been accompanied by fragments of one bowl.

Of the 24 identified late occupation burials, only 2 skeletons, subadults, were accompanied by one pot each.

DISCREPANCIES

Skeleton 13A is associated with a vessel identified by Lundberg as similar in style to ceramics of her Assemblage 1, but the skeleton is AMS dated to between cal. AD 560 and cal. AD 665 (2-sigma, Beta 83006) later than the time period generally assigned to that assemblage (Rouse &

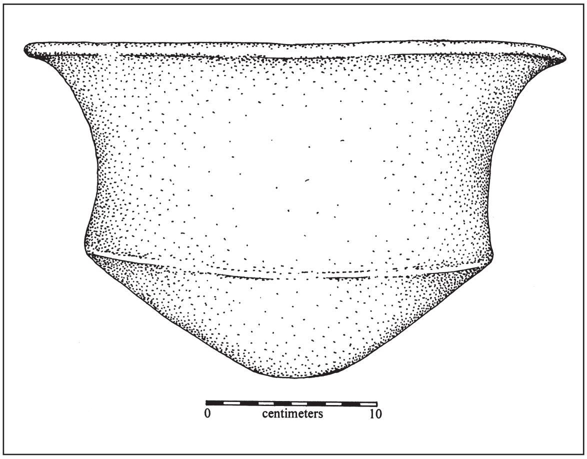


Figure 1.45 Bowl recovered from Burial 4/7 (reconstructed by Margaret and Phil Caesar).

Alegría, 1990). A polychrome vessel associated with the skeleton in Burial 21, likewise, is stylistically earlier than the 2-sigma AMS date range of between cal. AD 450 and cal. AD 640 (Beta 83011) for this individual. This discrepancy coincides with an unexplained tendency at the Tutu site for AMS dates on human bone collagen to be later than generally accepted dates for stylistic attributes of accompanying ceramic goods. A discrepancy between AMS dates and ceramic styles, also discussed by Lundberg in Chapter 5, was noted only in burial contexts. Siegel (1992) observed a similar discrepancy in some burials of the Maisabel site in Puerto Rico, which he attributed to a problem with the glycine depletion ratio in the human bone specimens dated. Observed discrepancies at Tutu may be attributed to continuance of certain stylistic attributes into later time periods, an heirloom factor, or a possible discrepancy between AMS radiometric dates returned on bone collagen (related to climate and diet) and those for plant carbon (Molto, Stewart & Reimer, 1997).

Problems which may affect interpretation of burial patterns of the early occupation

The degree to which discrepancies between AMS dates and ceramic styles occurred consistently at Tutu could not be established; however, the observed problem contributes to difficulties in grouping undated burials of the early occupation, as explained below.

Radiometric dates were not obtained for all skeletons accompanied by ceramic sherds or vessels. When ceramic comparisons could be made, ceramic grave goods associated with undated skeletons were assigned to either of Assemblages 1–3 (Chapter 5), and the temporal positions of ceramic assemblages were used to group undated burials with those that were dated. Dates of ceramic assemblages, however, are derived from dated midden levels and, as discussed in the previous paragraph, these may not correspond to dates that would be obtained if the accompanying skeletons were AMS dated. If adjustments to AMS dates on bone collagen are required in the future, undated Tutu burials, grouped on the basis of accompanying ceramics, may have to be reassigned.

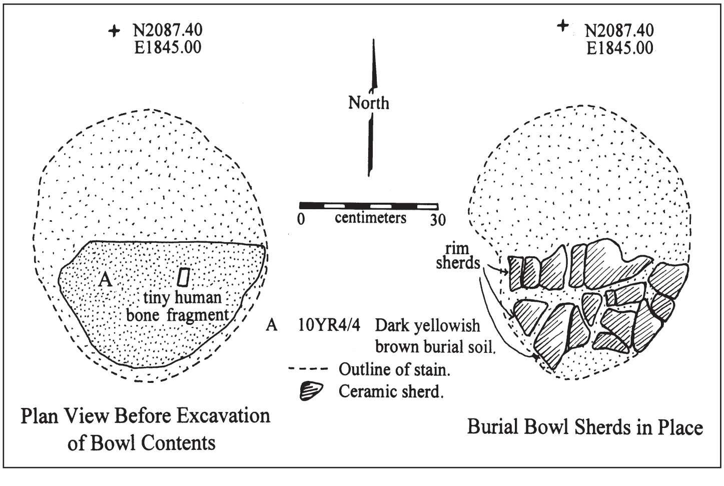


Figure 1.46 Plan view of bowl fragments exposed in Burial 24 (recorded by Meg O'Connor, graphic by Julie Smith).

Relationship of known early occupation burials to structures, to a central plaza-based cemetery and to each other

No burial or post dates overlap with the earliest 2-sigma dates for the Area 1 midden 2-sigma (*c.* 200 BC– AD 130) but it is likely that burials and post holes were present in a nearby uninvestigated section of Areas 1 or 8 or among undated post holes of the areas.

Dates for Feature P-82 in Area 1 range between cal. AD 415 and cal. AD 855 (2-sigma, Beta 108912) and overlap with those for Burials 13, 13A (between cal. AD 560 and cal. AD 665, Beta 83009, 83006). The post, which was among many other post holes, probably belonged to an early occupation structure in Area 1. Other structures, which overlapped in time with Burials 13, 13a, and with Burials 15 and 24 (assigned to the early occupation on the basis of accompanying ceramic bowl styles) also probably were present in Area 1.

In Area 2, date ranges for Burial 10 (Figure 1.47) overlap with those for P-146 suggesting that the burial, a structure represented by P-146, and several post holes in the vicinity, are contemporaneous. Burial 10 most likely is associated with one of the early structures in this area.

Similarly, in Area 13, a structure related to Burial 4/7 (Figure 1.48) can be conjectured (see Figure 12.36).

Burials 21, dated to between cal. AD 450 and cal. AD 640 (2-sigma, Beta, 83011) and 36 were sited in an apparent cemetery in the central open space. A soil anomaly, identified at the base of the bowl accompanying Burial 21, may be a sign of special ritual associated with the burial. Nearby Burial 36, from a similar time range, was accompanied by parts of several ceramic vessels. Burials 16, 23A and 23B, of which Burials 16 and 23B dated to the end of the Saladoid occupation (cal. AD 640 to cal. AD 870, Beta 73392, 83000), were grouped in close proximity to each other in the cemetery, at a distance from Burials 21, 36 and 41. Burial 23A was not dated, but because the edges of the pit, which contained a subadult less than 6 months old, touched that of Burial 23B, it was considered to belong to this group. The bowl with Burial 23B may have been considered a grave good of the Burial 23A interment also. If not, Burial 23A is the only subadult of the early occupation without an accompanying ceramic vessel and represents a change in burial patterns. The grouping of the burials in an apparent family group also represents a change that begins during the extension of the Saladoid series at Tutu into a time period when early Ostionoid series ceramics are present at sites in Puerto Rico (Rouse, 1992). Undated Burial 41 was also in the cemetery.

In summary, early occupation burials were found in habitation areas, where they presumably were associated with domiciles of the deceased, and in a cemetery at the center of the site. The early occupation burial pattern at Tutu, therefore, can be described as both

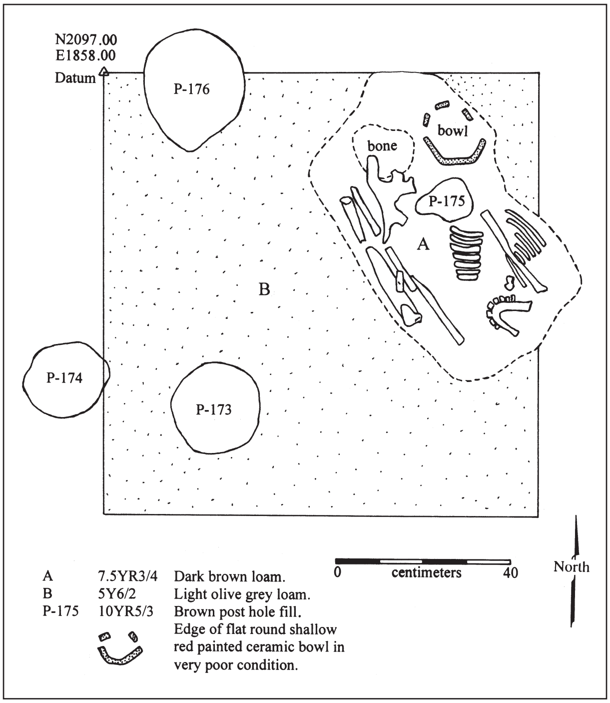


Figure 1.47 Plan view of Burial 10, showing location of accompanying bowl and intrusive post hole (recorded by Pat Sternheimer, graphic by Julie Smith).

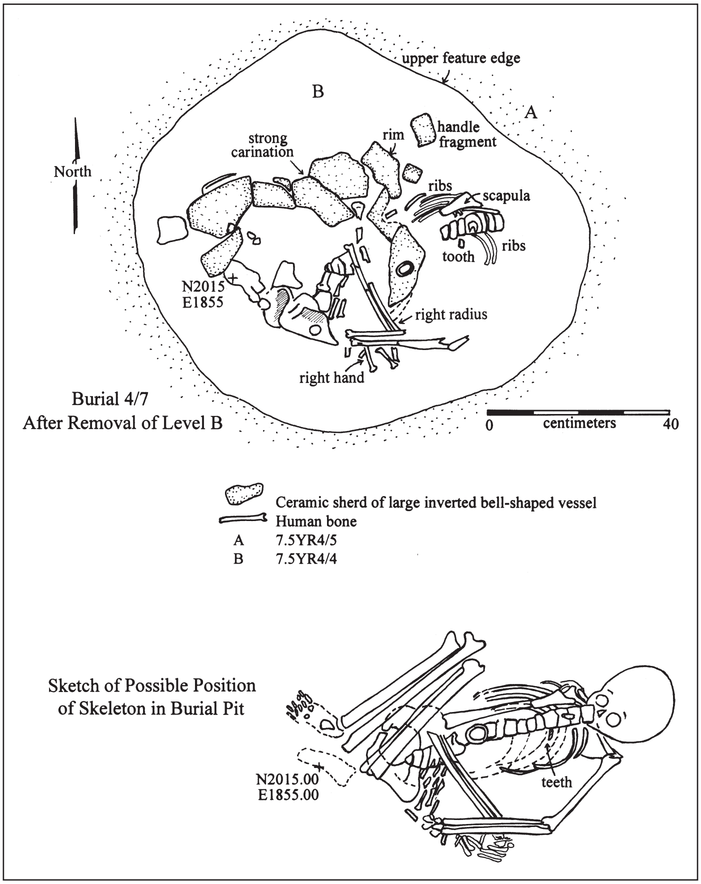


Figure 1.48 Plan view of Burial 4/7, showing relationship of adult skeleton and large inverted bell-shaped bowl (recorded by Emily Lundberg, graphic by Julie Smith).

symboled in a cemetery and house-related (Kingsley, 1985).

Relationship of known late occupation burials to structures, to a central plaza-based cemetery and to each other

Spatial distribution of burials during the late occupation at Tutu exhibits a marked change in emphasis from the early period (Table 1.11). During the late occupation, with the exception of one (or possibly two) burials in the cemetery, burials were either single or grouped (two or more individuals spatially close together) and, with the exception of Burial 20, associated with structures that presumably were their domiciles. The distribution pattern was almost entirely house-related. Where discrete structures could not be defined, the proximity of burials to structures could be deduced from driplines, nearby myriad post holes, or stratigraphy.

Late Tutu burials tended to be grouped in what appeared to be family units. An adult may be buried next to or with a subadult, and subadults were situated either alone, in close proximity to, or in the same grave with other subadults, and adjacent to adults of either sex. It is possible that the deceased were not all related by blood or marriage and that households included non-related persons or fictitious kin. Future DNA or other analysis will be needed to verify relationships among burials. Single burials were sometimes located either very close to exterior house walls or in line with outer wall posts. A single burial, especially that of a subadult, associated with a structure, may indicate that the structure was abandoned before the deaths of other household members.

In terms of site layout, identified burials and burial groups of the late occupation were distributed on the landscape of the site in relation to the distribution of houses with which they were associated, and, to some extent, to the central open area or plaza. Burials 19 and 30 must have been associated with structures that could not be identified among the myriad post holes of Area 9N. Post holes in Trench 1 and pits of Burials 25 and 32A that originated at or near pre-1990 grade in Area 13 also indicated late period occupation in that area of the site. No burials were associated with Structure 1 which was small in size and probably was a special-use building (Roe and Siegel, 1982; Riviere, 1994). Burial 41 was not investigated and the position of Burial 28A, 28B relative to structures could not be determined. Thus, the burial distribution at Tutu during the late occupation was a function of the distribu-

Table 1.11 Relationships of burials to each other, to structures and to the plaza at the Tutu site

Burial no.	*Grave goods*	*Nearest other burials of same period*	*Probably related burials*	*Related structures*	*Occupation period*	*Location on site*
1		2		? in Area 9N	Late	Domestic area
2		1		? in Area 9N	Late	Domestic area
3					End of early	Domestic area
4	Ceramic vessels	7		? in Area 13	Early	Domestic area
5		8A, 8B, 38, 39		Str 8	Late	Domestic area
6		29, 31, 11	29	Str 3	Late	Domestic area
7		4		? in Area 13	Early	Domestic area
8A	*Cittarium pica*	5, 8B, 38, 39	5, 8B, 38?, 39	Str 8	Late	Domestic area
8B		5, 8A, 38, 39	5, 8A, 38?, 39	Str 8	Late	Domestic area
9				Str 6	Late	Domestic area
10	Ceramic vessel			Str in Area 2	Early	Domestic area
11	Red ochre piece	31, 29, 6	31	Str 8	Late	Domestic area
12				Str in Area 4	Late	Domestic area
13	Ceramic vessels	13A, 24, 27	13A	Str in Area 1	Early	Domestic area
13A	Ceramic vessels	13, 24, 27	13	Str in Area 1	Early	Domestic area
15	Ceramic vessel			? in Area 1	Early	Domestic area
16		23A, 23B			Early	Cem
18	Ceramic vessel			Str in Area 4	Late	Domestic area
19				Str in Area 9N	Late	Domestic area
20				Str in Area 4	Late	Domestic area
21	Ceramic vessel	36, 41?			Early	Cem
22A		22B	22B	Str 2	Late	Domestic area
22B		22A	22A	Str 2	Late	Domestic area
23A		23B, 16	16, 23B		Early	Cem
23B	Ceramic vessel	23A, 16	16, 23A		Early	Cem
24	Ceramic vessel	13, 13A, 27		Str in Area 1	Early	Domestic area
25				Str in Area 13	Late	Domestic area
26					Late	Cem
27	Ceramic vessels	13, 13A, 24		Str in Area 1	Early	Domestic area
29		6, 11, 31		Str 3	Late	Domestic area
30				Str in Area 9N	Late	Domestic area
31				Str 8	Late	Domestic area
32A				Str in Area 13	Late	Domestic area
33		34	34	Str 4	Late	Domestic area
34		33	33	Str 4	Late	Domestic area
36	Ceramic vessels	21, 41?			Early	Cem
38		5, 8A, 8B, 39	5?, 8A?, 8B?, 39?	Str 7 or 8	Late	Domestic area
39	Ceramic vessel	5, 8A, 8B, 38	5, 8A, 8B, 38?	Str 8	Late	Domestic area
40		9, 12 (date unknown)	Date unknown	Str 6	?	Domestic area
41		Date unknown	Date unknown		?	Cem

tion of structures; and these, in turn, were situated in relationship to the central plaza, to physical characteristics of the site, and to sociopolitical position within the village (Chapter 12).

Most of the late occupation burials were present in the northern two-thirds of the site, where the majority of late occupation structures also were identified. This distribution may be a result of site expansion during the late occupation, reflecting a slightly different village structure *vis-à-vis* plaza size and shape (Chapter 12), or it may reflect the archaeological research methodology.

Burials that could be related to specific structures were, in all but possibly one case, located either in line with structural walls or in exterior areas adjacent to structures. Archaeological evidence in areas surrounding clearly defined structures suggests that exterior space around structures was intentionally and systematically divided (Chapter 12) into activity and designated-use areas, which included burial areas. Burial pit fill suggests that active burial areas were kept free of topsoil and refuse.

A discussion of burial distribution in relation to specific structures and site layout, and analysis of the implications for cultural and sociopolitical change, are presented in Chapter 12.

CHAPTER SUMMARY

Both meticulous data recovery and machine scraping to uncover post holes, related features and village structure were conducted at the Tutu Archaeological Village site between September 1990 and November 1991. Middens distributed about the site were sampled, and 37 burial pits and 34 other features were excavated. Site maps were prepared manually with a transit and tapes and in Autocad Release 9/10. As a result of the investigations, a wide range of samples was collected in the field and later analyzed by experts in a number of related disciplines. These and other findings were applied to interpretation of the site (Chapter 13).

A series of 92 radiometric dates was interpreted to identify a period of early site occupation between *c.* AD 65 and AD 900/960; a gap in the record between *c.* AD 900/960 and AD 1150; and a Chican Ostionoid occupation between *c.* AD 1150 and AD 1500.

Stratigraphy revealed aspects of site topography and midden disposal, which enabled interpretation of site structure, ritual behavior, and sociocultural change during the course of site occupation. Artifact analysis led to hypotheses concerning cultural and social behavior, as did analyses of floral and faunal remains. The identification of structures and analysis of burial characteristics and distributions provided insights to sociopolitical change between early and late occupations of the site.

Chapter Two

Analysis of charred botanical remains from the Tutu site

Deborah M. Pearsall

INTRODUCTION

This chapter covers the analysis of flotation and in situ-recovered charred botanical materials from the Tutu site. Two major periods of site occupation are recognized: the Cedrosan Saladoid (early period, between *c.* AD 65 and AD 950) and the Chican Ostionoid (late period, between *c.* AD 1200 and AD 1500). For purposes of analyzing the botanical remains from the site, proveniences are assigned to either the early or the late period (if association with dated levels and units was clear) or are placed in a third, undated group. Results are discussed on a site-wide basis (i.e., with no division by time).

Two classes of botanical remains are discussed in detail: charred wood, recovered mostly in situ or in excavation screens, and small seeds and other non-wood remains, recovered mostly by water flotation. Site-wide patterning and occurrence of remains by time period are presented for each class of materials. The Tutu botanical assemblage is then compared to other Caribbean island archaeobotanical data, and the nature of the plant component of subsistence is considered.

Differential rainfall patterns in the Virgin Islands (see Chapter 1) have a major impact on island vegetation. Although most of St Thomas is now covered by vegetation controlled by human beings (e.g. deliberate plantings, disturbed woody growth, etc.), descriptions of past vegetation patterns, such as Eggers (1879) and Borgesen (1909), and studies of remnant vegetation in Puerto Rico, the Virgin Islands, and other Caribbean islands, such as Little & Wadsworth (1964), Little, Woodbury & Wadsworth (1974), Dansereau (1966), and Beard (1949), allow the reconstruction of general trends of vegetation cover before major disturbances of the European era.

Eggers (1879: 6–13) describes four broad vegetation formations for West Indian islands: the littoral; the shrubby; the sylvan; and the cultivated formations.

1 The littoral formation is that vegetation formation which comes under the influence of salt spray. Very few of the plant taxa characteristic of the coastal area are found in the interior, even on small islands (Eggers 1879: 6–13). Distinctive plant communities are found on sandy soils, rocky cliffs, and swampy areas around lagoons. The last type of substrate supports the mangrove formation. The distinctive species of this formation, *Laguncularia racemosa* (white mangrove), *Conocarpus erectus* (button-wood), *Avicennia germinans* (black mangrove), and *Rhizophora mangle* (red mangrove), form part of a delicate habitat that is rich in shellfish resources.

2 The shrubby formation described by Eggers (1879: 6–13) for the Virgin Islands is the low, dry vegetation found on dry rocky soils of the eastern and southern parts of the islands. Common genera include low-growing *Croton* sp. *(marán*) and *Acacia* sp. (stink casha, wild tamarind) shrubs. This formation also is referred to as the *Croton* vegetation formation. This formation occurs upslope of the littoral formation. The Tutu site is located in the *Croton* vegetation formation.
3 The sylvan formation dominates the north and western parts of the Virgin Islands, with a dry forest also occurring on deeper soils in the uplands on the eastern and southern sides (Eggers, 1879: 6–13). Forest consists of evergreen and deciduous elements, and is composed of many species. The mix of species and relative abundance of deciduous and evergreen elements are dependent on both the amount of moisture and the nature of the substrate. Evergreen taxa, such as *Clusia rosea* (cupey) in the Guttiferae, *Nectandra* (laurel) in the Lauraceae, and *Annona* (soursop) in the Annonaceae, tend to dominate in the higher, moister forest areas.
4 The cultivated formation will not be considered here.

Although Eggers' 1879 description of the flora of the Virgin Islands is very useful as a picture of the nature of vegetation at that time, it does not attempt to generalize about the nature of vegetation prior to intensive human modification of the island habitat. A detailed study of this type has been conducted for Puerto Rico by Dansereau (1966), but no comparable analysis has been made for the Virgin Islands. The Dansereau study utilizes many fine-grained divisions of vegetation that are difficult to correlate to the topographic features of the smaller St Thomas. The interior of Puerto Rico also contains vegetation formations not present on the smaller islands of the region. A study which is more generalized than Dansereau's (1966), but does attempt to reconstruct past vegetation, is *The Vegetation of the Windward and Leeward Islands*, by Beard (1949). In this study, plant communities characteristic of the Caribbean islands are divided into six formations: four climatic climax formations (1–4 below), and two edaphic (soil) climax formations (5–6 below).

1 optimal formation (rainforest)
2 montane formations
3 seasonal formations
4 dry evergreen formations
5 swamp formation, and
6 seasonal swamp formations.

For each climax formation, variants are discussed, and characteristic secondary formations (e.g., vegetation in disturbed areas) are described.

Because the Tutu site is located on the southern, more arid, side of St Thomas, the climax vegetation formations "dry evergreen" and "seasonal," that occur in areas affected by drought (Beard, 1949), and which fall into Egger's (1879) shrubby vegetation formation, are perhaps the most relevant for reconstructing vegetation in the area around the site. Beard (1949: 58–87) described shrubby *Croton* thickets, *Acacia* bush, and *Leucaena* (tantan) thicket as common secondary formations of the disturbed dry forest formations, such as the dry evergreen formation and the seasonal formation. It is likely that such formations existed in the area of the Tutu site in the past.

The forests of the seasonal formations (evergreen seasonal forest, semi-evergreen seasonal forest, and deciduous seasonal forest) are conjectural: reconstructed from remnant trees observed in the drought-affected zones of the islands of the Caribbean (Beard, 1949: 74–80). These dry zones are utilized for agriculture today and only remnants of the climax forests, and secondary growth, exist. The driest forest, the deciduous seasonal forest, would perhaps have occurred around the Tutu site. This type of forest occurs on exposed land with shallow soil, generally under

70 m (200 feet) in elevation, and near the sea (Beard, 1949: 78–80). The woodland is between 10.44 m and 14 m (30–40 ft) high, with a closed canopy. A layer of shrubs exists below the trees. Bromeliads are common on the ground; cactus also is present. Typical tree genera include *Acacia, Guaiacum* (lignum vitae)*, Bursera* (turpentine-tree), *Pisonia* (*corcho*), *Lonchocarpus* (retama), *Citharexylum* (fiddlewood), *Tabebuia* (roble)*, Albizia* (albizia), *Cordia (capá)*, *Bourreria* (pigeonberry), and *Coccoloba* (sea-grape, doveplum). Among others the shrub layer contains members of the genera *Pithecellobium* (*cojoba, samán*), *Tecoma* (roble)*, Bauhinia,* (bauhinia), *Capparis* (caper), *Jacquinia* (barbasco), and *Plumeria* (paucipan). (Beard, 1949: 78). With increasing elevation and rainfall more evergreen elements occur in the seasonal formation, and the forest becomes taller and more closed. Among the tree taxa occurring in the moister seasonal formations are *Hymenaea* (West Indian locust), *Inga* (guamá, pomshock), *Simarouba* (aceitillo*)*, *Manilkara* (balatá), *Cedrela* (Spanish cedar), *Genipa* (genipa), *Ficus* (fig), *Ceiba* (kapok), and *Nectandra* (laurel) (Beard, 1949: 74–80).

The dry evergreen formations consist of the dry evergreen forest, the evergreen bushland, and the littoral woodland (Beard, 1949: 80–86). These formations occur under relatively dry conditions, but are an expression of physiological rather than physical drought. For example, a combination of shallow soil and strong sea winds can cause the replacement of a seasonal formation by a dry evergreen formation, even with relatively good rainfall. The littoral woodland formation generally occurs on the windward littoral, and is comprised of species resistant to strong wind and salt spray. Away from the sea, a taller woodland occurs (dry evergreen forest), which in turn grades into the lower montane rainforest (Beard, 1949: 80–6).

Since the Tutu site is not located on the windward end of St Thomas, it is not clear how widespread these dry evergreen formations might have been in this area. A tentative reconstruction of the Tutu area vegetation might include dominance of a deciduous seasonal forest, with occurrence of trees and shrubs of the moister seasonal formations at no great distance in interior, higher elevation locations. Clearly the inhabitants of the site could access a wide range of ecological zones, including the nearby coastal formations.

METHODS

Carbon samples

Some 91 samples including fragments of in situ charred posts, 1 sample of post wood, and other larger fragments of charred wood, were received from the Tutu project (in three lots) for wood identification. A total of 51 samples was selected for identification. Selection was made by simply identifying half of the samples sent in each of the first two lots (39) and all of the final lot (12), choosing as many discrete posts as possible (i.e.,duplicates of the same post were usually not examined).

Samples were identified by comparing the unknown charred wood to wood in the University of Missouri (MU) comparative collection for the Caribbean. The MU collection, which includes wood from the Virgin Islands, Puerto Rico, the Bahamas, and Cuba, was supplemented by reference to standard tropical wood identification guides (IAWA, 1989; Record & Hess, 1942–1948, 1943). Dr. Robin Kennedy, MU Biological Science Division, and Peter Warnock, MU Anthropology Department, assisted with the identification of cf. *Acacia*; Dr. Lee Newsom, Southern Illinois University-Carbondale, provided a number of helpful comparative specimens.

Many post specimens were single pieces of wood that had fragmented during or after excavation. In this case the type of wood was identified and the pieces were weighed rather than counted, since fragment count would have no meaning in this context. In some cases different kinds of wood were present in a single sample, indicating that the sample was not a single post. Each type was identified and counted. In these cases, count gives some idea of the relative abundance of the various identified types. If only a few pieces were present, all were identified; if wood was abundant, a sample of 20 pieces was examined.

Identification first involved description of discrete archaeological wood types. Examination of the 51 samples led to the establishment of 18 types. Each type was then studied in detail using examples from multiple samples. Some types, like Tutu Type 9, *Guaiacum* sp., were readily identifiable, while others superficially resembled a number of wood species. Ray, vascular, parenchyma, and ground mass tissue characteristics were used in combination to separate similar species (Pearsall, 1989a). Types 1, 2, and 4 eventually were combined and identified as cf. *Acacia* (cf. indicates that the material resembles the named taxon). Four types, Tutu Type 6, Tutu Type 15, Tutu Type 16, and Tutu Type 18, remain unidentified.

It is important to note that this assemblage of wood species is likely biased towards those species that survive charring. In other words, species in which soft wood burns to ash, leaving little charred wood, will be absent from the record. Similarly, since identifications were made by snapping fresh sections for examination at 30×–60× magnification, wood that is highly fragmented (i.e., represented by small pieces) or soft (difficult to snap cleanly) is more likely to end up in the unidentifiable category.

Flotation samples

Using a modified SMAP-style flotation machine (Pearsall, 1989a), Dr. Emily Lundberg, Starr Farr, Beau Farr and Margo Schwadron processed a total of 308 flotation samples during field investigations at the Tutu site. Flotation recovery rates were tested by introducing 100 charred poppy seeds into selected samples, and counting how many were recovered by flotation. Table 2.1 presents the results of some of the tests. Two samples that were soaked to deflocculate clays prior to flotation showed very poor recovery in light fractions (portion of the sample that floated). Two other samples showed low recovery (and possible cross-sample contamination, in one case). In the majority of samples, however, recovery was 89 percent or higher, indicating that the flotation system was functioning well. Non-buoyant remains were recovered by siphoning charcoal off the heavy fraction screen, and adding it to the light fractions.

Table 2.1 Results of poppy seed recovery tests

Sample	*Poppy seeds recovered (100 total)*	*Comment*
1	33	Counted and removed in field
2	92	Counted and removed in field
6	89	
14	90	
33	97	
43	96	
172	33	Not a test sample: contamination?
303	0	Sample soaked before flotation
304	0	Sample soaked before flotation

Note
Samples tested but recovery not evaluated: 30, 31, 64, 85, 105, 292, 299–302, 305–17.

Because of monetary constraints, not all floated samples could be analyzed. Samples were selected in the following ways:

1 especially "rich" samples (i.e., those bags with abundant charred material present);
2 samples from the same contexts as those with abundant charred food remains;
3 samples to fill in sequences of sorted samples, especially in C^{14} dated units; and
4 samples from the later, under-represented levels at the site.

In retrospect, beginning with the "richest" samples may have been a poor strategy, since the result was that many post mold features were sorted. While rich in wood remains, these contexts often did not have abundant charred food materials essential to analysis. The samples also were time-consuming to sort. This problem came to light once identifications began, and it was at this point that strategy (2) was initiated. Strategies (3) and (4) were used very late in the project; these samples were partially sorted by Pearsall (> 2 mm fraction, only) to search for charred corn, tuber/root fragments, and larger fruits. A total of 110 samples were completely sorted following standard procedures described in Pearsall (1989a) and 31 other samples were partially sorted.

It is important to note that charred wood and small seeds (< 2.0 mm fraction) from the last 31 examined samples were not tallied or identified. In addition, while charred wood was counted and weighed from all completely sorted samples, to save time wood, was identified from only a few flotation samples selected by Elizabeth Righter.

Identification of charred seeds, fruits, and other non-wood materials was carried out by comparing archaeological specimens to materials in the MU collection, to collections at the Missouri Botanical Garden Herbarium, and to standard references (Bertsch, 1941; Brouwer & Stählin, 1975). Specimens not readily recognized were described and assigned a seed type number (n=29). In many instances, these types were later identified, but some could not be because of the fragmented nature of the remains. In the latter case, these were tallied as "unknowns" by number. Other specimens were tallied simply as cotyledon fragment, endosperm fragment, tuber/root tissue, or fruit rind. In these cases, materials were so incomplete that assigning a type number seemed pointless. Identification to type of tissue was based on comparisons to known tissues of those kinds. Finally, two charred corn kernel fragments were identified. No charred cob fragments were identified, however. Wood from selected flotation samples was identified as described under carbon sample methods.

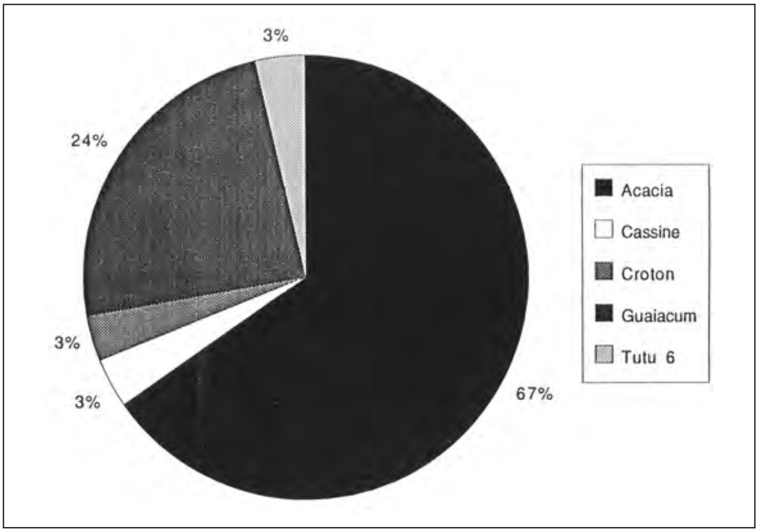


Figure 2.1 Occurrence and percentages of various types of wood used as posts at the Tutu site. Percentages calculated using total number of posts, from carbon sample data.

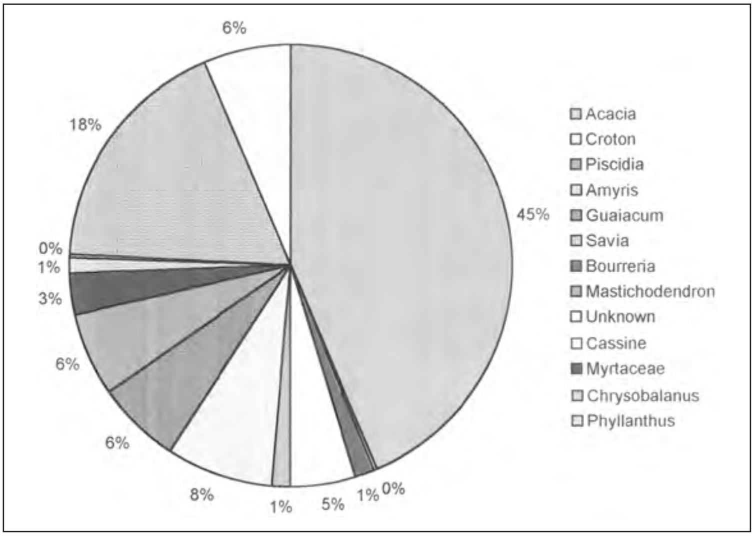


Figure 2.2 Occurrence and percentages of various types of non-post wood found at the Tutu site. Percentages calculated using total non-post wood count, from carbon sample data.

WOOD REMAINS

Site-wide patterning

Only a few of the wood species recovered from the Tutu site were present as posts. These include cf. *Acacia, Cassine, Croton*, and *Guaiacum* posts. There also was one post of Tutu Type 6 wood. Wood was determined to be from a post if all wood in a sample was the same (i.e. like a post broken into pieces). In many cases, the proveniences of the samples were also designated as postholes. Using these criteria, 29 samples of charred post wood were identified among the 48 discrete proveniences selected for wood identification. Of these, 19 were cf. *Acacia* and 7 were *Guaiacum* (Figure 2.1). The other species were represented by one post each. With the caution that the wood assemblage is naturally biased towards harder woods, it seems clear that cf. *Acacia* and *Guaiacum*, two very sturdy trees, were consistently selected for construction purposes. Both species were used in the construction of Structure 2, for example, with three large *Guaiacum* posts in the center of the structure (P-407A, P-410A, and P-419A; see Figure 12.6). Unlike cf. *Acacia* wood, which also was common in contexts other than post molds, *Guaiacum* occurred rarely except as posts.

The rest of the proveniences, 19 in all, contain more than one kind of wood per sample. It seems reasonable to interpret these assemblages as the remains of wood from cooking fires, in many cases redeposited in secondary contexts. Figure 2.2 shows the occurrence of each species identified in these proveniences, by fragment count. Cf. *Acacia* is the most abundant type identified, followed by cf. *Savia*. Table 2.2 shows the percentage presence,

Table 2.2 Site-wide percentage presence (ubiquity) of wood taxa in carbon samples

Taxon	*% presence*
Acacia spp.	73
cf. *Savia*	23
Croton	21
Guaiacum	19
cf. *Mastichodendron*	11
Cassine	8
cf. Myrtaceae	8
Bourreria	6
Hibiscus	6
Tutu Type 15	6
cf. *Chrysobalanus*	4
Piscidia	4
Amyris	2
cf. *Phyllanthus*	2
Tutu Type 16	2
Tutu Type 18	2

Note
There are 48 discrete sample proveniences (posts and non-post wood); each numerical value is the percentage of those proveniences in which the taxon occurs.

or ubiquity, of wood types for the entire data set (i.e., posts and all other contexts). Cf. *Acacia* again dominates (in 73% of samples), with cf. *Savia, Croton*, and *Guaiacum* about equally represented (in 19%–23% of samples).

Wood also was identified from 21 selected flotation samples (see Table 2.3 for summary). Twenty fragments were pulled at random from each sample and identified (or determined to be unidentifiable). No new wood types were encountered, and Myrtaceae, Tutu 6, and Tutu 16 did not occur. Cf. *Savia* is the most common wood type (31.6% of the total by count), followed by *Acacia* (23%). All other taxa are represented by a few pieces each.

Description of types

Description of wood types follows (with a brief discussion of site-wide occurrences in carbon samples and possible uses). Types are arranged alphabetically by genus, with unknown types at the end. Refer to the references on wood identification, or Pearsall (1989a), for illustrations of the characteristics employed to identify the types.

1 Identification: cf. *Acacia* spp. (Tutu Types 1/2/4) Leguminosae
  - Common name(s): stink casha, wild tamarind
  - Description: A number of species of *Acacia* are native to the Virgin Islands. These include *A. anegadensia* Britton, *A. macracantha* Humb, & Bonpl., *A. muricata* (L.) Willd., and *A. tortuosa* (L.) Willd. Introduced naturalized species include *A. farnesiana* (L.) Willd., *A. nilotica* (L.) Delile, and *A. polycantha* Willd. (Little & Wadsworth, 1964; Little, Woodbury & Wadsworth, 1974).
  - Acacias are small to medium trees or shrubs of deciduous habit. Adapted to xerophytic conditions, this group is common on the dry coasts and lower slopes of dry forest areas in the Virgin Islands and other islands of the Caribbean. The wood is hard and often resinous. The seed pods are eaten by livestock.
  - Acacias are a prominent component of the flora of dry rocky areas in the eastern and southern portions of the islands of the Virgin Island group, often forming shrubby thickets with various species of *Croton* (Eggers, 1879).
  - The archaeological wood is characterized by medium–large pores (P.S. 3–4[1]) in a diffuse porous pattern. Small pore groupings are common. Parenchyma is abundant to very abundant, occurring in festoons around pores and in irregular bands. Rays are uniseriate to two-celled. This wood is highly variable, with some specimens highly fissured parallel to the rays. More than one species of *Acacia* may be represented, and it is also possible that other legume genera with similar wood contributed to this type. *Acacia* is the best match, however. This is the most common wood in the Tutu carbon samples, and is second to cf. *Savia* in flotation samples. There are 19 cf. *Acacia* posts. Although this dense wood is undoubtedly over-represented relative to softer, more fragile woods, it was clearly an important wood species and was abundantly utilized for construction and fuel.

2 Identification: *Amyris* (Tutu Type 17) Rutaceae
  - Common name(s): tea or sea amyris, candlewood, torchwood
  - Description: One species of *Amyris, A. elemifera* L., is native to the Virgin Islands. It occurs in thickets of the dry limestone and dry coastal regions (Little & Wadsworth, 1964: 216–17). A second species, *A. balsamifera* L., occurs rarely in Puerto Rico (Little *et al.*, 1974: 321). Both species are evergreen small trees or shrubs. Tea amyris wood is very resinous, very hard, and strong. It is durable and resistant to termites, and widely used for

Table 2.3 Summary of wood occurrence by time period

	Site-wide %	*% early period*	*% late period*
Sample examined (Ct)	440.0	320.0	120.0
Acacia (T1/2/4)	23.0	21.9	25.8
Amyris (T17)	3.0	4.1	0.0
Bourreria (T14)	1.1	0.6	2.5
Cassine (T13)	6.8	4.1	14.2
cf. *Chrysobalanus* (T7)	1.6	1.3	2.5
Croton (T5)	5.0	5.3	4.2
Guaiacum (T9, Ct)	0.2	0.0	0.8
cf. *Mastichodendron* (T3)	2.7	2.2	4.2
cf. Myrtaceae (T10)	0.0	0.0	0.0
cf. *Phyllanthus* (T11)	0.5	0.6	0.0
Piscidia (T12)	0.0	0.0	0.0
cf. *Savia* (T8)	31.6	34.1	25.0
Tutu 6, unknown	0.0	0.0	0.0
Tutu 15, unknown	1.1	0.3	3.3
Tutu 16, unknown	0.0	0.0	0.0
Tutu 18, unknown	0.2	0.3	0.0
Unidentifiable	23.2	25.3	17.5

Note
Percentages were calculated using wood counts from selected flotation samples.
Ct = Count
T = Tutu type

posts, furniture, and fuel. Torches are also made from the resinous wood (Little & Wadsworth, 1964: 216).

- The archaeological wood has small pores (P.S. 2) that are abundant and either solitary or in radial chains. Rings are visible, and there is some decrease in pore size in the late wood. The ring edge is marked by marginal parenchyma. No other parenchyma is visible at 30×. Rays are uniseriate. The wood is very glossy. This type is a very good match to *Amyris*. *Amyris* is present in 2 percent of the carbon samples.

3 Identification: *Bourreria* (Tutu Type 14) Boraginaceae

- Common name(s): pigeon-berry, pigeon-wood, spoontree
- Description: One species of *Bourreria, B. succulenta* Jacq., occurs in the Virgin Islands and throughout the West Indies, with another, *B. virgata* (Sw.) G. Don, occurring in Cuba, Hispaniola, Puerto Rico, and Vieques (Little & Wadsworth, 1964: 466–67; Little *et al.,* 1974: 838–40). *B. succulenta* is a small tree or shrub distributed in open areas at low elevations, especially in coastal and limestone areas. It occurs in both wet and dry settings. Eggers (1879) reports that it is common in forests and thickets. Pigeon-berry is an evergreen tree or sometimes a shrub. The light brown, hard wood is used for fuel. This archaeological wood type has small pores (P.S. 2) that are solitary and abundant. There is a slight

decrease in pore size in the late wood. Rays are 2–4 cells wide and not storied. Parenchyma is inconspicuous, barely visible at 30× (fine line diffuse-in-aggregate). The wood is shiny and hard. *Bourreria* wood occurs in 6 percent of the carbon samples.

4 Identification: *Cassine* (Tutu Type 13) Celastraceae
- Common name(s): marble tree, wild nutmeg
- Description: *Cassine xylocarpa* Vent is a small evergreen tree or shrub that is common in coastal dry and moist forests up to 200 m (about 600 feet) in elevation (Little *et al.*, 1974: 460–61). The wood is light brown, hard, and strong. No use of this taxon is reported. Pores are very small (P.S. 1), diffuse, solitary, and very abundant. There are thick (2–4 cell) rays with very closely spaced uniseriate rays between them. Parenchyma occurs in regular, thick bands; some crystaliferous parenchyma is present. Wood is dense and hard. *Cassine* occurrs in 8.30 percent of carbon samples. This includes one *Cassine* post.

5 Identification: cf. *Chrysobalanus* (Tutu Type 7) Rosaceae
- Common name(s): coco-plum
- Description: *Chrysobalanus icaco* L. is an evergreen and mostly shrubby plant with soft fruits (drupes) resembling plums (Little & Wadsworth, 1964: 230–32). The oily seeds are also edible, and can be burned like candles. Coco-plum is locally common in the West Indies, including the Virgin Islands, forming thickets on coastal lowlands and sandy beaches. It can also grow on wet soils. Eggers (1879) reports that it was common. Under cultivation, coco-plum grows as a small tree.
- The archaeological wood has pores that are small (P.S. 2), mostly solitary, with some short oblique and radial chains. White crystal "plugs," sometimes elongated, are present in the vessels. Rays are uniseriate to 3-celled and closely spaced. Parenchyma is rare, and not readily visible at 30×. The wood is soft. This wood type most closely resembles *Chrysobalanus.* The uncertainty arises from the fact that the crystals are somewhat differently shaped from those in the comparative specimen. However, they are located in the vessel elements, and the overall appearance of the wood is very similar to *Chrysobalanus.* This wood type occurs in 4 percent of the carbon samples.

6 Identification: *Croton* (Tutu Type 5) Euphorbiaceae
- Common name(s): maran, yellow balsam
- Description: The genus *Croton* is one of 12 genera of trees or shrubs in the spurge family found in the Virgin Islands and Puerto Rico. Eleven species of *Croton* are reported by Little & Wadsworth (1964: 266). The two most common taxa, *C. astroites* Dryand. and *C. rigidus* are both shrubs (rarely small trees) which are widespread in dry areas near sea level. These taxa often form dense thickets, especially where other woody species have been eliminated due to heavy grazing or timbering (Little *et al.*, 1974: 396–99). Eggers (1879) named the dry shrubby vegetation formation of the eastern and southern parts of the Virgin Islands after this commonly occurring genus.
- The archaeological specimens have a light wood, with very finely reticulate-scalariform parenchyma (barely visible at 30×). Pores are small (P.S. 2), diffuse, single and in short radial chains. Rays are uniseriate 3 cells wide. *Croton* occurs in 21 percent of carbon samples. This includes one *Croton* post.

7 Identification: *Guaiacum* (Tutu Type 9) Zygophyllaceae
- Common name(s): lignum vitae

- Description: *Guaiacum officinale* L., common lignum vitae, ranges throughout most of the West Indies, including the Virgin Islands. A second species, *G. sanctum* L., occurs in the Florida Keys, Bahamas, Cuba, Hispaniola, and Puerto Rico (Little & Wadsworth, 1964: 212–15). Lignum vitae is a small evergreen tree of dry coastal and dry limestone regions. Eggers (1879) reports that it grew on the seashore and in forests. The wood is one of the heaviest commercial woods, and is extremely hard and resistant to decay (Little & Wadsworth, 1964: 212–15). The heartwood is also very resistant to termite attack. Long valued for its self-lubricating, resinous wood, lignum vitae was nearly exterminated in the wild in the Virgin Islands by the time Eggers did his study (Eggers, 1879). An extract of the wood was formerly used in medicines as a stimulant. The wood of *G. sanctum* had similar uses, but was considered less valuable.
- The archaeological specimens have pores of varying sizes. Early wood pores tend to be medium–large (P.S. 4–5); late wood pores are smaller (P.S. 2). Abruptness of pore size decline varies, but most examples are ring porous. Pores are solitary and not abundant. Rays are uniseriate and less than one pore diameter apart. They are storied and very distinct. Parenchyma is sparsely aliform to vasicentric, especially around the early wood pores. Thin-line parenchyma occurs occasionally in the late wood. The ground mass is very hard and dense. This is a certain match as *Guaiacum. Guaiacum* occurs in 19 percent of the carbon samples, including 7 posts.

8 Identification: cf. Mastichodendron (Tutu Type 3) Sapotaceae

- Common name(s): mastic, false-mastic, bully-mastic, mastwood
- Description: The Sapotaceae, or sapodilla family, is a large tropical family of trees and shrubs.
- Genera with species native to the West Indies include *Bumelia, Dipholis, Micropholis, Chrysophyllum, Manilkara, Pouteria*, and *Mastichodendron*, which is *Sideroxylon* in Little &Wadsworth, (1964: 454–55) (Little *et al.*, 1974: 775–76). Mastic, *Mastichodendron foetidissimum* (Jacq.) Cronq. is a small to medium-sized evergreen tree that ranges throughout most of the West Indies, including the Virgin Islands. It occurs in coastal and moist limestone forests. Eggers (1879) characterizes it as occurring in forests, and rare. The wood is hard, heavy, and durable, and valued for construction, furniture, and fenceposts. The fruits are edible, but are said to have an unpleasant taste.
- This archaeological type has large vessels (P.S. 4) that are solitary or in short oblique or radial chains. Pieces are small, making pore arrangement difficult to see. Rays are 2–3 celled, very closely and regularly spaced, and storied. Parenchyma is reticulate-scalariform, spaced slightly further apart than the rays, and thin. The ground mass is shiney. This type is probably *Mastichodendron*, but may be another genus in the family. The wood of the various genera in the Sapotaceae is very similar. The best match is to *Mastichodendron.* This wood occurs in 11 percent of the carbon samples.

9 Identification: cf. Myrtaceae (Tutu Type 10)

- Common name(s): myrtle family
- Description: The Myrtaceae, or myrtle family, is a large family of trees and shrubs of primarily tropical distribution. Genera with species native to the West Indies include *Myrcia, Calyptranthes*, the large genus *Eugenia, Gomidesia, Psidium, Myrcianthes, Myrciaria, Marlierea, Siphoneugena,* and *Pimenta* (Little & Wadsworth, 1964: 396–417; Little *et al.*, 1974: 622–95). Small trees, such as *Eugenia* spp., are used for posts and fuel. Some taxa produce edible fruits. The bay-rum-tree, *Pimenta racemosa* (Mill.) J. W. Moore, is valued for its oil, important in bay rum, cosmetics, and medicines.

- The archaeological wood has large pores (P.S. 4) that are abundant, and either solitary or occasionally in short radial or oblique chains. Late wood often lacks pores. Rays are two-celled, closely and evenly spaced. Parenchyma is reticulate-scalariform and very closely spaced. There is little parenchyma in the late wood. The ground mass is hard. This taxon resembled *Psidium* in the Myrtaceae, but has larger pores. It is likely to be some species in this family, but the match is not certain. This wood occurs in 8 percent of the carbon samples.

10 Identification: cf. *Phyllanthus* (Tutu Type 11) Euphorbiaceae

- Common name(s): millo, false gooseberry
- Description: There are 12 genera of trees or shrubs in the spurge family found in the Virgin Islands and Puerto Rico. *Phyllanthus* is represented by two native species, *P. nobilis* (L. f.) Muell.-Arg., *millo*, and the rare *P. juglandifolium* Willd., *jaguerillo* (Little & Wadsworth, 1964: 280–83; Little *et al.,* 1974: 420). The widely planted and escaped *grosella, P. acidus* (L.) Skeels, is a native of tropical Asia. *P. nobilis* is characterized by Eggers (1879) as occurring in forests and not uncommon.
- This archaeological wood type has small pores (P.S. 2) that are fairly abundant. Pores are commonly in radial chains that are sometimes wavy. Rays are conspicuous (3–5 celled), regular and widely spaced, and unstoried. Parenchyma is not obvious at 30×. At higher magnification, some marginal and some diffuse parenchyma are visible. The wood is light and shiny. This is a fairly good match to *Phyllanthus,* but the pores are a little larger. It may be another genus in the Euphorbiaceae. The wood occurs in 2 percent of the carbon samples.

11 Identification: *Piscidia* (Tutu Type 12) Leguminosae

- Common name(s): ventura, dogwood, fishpoison-tree
- Description: *Piscidia carthagenensis* Jacq. is a medium-sized tree of dry coastal areas (Little *et al*., 1974: 306–7). Eggers (1879) reports that it was common in thickets. It is deciduous and grows to about 11.50 m (35 ft). The wood is hard, heavy, and strong; wood of related species is used elsewhere for boat building, posts, and charcoal (Little *et al*., 1974: 306–7). Indians in the West Indies are reported to have used the root bark, young branches, and powdered leaves of fishpoison-tree to stupefy fish. The tree also has medicinal uses.
- Pores are large (P.S. 3–4) in this type, few, and solitary. Pores occur both within and between the parenchyma bands. Rays are 2- to 3-celled, evenly spaced, and storied. Parenchyma occurs in medium-thick bands that are regularly spaced. Fibers of the ground mass are thick; the wood is soft. *Piscidia* occurs in 4 percent of the carbon samples.

12 Identification: cf. *Savia* (Tutu Type 8) Euphorbiaceae

- Common name(s): *amansa guapo*
- Description: There are 12 genera of trees or shrubs in the Eurphorbiaceae found in the Virgin Islands and Puerto Rico. *Savia sessiliflora* (Sw.) Willd. is a shrub or small tree of dry areas. It is deciduous. The wood is light brown and hard. No uses are reported (Little *et al*., 1974: 428–29).
- The archaeological type has small pores (P.S. 1–2) that are abundant and commonly solitary, but sometimes in short radial or oblique chains. Pore size decreases somewhat in the late wood, which also has fewer pores. Rays are uniseriate to 2-celled, closely and evenly spaced, and unstoried. Parenchyma is scantly vasicentric to confluent, also marginal. It is barely visible at 30×. The wood is hard. This type is similar in appearance

to *Croton* (Tutu Type 5), and could perhaps be another species of that genus. (In Type 5 pores are commonly in radial chains and there are fewer vessels and no obvious ring structure.) Cf. *Savia* occurs in 23 percent of the carbon samples.

13 Unknown: Tutu Type 6

- This unknown wood type has large vessels (P.S. 4–5) that are solitary or in dendritic to wavy clusters. Rays are uniseriate or 2-celled. Rays are tall and not storied. Parenchyma is diffuse, with some fine lined and vasicentric parenchyma. The ground mass is composed of large cells, giving it an "open" appearance. There was no good match in the comparative collection. Tutu Type 6 occurred in 6 percent of the carbon samples, including one post.

14 Unknown: Tutu Type 15

- This unknown wood type has very small vessels (P.S. 1) that are fairly abundant, and either solitary or in short radial or (rarely) oblique chains. There are occasional shiny pore inclusions. Rays are uniseriate, very closely spaced, and storied. Parenchyma is paratracheal, linking pores radially and sometimes obliquely. This is a sturdy but light wood. There was no good match in the comparative collection. Type 15 occurred in 6 percent of the carbon samples.

15 Unknown: Tutu Type 16

- This unknown wood type has medium-sized pores (P.S. 3), with some smaller. Pores are solitary and few. Tyloses are present in pores. Rays are uniseriate and very inconspicuous. Parenchyma is abundant, making up most of the wood. The ground mass is very glossy. This is a single occurrence type (2% of carbon samples) represented by a small specimen that could not be matched with any accuracy to the comparative collection.

16 Unknown: Tutu Type 18

- This unknown type has small pores (P.S. 2) that are solitary and associated with the narrow parenchyma bands. Pores are moderately abundant and some have tyloses. Rays are uniseriate to 2-celled and inconspicuous. Parenchyma is reticulate-scalariform, spaced about as closely together as the rays. This type is represented by a single, small piece (2% of carbon samples) that could not be matched with any accuracy to the comparative collection.

Temporal patterning

The distribution of samples between the early and late periods of site occupation is very uneven, with only six falling into the early period. This makes it difficult to assess change in wood use over time, since the more diverse assemblage of wood present in the late period may be due to sampling bias. It is interesting to note, however, that both cf. *Acacia* and *Guaiacum,* the most common woods used, are present from the beginning of site occupation.

SEEDS, FRUITS, AND OTHER NON-WOOD REMAINS

Site-wide patterning

Few remains other than wood were recovered in Tutu carbon samples. Only one "cache" of edible remains, Sapotaceae fruits in Post hole 53 (discussed below), was recovered. One seed each of cf. *Brysonima* and *Celtis* also were recovered from carbon samples. All other materials discussed here were recovered by water flotation.

Identification of materials from flotation samples was hampered by the fragmentary nature of many of the remains. In the case of the Sapotaceae fruits (Seed Type 14/15), for instance, whole specimens (i.e. with seed coat and attachment area) were very rare. Although all Caribbean species of this family represented in the Missouri Botanical Garden Herbarium collections were examined, a one-to-one match was not achieved. Based on the appearance of the attachment area of one completely intact specimen, it is possible that these fruits are *Mastichodendron.* However, fruit size better matches species of *Bumelia* or *Dopholis.* Similar problems were encountered with other identifications.

This situation is fairly typical for the lowland tropics, where climatic and soil conditions often combine to create conditions detrimental to the preservation and recovery of charred botanical remains (Pearsall, 1995). In soils with high clay content, such as those at the Tutu site, cycles of wetting and drying serve to break up more fragile charred materials over time. In addition, the process of flotation can be hard on fragile remains. Newsom (personal communication, 1995) has suggested that dry fine sieving may result in less fragmentation than flotation in soils that are habitually dry. While this may be the case, dry sieving would not have helped at Tutu; clayey soils are very difficult to dry sieve, and Tutu soils in situ were wetted and dried on a regular basis. Floating large soil samples remains the best strategy in such situations.

Materials that could not be identified to botanical taxon were classified as dense cotyledon fragment, porous endosperm fragment, tuber/root tissue, or seed/fruit rind when possible. Tallying materials this way gives some indication of what kinds of plant resources were used, even if the species cannot be identified. Many of the dense cotyledon remains are probably small fragments of Sapotaceae fruits. It is also possible that some of the porous endosperm fragments are small bits of corn kernels; corn was identified in only two cases in which the kernel was fairly complete and had an intact outer surface.

Looking at the assemblage of seeds, fruits, and other non-wood remains as a whole, the inhabitants of Tutu utilized a broad array of foods plants, including tree fruits (*doncella*, hackberry, wild fig, mastic, guava), small-seeded annual plants (cheno-ams, wild beans, purslane: perhaps used for both seeds and greens), and root/tuber foods. Corn was present, at least by the later occupation, and cotton was used. Passion fruits were grown or gathered, and nightshade or ground cherry fruits were used. The presence of seeds of cheno-ams, purslane, *Talinum*, mallow family, and grass family also suggests that the area around the site was fairly open and disturbed by human activities.

Description of seeds, fruits, and other non-wood remains

In this section of taxon by taxon descriptions, identified types are presented first, in alphabetical order, followed by tissue categories (dense cotyledon fragment, porous endosperm fragment, tuber/root tissue, or seed/fruit rind) and unknown types.

1 Identification: cf. *Brysonima* (Seed Type 21) Malpighiaceae
  - Common name(s): *doncella*
  - Description: *Brysonima* is a genus of evergreen shrubs or small trees in the malpighia family. The fleshy, edible fruits have a thick-walled stone containing three or fewer seeds. Flowering and fruiting occurs intermittently throughout the year. *B. coriacea* (Sw.) DC. is a medium-sized tree, with juicy, though bitter, fruits. It is common in moist, secondary forests (Little & Wadsworth, 1964: 256) *B. lucida* DC is a shrub or small tree scattered and locally common in dry coastal forests and lower elevation hills in the Virgin Islands and elsewhere in the Caribbean (Little *et al.*, 1974: 366). Eggers (1879: 34) lists a second species, *B. spicata* Rich, as being rare in forests in the Virgin Islands, and Beard (1949: 37) notes the occurrence of *Brysonima* species in wetter forests elsewhere in the Caribbean.

- The fruit pits have a ridged and furrowed surface. They are spheroidal in shape, 6 mm long by 3.5 mm in diameter. Ridges cover all surfaces. Shape and size are consistent with *Brysonima*, or a related taxon. *Malpighia retusa* is similar, but much larger. Two pits were recovered; one (No. 2593) is uncharred.

2 Identification: *Celtis* Ulmaceae
- Common name(s): hackberry, almez
- Description: Little *et al.* (1974: 104) list one species of *Celtis* for the Virgin Islands, *C. trinervia* Lam. Almez is a small to medium-sized deciduous tree. The fruits (drupes) have a thin flesh and a large stone with one seed. Almez flowers and fruits throughout the year; it is classed as a honey plant.
- A single stone was recovered from a carbon sample.

3 Identification: cheno-am
- Description: *Chenopodium* (Chenopodiaceae) and *Amaranthus* (Amaranthaceae) seeds can be difficult to distinguish, especially when seed coats are eroded or lacking, so damaged or distorted seeds are usually identified only as cheno-am (i.e., specimens could be either genus). *Chenopodium* and *Amaranthus* species favor disturbed or open habitats. Some are invasive weeds. Since both young greens and mature seeds are edible, however, occurrence of cheno-am seeds should not be dismissed outright as being incidental inclusions.
- Seed coat surfaces are damaged on the two specimens recovered, but size (1.50 mm in diameter) and presence of a curved embryo are consistent with cheno-am.

4 Identification: cf. *Ficus* Moraceae
- Common name(s): wild fig
- Description: A number of species of wild fig (and many introduced species) occur in the Virgin Islands. *F. laevigata* Vahl, the white fig, is one of the most common species, growing in forests, thickets, and along roadsides (Little & Wadsworth, 1964: 70). This is a small to medium-sized evergreen tree, with small fruits borne throughout the year. Other native species include *F. obtusifolia* H. B. K. and *F. trigonata* L. (Little *et al.*, 1974: 118–24).
- Eight small-diameter (1–2 mm) fruit calyxes (flower remnants attached to the top of berries and some other fruits) were found that are similar in size to calyxes from fig fruits. This tentative identification is based on the sizes and shapes of the calyxes, and the fact that figs produce one of the edible berries in the flora.

5 Identification: cf. *Gossypium* (Seed Type 10) Malvaceae
- Common name(s): cotton
- Description: Sea island cotton, *G. barbadense* L., was introduced and cultivated during prehistory in the Caribbean, and additional varieties were introduced and grown after contact. Various hybrids and feral forms occur in the islands today, including on St Thomas. These "wild" cottons range from herbs to medium shrubs, and are uncommon in disturbed habitats in dry limestone and coastal forest zones (Little *et al.*, 1974: 516–18).
- Cotton seeds, especially when charred, do not have many diagnostic features. While uncharred specimens often have a tuft of hair around a circular attachment area, and a clear "seam" running down the length of the seed, these features are often lost when seeds char. In the absence of these characteristics, shape (rounded on one end, tapering to a blunt point), size (between 3 mm and 4 mm in diameter and between 5 mm and 6 mm in

length), and smooth appearance can be used to make a tentative identification. Eight probable cotton seeds were identified from Tutu flotation samples.

6 Identification: Gramineae (Seed Types 6, 7/24, 11)
- Common name(s): wild grasses
- Description: Seeds of wild grasses can become incorporated into the archaeological record in several ways: when grass is used as a fire starter or as a fuel (e.g., sod is burned), by accidental inclusion (e.g., seeds are blown in, trapped on clothing), or as a gathered food resource. Since the grass family is very large, and seeds of different species often resemble each other, identifications were only made at the family level for the few remains that were recovered. Criteria used to identify grasses include shape and presence of the attachment area in the lower bottom or side of the seed.
- Seed Type 6 Gramineae is a small elongated seed, 1 mm long and 0.50 mm wide. A total of 12 seeds were recovered.
- Seed Type 7/24 Gramineae is a small seed flattened on one face, curved on the opposite, with smooth surfaces. The seed size is 0.80 mm long and 0.50 mm wide. Too small to be *Panicum* or *Setaria,* it is perhaps a related grass of the panicoideae type (sensu Gunn [1972]). Three examples occurred.
- Seed Type 11 Gramineae is a medium-sized seed of the panicoideae type (sensu Gunn), measuring 2.50 mm in length by 1.80 mm in width. Four examples occurred.

7 Identification: Leguminosae (Seed Types 9, 27)
- Common name(s): wild beans
- Description: Within the legume (bean) family, species native to the Virgin Islands range from herbaceous twinners to large trees. Considered either as three families, or one family with three subfamilies, the legumes are a very diverse group that includes many useful plants. Legume seeds of the papilionoideae type (kidney-bean shaped) are produced by small, herbaceous species for the most part. The other two subfamilies/families produce quite different seeds. No seeds from tree legumes were recovered from Tutu. None of the papilionoideae seeds recovered was from cultivated species.
- Seed Type 9 Leguminosae is a medium-sized papilionoideae legume, 3.80 mm long and 2.50 mm wide. The hilum is located in the center of the long edge; there is a slight indentation. A wild herbaceous legume is the likely source of the 4 seeds.
- Seed Type 27 Leguminosae is a small papilionoideae seed with a relatively long hilum. Size is 1.80 mm in width and 2 mm long, with a “squarish” outline. Type 27 is clearly a legume, but there is no close match in the comparative collection. It is likely to be a herbaceous taxon. Six seeds were recovered.

8 Identification: cf. Malvaceae (Seed Type 8)
- Common name(s): mallow family
- Description: The mallow family is represented by some 36 species in the Virgin Islands (Eggers, 1879: 28–31). Genera include *Malvastrum*, *Sida, Abutilon, Malachra, Urena*, and *Pavonia,* among others. Most native species are robust herbs that favor disturbed or open habitats; shrubs and trees of the genus *Hibiscus* are introduced. No uses for the native species are noted.
- Cf. Malvaceae is a thick, wedge-shaped seed, 1.50 mm long and 1.30 mm wide. Surfaces are smooth. The shape and size are consistent with Malvaceae; *Sida* is one possible identification. Thirteen seeds were recovered.

9 Identification: *Malvastrum* Malvaceae

- As noted above, *Malvastrum* is a genus of herbaceous plants in the mallow family that are frequently encountered in disturbed or open habitats. *M. spicatum* Gris. and *M. tricuspidatum* Asa Gray are common weeds in the Virgin Islands (Eggers 1879: 28). No uses are known.
- *Malvastrum* seeds are flat and curved, with a deep, broad notch in the attachment area, and one narrow end and one broad end. Seed surfaces are smooth. Seed length is between 1 mm and 2 mm. A total of 31 seeds were recovered.

10 Identification: cf. *Mastichodendron* (Seed Type 16) Sapotaceae

- Common name(s): mastic
- Description: Refer to the discussion of mastic wood for information on this taxon (see p. 118).
- One Sapotaceae cotyledon fragment was recovered that falls in the size range of *Mastichodendron* specimens examined at the Missouri Botanical Gardens Herbarium. Width is 7 mm and thickness (two cotyledons thick) is 5 mm. Full length could not be measured, but appears larger than other Sapotaceae fragments (see 14 below).

11 Identification: *Passiflora* (Seed Type 17) Passifloraceae

- Common name(s): passion fruit
- Description: Eggers (1879: 56–57) lists 8 species of *Passiflora* in the flora of the Virgin Islands. *P. suberosa* L., pop or Indigo-berry, is common on rocks and fences, for example. *P. rubra* L. is common in forested and rocky areas. *P. laurifolia*, bell-apple, is cultivated, and naturalized in thickets. *P. foetida* L., love-in-the-mist, is common in disturbed habitats. All species are herbacious twinners that produce edible berries.
- *Passiflora* seeds are flattish, elliptical in outline, with the flat surfaces marked by shallow pits and raised curvilinear ridges. The seeds are fairly robust, with thick seed coat walls. One entire seed was recovered, measuring 3 mm in width by 3.50 mm in length; a second, somewhat eroded seed appears to be somewhat larger.

12 Identification: *Portulaca* Portulacaceae

- Common name(s): purslane
- Description: Four species of Portulaca are listed by Eggers (1879: 27–28): *P. oleracea* L., *P. quadrifida* L., *P. pilosa* L., and *P. halimoides* L. All are common along roadsides, in open habitats, and as weeds in gardens. Young greens are edible.
- Plants in the Portulacaceae are characterized by very small seeds that are round to somewhat curved in outline, often with reticulate surfaces. Portulaca seeds are typically between 0.50 mm and 1 mm in diameter, with concentric rows of knobby tubercles on the surfaces. Since the seeds are black when fresh, the Tutu specimens were checked carefully to be sure they were charred. One charred *Portulaca* seed was recovered.

13 Identification: *Psidium* Myrtaceae

- Common name(s): guayaba, guava, mountain guava
- Description: *P. amplexicaule* Pers, mountain guava, is native to the Virgin Islands. An evergreen tree, it grows in moist limestone forests (Little *et al.*, 1974: 692). *P. guajava* L. is commonly cultivated as a fruit tree (Little & Wadsworth, 1964: 416). It forms thickets and spreads in pastures on the coastal plains and in the lower mountains in the Virgin Islands, and elsewhere in the Caribbean. The original range was probably from southern Mexico to South America.
- The Tutu *Psidium* seeds are small, between 3 mm and 3.50 mm long, and between 2 mm and 2.50 mm wide, curved, with the distinctive end attachment area/opening of Myrtaceae seeds. The six recovered seeds closely resemble *Psidium*; a number of species

of Eugenia and *Calyptranthes* were checked at the Missouri Botanical Garden Herbarium and found not to resemble the Tutu seeds closely.

14 Identification: Sapotaceae (Seed Type 14/15)
- Common name(s): mastic family
- Description: Refer to the discussion of wood types for information on this family (see pp. 115–120).
- The Tutu Sapotaceae seeds are spheroidal seeds, varying in size from between 3.50 mm and 5.50 mm in minimum diameter, 3.80 mm and 6 mm in maximum diameter, and 5.50 mm and 6.50 mm in length. Most examples lack the seed coat, and consist of two joined cotyledons, usually with a small cavity between them. Seeds break both along and across cotyledon lines. The cotyledon tissue is dense, and contains minute crystals. Some examples of the Tutu Sapotaceae seeds have two parallel lines running down the long axis. The seed coat, when present, is thin (0.50 mm thick), with a raised attachment area near the center of the longest side. The cotyledons are slightly depressed under this attachment. As discussed earlier, it was difficult to match the Tutu seeds to any one species; *Mastichodendron* is perhaps the most likely (seed shape and attachment area positioning are good), but the archaeological seeds are smaller than the comparative species examined, even taking a 10 percent shrinkage factor into account. Charring experiments could perhaps clarify the identification further. A total of 183 seeds or seed fragments were recovered.

15 Identification: *Solanum* or *Physalis* Solanaceae
- Common name(s): nightshade, ground cherry
- Description: Eleven species of *Solanum* are listed by Eggers (1879: 77–78) for the Virgin Islands. Habitats include waste places, coasts, forests, or dry thickets. *Solanum* plants are procumbant to robust herbs. Whether fruits are edible or not varies among species. Four species of the related genus *Physalis* also occur in similar habitats (Eggers, 1879: 76).
- Seeds of the nightshade family are typically small, circular in outline with a faint notch, and often very flat. The Tutu *Solanum/Physalis* seed fits this description. Surfaces are faintly reticulate; size is about 2 mm in diameter. A single example was recovered. Since seeds of a number of species of *Solanum* are very similar to *Physalis*, it seemed best to identify the Tutu specimen only as belonging to one of these two genera.

16 Identification: *Talinum* Portulacaceae
- Description: Two species of *Talinum, T. triangulare* W. and *T. patens* W., are listed for the Virgin Islands (Eggers, 1879: 27). Both are herbs that grow in rocky situations, including near the sea. No use is noted.
- *Talinum* seeds are small (1 mm by 1.50 mm in size), ovoid seeds with a slight notch in one end. Like the related genus *Portulaca, Talinum* seeds have surface texturing, but in this case it is a fine reticulation. Since *Talinum* seeds in the MU comparative collection are indistinguishable from another Portulacaceae genus, *Calandrinia*; the identification is made as *Talinum* on the basis of the geographic distribution of the two genera. One seed was recovered.

17 Identification: *Zea mays* L. Gramineae
- Common name: corn, maize
- Description: Corn was domesticated in southern Mexico/Guatemala and spread widely throughout the New World prior to European contact (Pearsall, 1992). It was introduced to the Caribbean in prehistory.
- Two charred corn kernel fragments were recovered from flotation samples. Sample No. 225 is at 2037N/1842E, SE quadrant of a 1 m^2 unit, Level C, 57–67 below datum; cat. No.

5050. The fragment in No. 225 is a small piece of porous endosperm tissue with a smooth epidermis. The shape and size is consistent with corn. Sample No. 147 is at 2033.5N/1843.5E, north half, Level B, 19–26 bd. This is a fairly complete kernel. The top is present, and the indentation for the embryo is preserved (the embryo itself has fallen out). Kernel width is 3.90 mm and thickness is 2.55 mm. Incomplete length (height) is 3.80 mm.

18 Tissue category: dense cotyledon fragments
  - Description: This category includes two seed types (4, 13), described below, that were collapsed into this group of dense, smooth-surfaced fragments of the embryonic leaves (cotyledons) of large seeds. Seeds are composed of several classes of tissue, one of which is the embryonic leaf (monocotyledons) or leaves (dicotyledons). Endosperm tissue, which provides energy to the germinating plant, is present in many seeds as well. Some seeds have little to no endosperm, and are made up mainly of large, thick cotyledons (the "halves" of kidney beans, for instance, or the "meats" of nuts like acorn or tree fruits in the Sapotaceae). Since it is difficult to identify these cotyledon fragments to plant species unless the attachment area of a seed or the epidermis is preserved, they have all been grouped together in this tissue category. Many fragments are likely pieces of Sapotaceae seeds. "Dense" is used to describe tissue that does not have vessel elements or internal air chambers, and in which the cell structure is very fine-grained. A total of 158 dense cotyledon fragments were recovered.
  - Seed Type 4 is one-third to one-half of a spheroidal seed with a smooth exterior and dense tissue. Size is between approximately 3 mm and 4 mm in diameter. This unknown is smaller than the Sapotaceae fruit (Type 14/15), and appears spherical rather than oblong in outline.
  - Seed Type 13 is a fragmentary cotyledon, smaller than Seed Type 4.

19 Tissue category: porous endosperm fragments
  - Description: Small pieces of the energy-producing portion of seeds, the endosperm, can also be difficult to identify without an exterior surface or attachment area. Once the epidermis erodes from a cotton seed or maize kernel, for instance, the remaining tissue, the endosperm, is porous (made up of large, thin-walled cells) and often has interior air spaces (pockets that open up as the tissue shrinks during charring). While cell size and size of air spaces vary among seeds, these criteria are too shaky to use for identifying the material without scanning electron microscope study of the micro-anatomy. The porous endosperm tissue category does not contain the remains of seeds in which endosperm is rare (i.e., the dense cotyledon category). A total of 184 porous endosperm fragments were recovered.

20 Tissue category: root/tuber fragments
  - Description: Subterranean storage organs, found in archaeological contexts, are notoriously difficult to recover and identify. Peels decay without being charred; or, if charred, break up into unidentifiable fragments. The flesh is either wholly consumed (e.g., sweet potatoes, cocoyams, sweet manioc) or is processed to remove toxins in ways that usually render it unidentifiable (e.g., bitter manioc, *Zamia*). If roasting leads to preservation of charred roots, these may still break up completely, since the tissues are often very fragile. It is not surprising, therefore, that no roots were identified to species at Tutu. The tissue category root/tuber is an attempt to classify small pieces that might be subterranean storage organs. Further identification is not possible without scanning electron microscope study of the material. This material is not wood and not the remains of the cotyledons or endosperm of seeds. It is irregularly porous in appearance. A total of 123 porous root/tuber fragments were recovered.

21 Tissue category: dicot root/tuber fragments

- Description: Flotation sample No. 264 contains fairly complete pieces of dicot root tissue. The pith and cortex are distinguishable, and the root has what appears to be a dicot arrangement of vascular tissue. The epidermis shows rootlet scars, but lacks distinctive nodes, suggesting a true root rather than a rhizome (an underground stem). The tissue was compared to roots and tubers in the MU comparative collection, and resembles sweet potato in some respects, such as having large voids created by charring, and in the scattered placement of vascular tissue. The archaeological specimens have a center of thick-walled tissue that does not resemble the lab sweet potato specimen, however. No precise identification can be made at this time. Forty-one fragments were recovered in this sample.

22 Tissue category: seed coat/rind fragments

- Description: This is a catch-all category for fragments of seed or fruit epidermis. Thickness and curvature vary among fragments. Some fragments are probably from Sapotaceae fruits. A total of 168 fragments were recovered.

23 Identification: fungal spores

- Description: It is not uncommon to recover small (0.50 mm) spherical fungal spores in flotation samples. Spores from fungi growing on wood can be charred as firewood burns. Eight fungal spores were recovered.

24 Identification: termite dung

- Description: Termites produce small, barrel-shaped droppings that can become charred with wood. Single specimens, or charred masses, may occur. Six single droppings, and one charred mass, were recovered.

25 Unknown: Seed Type 1

- Description: The first unknown seed type is teardrop-shaped, 1 mm wide and 2 mm long, curved, with a concave interior and a ridged convex exterior. Various families produce small seeds that occur in pairs, concave sides together, among them the Rubiaceae and the Umbelliferae. Seed Type 1 does not match any comparative specimens in these families closely, however. Four seeds were recovered.

26 Unknown: Seed Type 2

- Description: Seed Type 2 is a fruit pit, 6.50 mm long with a 3.50 mm diameter. It is oblong in shape, with five tall ridges along the long axis, giving a “star” shape in cross section. The center is 5-chambered. No good match was found in the comparative collection for the single specimen of Seed Type 2 that was recovered.

27 Unknown: Seed Type 5

- Description: Seed Type 5 is a 3-sided seed, 1 mm long and 0.80 mm wide. The general form is similar to Polygonaceae, but only two partial seeds were recovered, so they are tallied as unknown.

28 Unknown: Seed Type 17a

- Description: Seed Type 17a is a fragmentary seed that is spherical, with ridges. One was recovered.

29 Unknown: Seed Type 18

- Description: Seed Type 18 is a spheroidal seed, 3 mm in diameter and 3.50 mm long, with two distinct projections on the smaller end. One was recovered.

30 Unknown: Seed Type 19
- Description: Seed Type 19 is a small triangular-shaped seed, 0.80 mm wide at the thicker end, and 0.80 mm long. Three seeds were recovered.

31 Unknown: Seed Type 20
- Description: Seed Type 20 is a fragment of thick seed coat, from a flat seed. It is 3.50 mm long, 2.50 mm wide, and curved in shape. Seed Type 20 does not match Sapotaceae seed coat fragments. One example was recovered.

32 Unknown: Seed Type 22
- Description: Seed Type 22 is a large, flat seed, possibly a grass, but too distorted to be identified with certainty. The one specimen measured was 3 mm wide and 4.50 mm long. A total of six seeds were present.

33 Unknown: Seed Type 23
- Description: Seed Type 23 is an elongated seed with a bumpy-reticulate surface. It is bluntly pointed on both ends. Size is 3.50 mm wide and 5.50 mm long. One was recovered.

34 Unknown: Seed Type 25
- Description: Seed Type 25 is a cylindrical seed, with a smooth exterior and slight roughening on one end (an attachment area?). Size is 2 mm long by 1 mm in diameter. One was recovered.

35 Unknown: Seed Type 26
- Description: Seed Type 26 is an elongated seed, flat on one face, convex on the other, with a side attachment area. The surface has circular patterning. One was recovered.

36 Unknown: Seed Type 28
- Description: Seed Type 28 is the thick epidermis of a robust seed or fruit. The seed has distinctive circular indentations, and an attachment area which is a deep indentation with a raised edge. Its thickness is about 1 mm. The seed/fruit may be multi-carpeled. The largest diameter of the five fragments recovered is about 7 mm.

37 Unknown: Seed Type 29
- Description: Seed Type 29 appears to be a shriveled spherical seed, between 0.50 mm and 0.80 mm in diameter. The surface is reticulate. Three examples were recovered.

Temporal patterning in the occurrences of botanical remains in flotation samples

Many flotation samples could be assigned to either the early or the late period of site occupation. These assignments were made on the basis of associated radiocarbon dates and stratigraphic positioning. Final artifact analyses and dating may alter the temporal assignments of some proveniences.

Table 2.4 presents a number of summary data contrasting the occurrence of flotation-recovered botanical remains (excluding wood, which is discussed below) from the two periods. Before discussing these data, it is important to consider whether the two data sets are comparable. Was preservation equal in each period? This can be assessed in general terms by looking at the abundance of material recovered per liter of soil floated. In the case of charred wood, for example, one can reason that the more charred wood that is recovered, the more burning activity there was at the site. Higher burning activity probably leads to enhanced preservation of accidentally charred food remains. As is apparent from Table 2.4, the two time periods differed markedly in the quantity of wood recovered per liter of floated soil, with more than five times as much recovered in samples of the later period (84/liter, compared to 14/liter). (If wood from late period post mold samples is excluded, the wood/liter ratio remains virtually the same.) Looking at some of the more common food remains (major foods/liter), a similar situation is seen: more than six times the material was recovered from the late period (2.60/liter, compared to 0.40/liter).

Greater abundance of wood and increased burning activity in the late period may be the result of more intensive use of the site (more people, more cooking fires, and so forth), or differences in the functions of the areas sampled. For example, while excavating in an area where most of the late period material was located (N2033.50/1843.50E and N2036/1842E, N2037/1842E, top levels), Righter (personal communication, 1997) noted an abundance of greasy charcoal and manatee bones, perhaps an indication that this was an area where meat roasting was carried out. Removing post hole flotation samples did not change the ratios, but other differences in sample contexts (for example, midden vs features, different types of features) may be revealed in artifact analyses. Alternatively, the lower abundances of wood and food remains in the early period could be due to loss of material from the record, due to breaking up of charcoal over time. Finally, if choice of fuel differed between the time periods (softer, more easily ashed or fragmented wood in the early period, for example) or cooking techniques changed (steaming replaced by roasting, for example: Righter, personal communication, 1997), the pattern of wood preservation could be affected. All these factors may have been at work.

Regardless of the explanation for the difference in abundance of material, it must be taken into account in interpreting the results. Reduced abundance has two important effects: loss of rarely occurring data, and reduced percentage presence. Corn provides a good example of the first effect. With only two kernel fragments preserved in the late period, a time when corn is documented elsewhere in the Caribbean (see below), decreased preservation could easily lead to its disappearance from the record in the early period. It would be a mistake to place too much emphasis on absence of rarely occurring remains, such as corn and dicot roots, in the early period. Percentage presence (or ubiquity) is calculated by counting the number of discrete proveniences in which remains occur. Dense cotyledon fragments occurred in 20 late period samples, for instance, giving a percentage presence of 50 percent. These remains occurred in only 18 percent or 20 percent of early period proveniences. If preservation were even, this could be interpreted as a substantial increase in use of the fruits producing these remains; the more commonly a plant is used around a site, the more likely it is to be accidentally preserved. With many fewer remains preserved in the early period, however, the difference is likely less significant. The fact that all food remains increase in percentage presence from the early to the late period (rather than one food replacing another, for instance) suggests that preservation bias is affecting this measure. However, the very large increase in seed coat/rind fragments between the early and late periods, combined with the doubling of dense cotyledon material and Sapotaceae fruit fragments, is suggestive of some increase in use of tree fruits, including Sapotaceae, in the late period.

With the caution that rare remains are likely under-represented in the early period, it is useful to look at the frequency of food plant remains by period (Table 2.4), as well as their ubiquity. As Figure 2.3 illustrates, the early period assemblage is dominated by porous endosperm fragments (63% by count), which occur in 24 percent of all samples. Many fewer porous root/tuber remains (13%) and dense cotyledon remains (11%) occur, but these are scattered in a similar number of samples. The late period, by contrast, is not dominated by any one type of food remain (Figure 2.4). Seed coat/rind fragments (27%) and dense cotyledon fragments (24%) are both abundant, followed by porous root/tuber (17%) and Sapotaceae fruits (13%; note that the "cache" of fruits in P-53 was omitted from the calculation). Roots and tree fruits account for the majority of food remains in the late period, while endosperm fragments of smaller seeds dominate in the early period. Unfortunately, the relative importance of corn between the two periods cannot be addressed with these data.

Flotation-recovered wood also was identified from samples dating to the early and late time periods (Table 2.3). As discussed earlier, the types of wood species present in flotation samples, and their site-wide occurrences, are very similar to the data derived from carbon samples. A higher

Table 2.4 Summary of flotation results, excluding wood, by time period

	Early time period			*Late time period*		
	Totals Wt = g Ct = n Vol = l	*Frequency of major foods (%)*	*Presence of major foods (%)*	*Totals Wt = g Ct = n Vol = l*	*Frequency of major foods (%)*	*Presence of major foods (%)*
Soil volume floated[a]	469.8l (338.8 l)	—	—	256.3l (205.8 l)	—	—
Number of proveniences	51	—	—	40	—	—
Wood Ct/l soil[b]	14 pieces/l	—	—	84 pieces/l	—	—
Major foods Ct/l soil[c]	0.4 pieces/l	—	—	2.6 pieces/l	—	—
Wood, Ct	4701	—	—	17283	—	—
Wood, Wt	50.02929 g	—	—	304.1408 g	—	—
Corn kernel fragment, Ct	0	—	—	2	0.3	5
Corn kernel fragment, Wt	0	—	—	0.0098 g	—	—
Dense cotyledon (seed 4, 13, fragments) Ct	18	11	20	136	24	50
Dense cotyledon (seed 4, 13, fragments) Wt	0.0662 g	—	—	1.164 g	—	—
Porous endosperm fragment, Ct	110	64	24	70	12	42.5
Porous endosperm fragment, Wt	0.1756 g	—	—	0.309 g	—	—
Porous, root/tuber, Ct	22	13	18	100	17	40
Porous, root/tuber, Wt	0.2228 g	—	—	1.1382 g		
Dicot root fragment, Ct	0	—	—	41	7	2.5
Dicot root fragment, Wt	0	—	—	0.004 1	—	—
Seed coat/rind fragments, Ct	13	8	12	155	27	60
Seed coat/rind fragments, Wt	0.0742 g	—	—	1.0508 g	—	—
Sapotaceae (Seed 14/15), Ct	8	5	6	175 (72[d])	13	20
Sapotaceae (Seed 14/15), Wt	0.1182 g	—	—	6.0499 g	—	—
Total major foods	171			679 (576[d])		
Poppy seeds	275	—	—	34	—	—
cf. *Brysonima* (seed 21), Ct	0	—	—	2	—	—
cf. *Brysonima*, Wt	0	—	—	0.0714 g	—	—
Cheno-Am (seed 12), Ct	0	—	—	2	—	—
cf. *Ficus*, calyx, Ct	6	—	—	2	—	—

(continued on next page)

Table 2.4 (cont).

	Early time period			*Late time period*		
	Totals Wt = g Ct = n Vol = l	*Frequency of major foods (%)*	*Presence of major foods (%)*	*Totals Wt = g Ct = n Vol = l*	*Frequency of major foods (%)*	*Presence of major foods (%)*
cf. *Ficus*, Wt	0.021 g	—	—	0	—	—
cf. *Gossypium* (Seed 10), Ct	3	—	—	5	—	—
cf. *Gossypium*, Wt	0.0144 g	—	—	0.0654 g	—	—
Gramineae, small elongated (seed 6)	1	—	—	7	—	—
Gramineae, small (seed 7/24)	0	—	—	3	—	—
Gramineae, pan. (seed 11), Ct	0	—	—	1	—	—
Seed 11, Wt	0	—	—	0	—	—
Leguminosae, papil. 1 (seed 9), Ct	0	—	—	2	—	—
Seed 9, Wt	0	—	—	0.0137 g	—	—
Leguminosae, pap. 2 (seed 27)	6	—	—	0	—	—
Seed 27, Wt	0.0031 g	—	—	0	—	—
cf. Malvaceae (Seed 8)	1	—	—	12	—	—
Malvastrum, Ct	10	—	—	21	—	—
cf. *Mastichodendron* (seed 16)	0	—	—	1	—	—
Passiflora (seed 17), Ct	0	—	—	2	—	—
Passiflora, Wt	0	—	—	0.0103 g	—	—
Portulaca	1	—	—	0	—	—
Psidium (Seed 3), Ct	0	—	—	6	—	—
Psidium, Wt	0	—	—	0.0086 g	—	—
cf. *Solanum*	0	—	—	1	—	—
Talinium	0	—	—	1	—	—
Fungal spores	0	—	—	8	—	—
Termite dung	3	—	—	3	—	—
Tutu seed type 1	1	—	—	3	—	—
Tutu seed type 2, Ct	0	—	—	1	—	—
Tutu seed type 2, Wt	0	—	—	0.0144 g	—	—
Tutu seed type 5	0	—	—	2	—	—
Tutu seed type 17a, Ct	0	—	—	1	—	—
Tutu seed type 17a, Wt	0	—	—	0.0071 g	—	—
Tutu seed type 18, Ct	0	—	—	1	—	—
Tutu seed type 18, Wt	0	—	—	0.0075 g	—	—

(continued on next page)

Table 2.4 (cont.)

	Early time period			*Late time period*		
	Totals Wt = g Ct = n Vol = l	*Frequency of major foods (%)*	*Presence of major foods (%)*	*Totals Wt = g Ct = n Vol = l*	*Frequency of major foods (%)*	*Presence of major foods (%)*
Tutu seed type 19	2	—	—	1	—	—
Tutu seed type 20	1	—	—	0	—	—
Tutu seed type 22, Ct	2	—	—	3	—	—
Tutu seed type 22, Wt	0	—	—	0.0057 g	—	—
Tutu seed type 23, Ct	0	—	—	1	—	—
Tutu seed type 23, Wt	0	—	—	0.0123 g	—	—
Tutu seed type 25	1	—	—	0	—	—
Tutu seed type 26	1	—	—	0	—	—
Tutu seed type 28, Ct	5	—	—	0	—	—
Tutu seed type 28, Wt	0.0666 g	—	—	0	—	—
Tutu seed type 29	1	—	—	0	—	—

Notes

a The first figure is total soil floated; the second is total for completely sorted samples.

b Wood/l of soil ratio is calculated using samples that were completely sorted.

c Major foods/l of soil ratio is calculated using all samples. Foods include corn, dense cotyledon, porous endosperm, root/tuber, dicot root, seed coat, and Sapotaceae seeds.

d Major food total used in calculations for the late period omits Sapotaceae seed cache of 103 g.

percentage of wood is unidentifiable in flotation samples, however, because pieces are typically smaller. *Acacia* and cf. *Savia* are abundantly represented in both time periods, with the late period characterized by a relatively high percentage of *Cassine*. Numbers of kinds of wood present are quite similar (11 kinds in the early period, 9 kinds in the late).

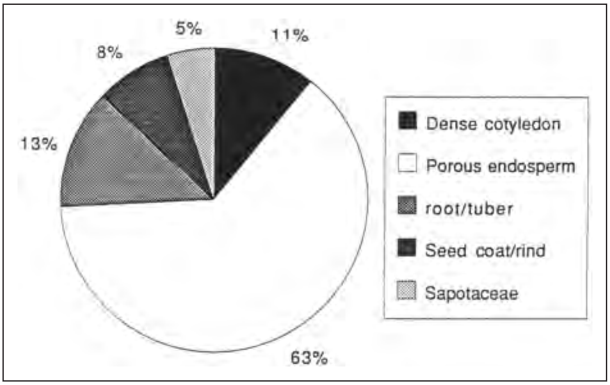


Figure 2.3 Occurrence and percentages of major plant foods, early period.

COMPARISONS TO OTHER CARIBBEAN ISLAND SITES

The study of archaeological plant remains is growing in the Caribbean region, but relatively few studies have been completed to date (Newsom, 1993; Newsom & Pearsall, 1997). Ethnobotanical studies on St Thomas prior to the Tutu project were carried out only at the preceramic Krum Bay site (Lundberg, 1989; Pearsall, 1989b). To place the results of the Tutu ethnobotanical study in perspective, it is therefore necessary to look at contemporary sites elsewhere in the

Caribbean, and to consider what is known about prehistoric plant use from ethnohistoric data.

The early occupation at the Tutu site is by peoples of the Cedrosan Saladoid ceramic tradition (Rouse, 1992). Rouse (1992) proposes that occupation of the Virgin Islands by peoples of this tradition occurred around 300 BC, and continued until around AD 600, when a period of change began that resulted in the emergence of the Elenan Ostionoid, and finally the Chican Ostionoid tradition. The Chican Ostionoid is dated to between AD 1200 and AD 1500; the late occupation at Tutu is part of this tradition.

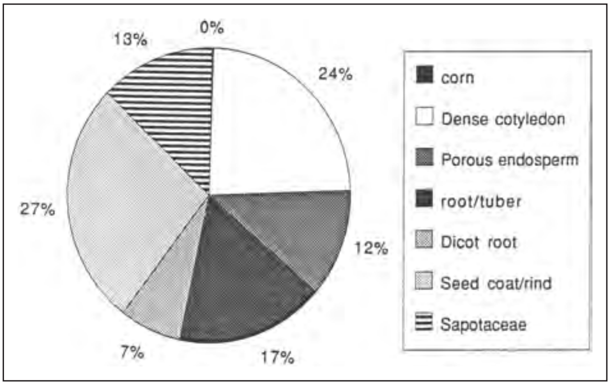


Figure 2.4 Occurrence and percentages of major plant foods, late period.

Leaving aside the issue of the nature of plant use in the Virgin Islands during the preceramic period, by 1000 BC when peoples bearing Saladoid pottery set out into the Caribbean, the process of plant domestication in the tropical lowlands of South America was well advanced. Data on prehistoric plant use in the lower Orinoco region are more meager than for the Caribbean, but it is likely that most of the tropical forest root crops (manioc, sweet potato, lairen, achira, yam, cocoyam, arrowroot), tree crops, domesticated legumes, and other foods (refer to Harlan 1992 for a complete list of crops), as well as the introduced grain, maize, were in use in the Orinoco lowlands by this time. Manioc and sweet potato were introduced to the arid coast of Peru before 1000 BC (Pearsall, 1992). Charred maize was recovered from sites in the Parmana region of the middle Orinoco by 800 BC (Roosevelt, 1980); maize pollen and phytoliths occur in lake cores in the western Amazon beginning at 3300 BC (Piperno, 1990). So although direct data on plants used by Saladoid peoples of the lower Orinoco is lacking, it is reasonable to propose that the full array of lowland crops and maize was available and could have been introduced with the Saladoid settlers. The relative importance of these resources is also unknown; however, the Parmana data suggest that maize was not very important in diet in the lowlands at this time. Unfortunately, ethnobotanical data are very weak for Caribbean sites in the Saladoid tradition (Newsom, 1993; Newsom & Pearsall, 1997), making it difficult to evaluate what crops were in fact introduced, and what local resources were utilized. No macroremains of maize or manioc are known, for example. As discussed above, preservation of plant remains in samples dating to the Saladoid occupation at Tutu also is inferior to that of the later Ostionoid occupation.

The best Caribbean island site comparable to Tutu in both scope of ethnobotanical research and quality of preservation is the En Bas Saline site in Haiti (Newsom, 1993). This site is Chican Ostionoid, occupied from between AD 1250 and AD 1500. The prehistoric levels at En Bas Saline are thus contemporary with the late period occupation at Tutu. The En Bas Saline site is an oval-shaped town of some 200,000 m^2. At contact, the town's inhabitants were said to be horticulturalists, with an emphasis on the cultivation of root crops. This description fits with other accounts of Taíno subsistence (Rouse, 1992). Newsom's analysis of charred botanical remains revealed use of the following crops during the prehistoric period: cf. *Manihot esculenta* roots, *Zea mays* grains, cf. *Annona* fruit, *Capsicum* fruit, cf. *Inga* fruit, *Oenothera* seeds/greens, Palmae fruit, cf. *Psidium guajava* fruit, and cf. Sapotaceae fruit (Newsom, 1993). Also used were a number of wild foods, including Cheno/Am seeds/greens, Chenopodiaceae seeds, Gramineae seeds, Solanaceae fruit, *Trianthema portulacastrum* seeds, and *Portulaca* seeds/greens. A diverse assemblage of wood also was identified. Maize and tuber fragments (of two kinds, one probably manioc, and another unidentified type) were relatively common at En Bas Saline, occurring in 25 percent and 47 percent of prehistoric contexts respectively. Given the fragile nature of root and tuber remains, the high percentage presence (ubiquity) is impressive, and supports ethnohistoric accounts of the importance of root and tuber crops in subsistence.

There are many similarities between the En Bas Saline and late period Tutu assemblages. As at En Bas Saline, root/tuber remains occur in a large number of samples (40%) at Tutu. Corn is also present in two contexts, and many more (42.5%) contain highly fragmented endosperm fragments that likely include corn. Both sites show abundant evidence for use of tree fruits, including mastic family and guayaba, and continued utilization of seeds and greens of wild annuals. Although the specific taxa present vary, ethnobotanical data from these two sites suggest that the floral component of Chican Ostionoid subsistence was a broad-based mixture of root crop and maize horticulture, arboriculture, and collections of wild annuals favoring disturbed habitats.

CONCLUSIONS

A program of systematic water flotation and in situ retrieval of charred botanical remains resulted in the recovery of a diverse assemblage of food resources and wood used for construction and fuel at the Tutu site, providing information on plant utilization during two critical periods in Caribbean prehistory. However, because preservation was poorer during the early, Cedrosan Saladoid occupation than during the later, Chican Ostionoid occupation at Tutu, changes in plant use between the two periods can be addressed only with caution. The less diverse assemblage of food remains in the early period is likely due, partly, to poorer preservation rather than a narrower dietary base. Roots and tubers, tree fruits, and wild gathered food resources were used from the beginning of site occupation. Probable cotton seeds are present beginning in the early period, but maize remains cannot be identified with certainty. The better-preserved remains of the late period occupation document a mixed subsistence system that included corn, roots and tubers, tree fruits, including mastic family, *Brysonima,* and guayaba, and a variety of wild annuals favoring disturbed habitats.

Throughout the occupation at Tutu, wood was gathered for fuel and construction from the dry forest formation that likely grew in the site area, with some use of taxa from higher elevation, moister forest formations. No evidence exists for use of mangrove species. Cf. *Acacia* and *Croton* may have come from quite near the site, since these taxa, among others, grow in abundance in areas where dry forest has been removed for agriculture. *Acacia* and *Guaiacum* were favored for construction purposes.

Although the fragmentary nature of many of the Tutu ethnobotanical remains hindered precise identification, botanical subsistence resources during the Chican Ostionoid occupation at the site resemble those of the contemporary En Bas Saline site in Haiti – a mixture of root crop and maize horticulture, arboriculture, and use of wild annuals. The details of how and when this broad-based subsistence system evolved are still not clear; this question awaits further research.

NOTE

1 This is a qualitative scale of pore (vessel) diameter, P.S. 1–6, with 1 being the smallest pore size.

Chapter Three

Phytolithic remains from the Tutu site

Dolores Piperno

INTRODUCTION

This report presents the results of phytolith and pollen analysis at the Tutu site. The study is the first such analysis of silicified plant remains from prehistoric contexts in the Virgin Islands, where questions about the nature of the subsistence and settlement systems that Columbus eventually "discovered" are many. Pollen was not preserved, however, a variety of plants, including *Cucurbita* (squash), was evidenced in the Tutu phytolith record.

Overall, the phytolith remains indicate that maize was not an important crop, and, possibly, was not even a minor component of the subsistence strategies at the site. Root crops and such tree crops as palms, in addition to squash, appear to have played the most significant dietary role from the beginning to the end of the site occupation.

METHODOLOGY

Thirty-two samples from various contexts of the Tutu site were examined for pollen and phytolith remains. That pollen was not preserved is not an unusual situation, since degradation due to oxidation is common in soil environments like those of the site. Consequently, this report will deal with the phytolith record (Table 3.1).

Phytoliths are microscopic bodies of silica deposited in the cells of living plants and then released into the soil when the plant dies and decays (Piperno, 1988). Because phytoliths are mineralized, they survive in soils over long periods of time, even in the unforgiving environments of the humid tropics where soils are heavily leached and oxidized. Over the last ten years, phytoliths have been shown to have numerous applications in archaeology and paleoecology (e.g. Piperno, 1988; Pearsall & Piperno, 1993).

Phytolith morphology, once thought to be "highly redundant" and legitimate for identifying only grasses, is now known to be highly significant at varying taxonomic levels across the plant kingdom (Piperno, 1988; Rapp & Mulholland, 1992). Tropical plants, especially, tend to silicify their various organs, possibly to deter herbivory (Piperno, 1991). The result is a cornucopia of fascinating shapes that often are diagnostic of individual families and genera of plants (Piperno, 1991, 1995a; Piperno & Pearsall, 1993a). These include the tropical domesticates *Cucurbita* and *Zea mays*, as well as the Palmae, Marantaceae, Bambusoideae (bamboos), and other plants of economic significance.

Table 3.1 Sample number, provenience, level, and chronology of each soil sample analyzed for phytoliths

Sample number	*Provenience level*	*Period*	*Comments*
Area 1			
761	N2096/1827E, Level B	early	cal. AD 65–420
9016	N2098/1822.50E, Level D	early	cal. 200 BC–AD 25
1194	N2096/1827E, Level B	early	from profile, same date as 761
1193	N2096/1827E, Level B	early	from profile, same date as 761
760	N2097/1823.50E, Level B	early	cal. AD 15–635
1005	N2098/1822.50E, Level D	early	same date as 9016
1048	N2097/1822.50E, Level B	early	
2120	N2098/1822.70E, Level B	early	
3266	Feature 21	late	under rocks of hearth, cal. AD 1225–1400
Area 4			
3649	N2090/1948, Level E	early	under Sherd Ae
3646	N2090/1948E, Level E, F-3	early	under pot – samples 3649 and 3646 range between cal. AD 330 and 660 or earlier
1583	N2087/1952E, Level BII	early	
1635	N2087/1952E, Level BIII	early	
5155	N2112.50/1937E, Level C	early	
3804	N2089/1947E, Level C	early	associated with Pot IV
Area 8			
9015a	N2115.50/1837.50E, Level B	early	under turtle carapace
2290	N2117/1849E, Level B	early	
1737c	N2117/1849E, Level C	?	
9014	N2117/1849.50E, Level B	early	midden clump
3347	N2113/1840E, Level B	early	cal. AD 390–630
Area 9N			
1723	N2075/1810E, Level B2	early	around Artifact D, cal. AD 415–630
2652	N2075/1810E, Level B2	early	under bowl, same date as 1723
Area 9W			
577	N2044/1837E, Level F	early	cal. AD 420–885
Area 9S			
5131	N2036/1842E, Level B	late	under *Codakia* sp. shell, cal. AD 1035–1435
5130	N2036/1842E, Level BI	late	base of level, same date as 5131
9017	N2033.50/1843.50E, Level C	late	30–32 cm below datum
9018	N2033.50/1843.50E, Level F	late	dark stain, mid pit
4028	N2033.50/1843.50E, Level DI		
5066	N2037/1842E, Level C	late	60–66 cm below datum
1002	N2037/1842E, Level E	early?	under Sherd Q
7022A	N2037/1842E, Level F	early?	under Sherd A
7022B	N2037/1842E, Level F	early?	under stone mid-unit

Note
Date ranges are at 2-sigma.

Isolating and removing phytoliths from the sediment matrix of archaeological sites requires a laboratory procedure that will, initially, "free" phytoliths that may be bonded to soil particles and, finally, liberate them by means of chemical flotation using a heavy liquid. The procedure followed for this study was developed for tropical soils that typically contain high amounts of dissolved humic acids. In some cases, however, organic preservation in the form of seeds, tubers, pollen, etc. may be poor and phytolith recovery may be low (Piperno, 1988: 120–23).

First, soils for analysis are placed in a 5 percent solution of Calgon or sodium bicarbonate and repeatedly stirred to deflocculate (separate) the soil particles. The next step is separation of sands (soil particles greater than 50 microns in diameter) from the silts and clays, which is accomplished by wet sieving through a 270-mesh sieve. The sand fraction is set aside for later analysis.

Next, clays, soil particles less than 5 microns in diameter, are removed. This step is essential because light clay particles will float in the heavy liquid solution and cause contamination of the phytolith separations. Clay removal is accomplished by gravity sedimentation. Next, the remaining silt is fractionated into a fine (5–20 micron) and a coarse (20–50 micron) fraction, also by gravity sedimentation.

At this stage of the procedure, there are three soil fractions to work with. Between 1 g and 1.50 g of each fraction is placed in 16 x 100 test tubes and the following chemical steps are carried out:

1 removal of carbonates with a 30 percent solution of HCL, and
2 removal of all organic material with a solution of concentrated HNO_3 and potassium chlorate.

With carbonates and organics removed, the soils are ready for heavy liquid flotation.

This is accomplished by adding a solution of cadmium and potassium iodide, at a density of 2.30, to the soils. Since phytoliths have a specific gravity of between 1.50 and 2.30, they float in the heavy liquid while the denser soil particles sink to the bottom of the tube. Phytoliths are then removed, washed with water, and dried quickly in acetone before they are mounted on slides with Permount, a histological fixative.

Phytoliths isolated from the soils at the Tutu site were identified by comparison to a modern reference collection of 2,000 species of plants. Most of these are from lowland Central America and South America. A representative modern collection for study is not yet available from the Virgin Islands, but since many plants and plant families are pantropical in distribution, and some of the focus here is on plants, well studied elsewhere (e.g. maize), that may have been introduced into the region, the analysis is not seriously compromised by lack of local plants. Future studies are planned to build a phytolith reference collection for Tutu and other important sites in the region.

RESULTS

Of the 32 soil samples analyzed from the Tutu site, most date from shortly after the time of Christ to approximately AD 600, while a few are from the apparently rich midden of the late occupation between about AD 1150 and AD 1500. Phytolith content of the samples varied, but was generally high. Phytoliths were observed in high numbers in samples 5131, 4028, 761, 9017, 3649, 9015a, 9016, 1194, and 3646 (Figure 3.1; Table 3.1). Of these, Samples 5131 and 9017 were collected from the late occupation midden of the site; and 4028 was a sample from an underlying level of consolidated clay loam with sparse cultural material. Sample 9015a was collected from under a turtle carapace in the Area 8 midden (Figures 1.17c, 1.18, 1.19), and Samples 761, 9016 and 1194 were collected from an early occupation midden in Area 1. Sample 3649 was retrieved from under a ceramic sherd in low

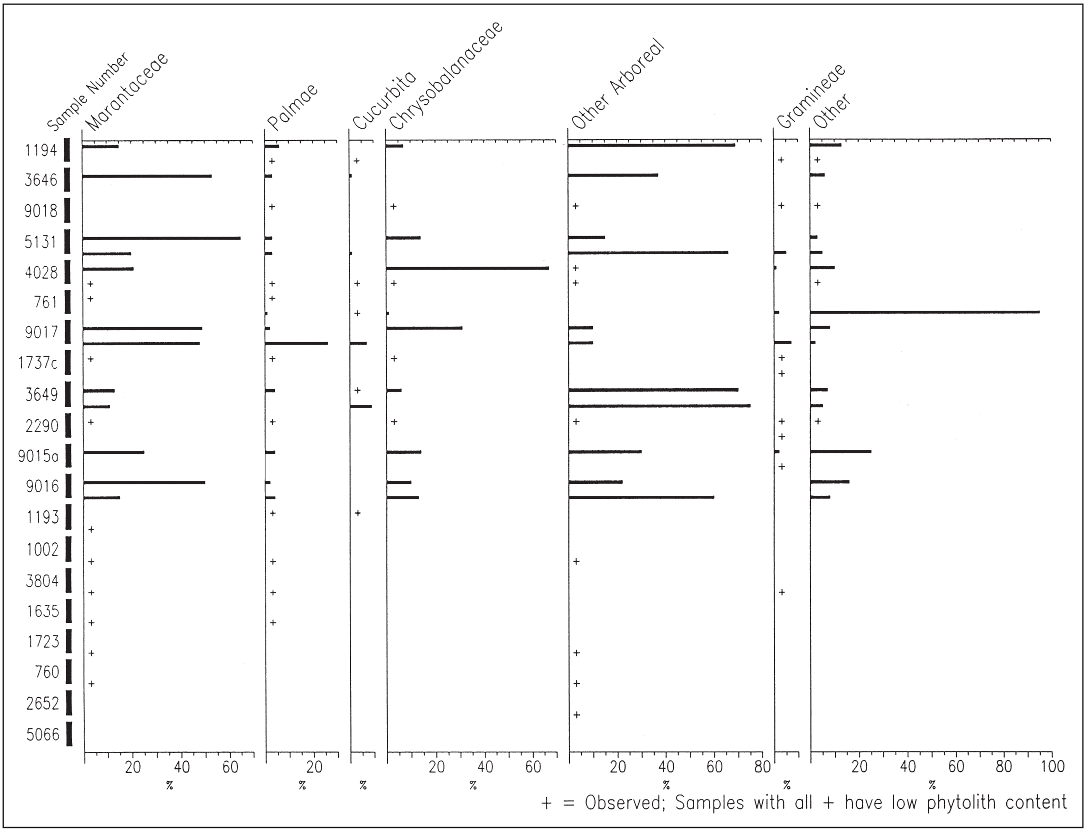


Figure 3.1 Occurrence and percentages of phytoliths in analyzed samples from the Tutu site.

levels of the early occupation Area 4 midden. Phytoliths were observed in lower numbers in: 1737c, 2290, 1002, 3804, 3266, 1635, 1723, 5066, 1193, 760, and 2652. Other samples had no phytoliths.

Presence/absence of major plant domesticates

Figure 3.1 presents the occurrence and percentages of phytoliths in the samples analyzed. Each sample is associated with two bars indicating percentage frequencies. The upper bar represents the fine silt and the lower bar the coarse silt. With the exception of a few Compositae phytoliths, sand phytoliths were largely absent, while phytoliths from *Cucurbita* rinds (Figure 3.2a) were common. These phytoliths were present in samples 5131, 4028, 761, 9017, 3649, 1193, 1194, and 3646. Samples number 761, 1193, and 1194 are associated with a date range of between cal. AD 65 and cal. AD 420 (2-sigma, Beta 65474). Wild *Cucurbita* has not been identified from the Virgin Islands, but it must be cautioned that a species of wild squash related to *Cucurbita argyrosperma* ssp. *sororia*, the wild ancestor of the domesticated *Cucurbita argyrosperma*, was recently discovered in Panama (Andres & Piperno, 1995). It is possible that it is the wild ancestor of *Cucurbita moschata*. The Virgin Islands has similar environments with prolonged dry seasons and xerophytic vegetation suitable for growth of wild squashes. Given the age of the site and the lack of reports for the occurrence of wild members of the genus in the area, we may tentatively assign a domesticated status to the remains at Tutu, with the caveat that botanical survey needs to be undertaken to rule out the presence of wild *Cucurbita*.

Figure 3.2a Phytolith type from the Tutu site: *Curcurbita* (20×).

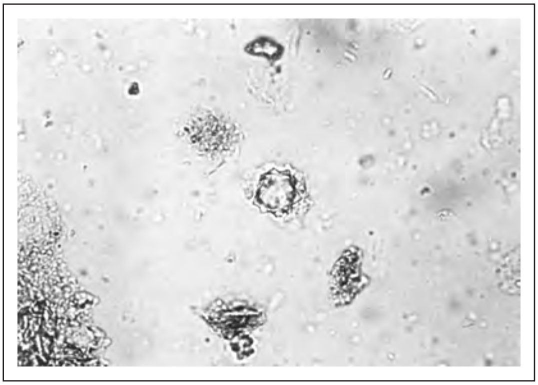


Figure 3.2b Phytolith type from the Tutu site: Marantaceae (20×).

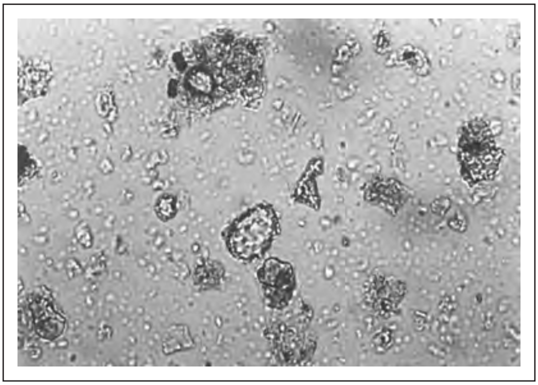


Figure 3.2c Phytolith type from the Tutu site: Palma esferico (20×).

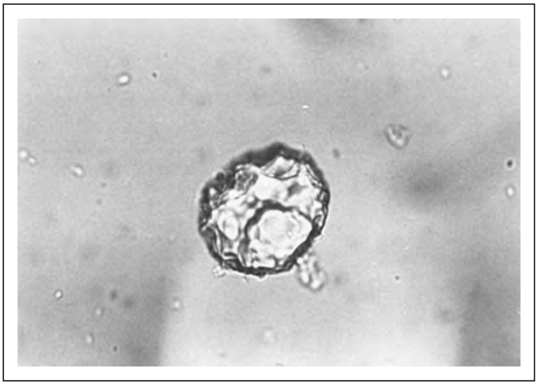


Figure 3.2d Phytolith type from the Tutu site: unknown phytolith (probable tree) (20×).

Squash-bearing contexts at Tutu included soils from directly underneath pots, further suggesting that the plant in question was consumed as a food item. The phytoliths came from Levels F, E, D, C, and B, indicating use of the plant throughout the occupation of the site.

A major question in New World paleoethnobotany is the time of introduction of maize into the subsistence economy of particular areas, and the Virgin Islands are certainly no exception. Columbus apparently saw the plant upon landing in the area. However, most interestingly, not a single phytolith like those produced either by maize cobs or leaves was identified in the contexts examined. Pearsall's analysis of macrobotanical remains revealed a few carbonized kernels of maize, but, because of their contexts in upper midden levels where insect holes might introduce small material from the surface, there is a slight chance that they post-date the major occupation of the site reported herein.

The vegetative and reproductive structures of modern varieties of maize produce high numbers of phytoliths (Piperno, 1991; Piperno & Pearsall, 1993b). They include "cross-shaped" phytoliths, which are diagnostic of maize leaves, and "circular to acircular" forms, which are characteristic of cobs and cupules. These phytoliths have been commonly reported in ancient sites from the mainland New World tropics (Piperno, 1995a). The complete absence of these phytoliths in the Tutu midden is highly suggestive of the absence of maize in the subsistence economy of the site.

If not maize, then what were people eating? One of the most abundant plant families represented in the samples is the Marantaceae, a herbacious family to which the (now) minor tubers arrowroot (*Maranta arundinacea*) and *Calathea* belong (Figures 3.1, 3.2b). We cannot, unfortunately, make a positive identification of these tubers on present evidence because some other members of their family also contribute the types of phytoliths found at Tutu. Also, members of this family are commonly used by indigenous people for matting, bedding, and even toilet paper. However, abundant presence of the Marantaceae is certainly consistent with the notion that root crops formed the basis of the agricultural economy at the site.

The other major category of plant remains in the Tutu phytolith record derives from the Palmae (palms). They were fairly common in all of the samples that possessed a high phytolith content. They cannot be identified below the subfamily level, but all of the palm phytoliths were the "spherical, spinulated" variety, which could have been contributed by such genera as *Scheelia*, *Sabal*, and *Elaeis*, and not by *Bactris* (which includes the pehibaye or peach palm), *Acrocomia* or *Geonoma* (Piperno, 1988) (Figure 3.2c). Use of the last three genera in the contexts sampled can probably be ruled out.

Other phytoliths at the site

Phytoliths deriving from various arboreal taxa were fairly common at Tutu. They include such families as the Chrysobalanaceae (*Licania*, *Chrysobalanus*, *Hirtella*) and others that presently are not represented in the modern reference collection (the category "Other Arboreal" in Figure 3.1) (Figure 3.2d). The fruits of the Chrysobalanaceae have economic value for indigenous people of tropical areas today, and may have done so in the past. *Chrysobalanus icaco* is still widely cultivated in Panama.

Alternatively, these phytoliths may have found their ways into the midden attached to leaves on firewood, or simply may have been deposited into the site from vegetation growing nearby.

CONCLUSIONS

Phytolith studies at Tutu revealed the presence of *Cucurbita* (squash); but it is not possible at this time positively to assign a domesticated status to the plant at Tutu. The area has seen little intensive botanical survey that might reveal the presence of wild *Cucurbita*. However, judging from its presence in many of the contexts studied, some form of squash appears to have been commonly consumed.

Evidence for maize, either in the form of vegetative (leaf) or cob phytoliths, is lacking. This significant negative evidence indicates that the crop was not grown because maize is a prolific producer of phytoliths, which are likely to have been introduced into the midden if the plant was consumed. On the other hand, phytoliths from families of tuber-producing plants are commonat Tutu. Taken in total, the phytolith record is consistent with an argument that subsistence was based largely on root and tree crops, with some substantial input also from seed crops like squash.

Many of the plants identified in the phytolith record can exist in a relatively undisturbed, forested setting. Grass and other weedy-type phytoliths such as sedges (Cyperaceae) and the Compositae were rare, suggesting little environmental modification of the area near the site. This environmental scenario would also be consistent with an agricultural economy based on tubers and tree crops, with little input from more soil-demanding seed crops such as maize.

Chapter Four

Faunal remains from the Tutu site

Elizabeth S. Wing, Susan D. deFrance
and Laura Kozuch

INTRODUCTION

Numerous large samples of faunal remains recovered from the Tutu site provide the opportunity to examine many aspects of the exploitation of animal resources at this extensive and complex village site. Faunal samples from the site were studied from deposits of Ceramic Age occupation which date from approximately AD 65 to AD 1500. Major changes in the faunal assemblages during this time period were first noted by Rainey (1940) in Puerto Rican sites. The changes he described are a shift from what he called the crab culture to the shell culture. Since Rainey's discovery, this faunal change has been observed in many West Indian sites in which deposits associated with Saladoid people contain abundant crab remains, followed by refuse left by Ostionoid or post-Saladoid people, in which mollusk shells predominate (Rouse, 1992:94). The causes and timing of this change have been debated since Rainey's description of this apparent shift in resource consumption (Wing, 1995). Multiple samples from this time range at Tutu allow further examination of this faunal change and other accompanying changes in the use of animal resources on St Thomas.

A better understanding of regional patterns of resource use is also obtained by comparison of the faunal assemblage from the Tutu site with faunal assemblages from two other sites on St Thomas. These sites are Main Street and Magens Bay. Both Main Street and Magens Bay differ from the Tutu site in being located directly on the coast. The Main Street site is in what is now the town of Charlotte Amalie on the edge of southward facing St Thomas Harbor, while the Magens Bay site is situated on the shore of the large northward facing bay after which it was named (Figure 1.2).

The Virgin Islands are uniquely positioned between the Greater and Lesser Antilles. This is a location between the large islands with their diverse terrestrial faunas, and the smaller Antillean stepping stones leading from the South American mainland. Based on their abundance in middens (Wing, 1989; 1993), the large endemic rodents known as hutia (Capromyidae) were important in the subsistence of people living in the Greater Antilles. These rodents are absent in the Lesser Antilles, but in their stead are several different species of rice rats (Cricetidae). The use of endemic species was supplemented by introduced mainland animals in the Lesser Antilles. The Virgin Islands had neither endemic hutia nor rice rats. Mammals represented in the sites of the Virgin Islands were the insectivore, *Nesophontes edithae,* and the hutia, *Isolobodon portoricensis,* which were introduced from the Greater Antilles and provide tangible evidence of prehispanic contact with the Greater Antilles. Detailed examination of the faunal remains from the Tutu site provides further information about the management of these animals.

The ancestral experience of the colonizing advance up the island chain from the South American mainland undoubtedly added increasing seafaring and fishing experience for the efficient exploitation of the waters surrounding these islands. How this experience is reflected in the fauna from the Virgin Islands requires detailed analysis of large faunal samples such as those excavated from the Tutu site.

Prolonged occupation by people who made ceramics, cultivated plants, and exploited a diverse array of animals would be expected to have an impact on the environment and its animal populations (Newsom, 1993; Rouse, 1992; Wing, 1989). Comparisons of the faunal assemblages from early and late periods of occupation chart both the persistence of some aspects of the exploitation strategies and the changes that took place as a result of the intensity of exploitation necessary to support the human population at the village site.

These faunal samples from large excavations, at which a fine-gauge screen recovery strategy was used, allow further exploration of well known faunal changes, such as the shift from land crabs to marine mollusks, as well as issues of animal management and the effects of prolonged and intensive exploitation on island resources.

MATERIALS AND METHODS

All of the faunal remains that form the basis of this study were excavated under the direction of Elizabeth Righter, who also provided the recovery and chronological information. The proveniences included are only those that were recovered by sieving with all three screen gauge sizes, 0.635 cm, 0.3175 cm and 0.159 cm (¼ in., ⅛ in. and (1/16 in.). This insures the recovery of both large and small bones, teeth, and shells and, therefore, the representation of the full range of sizes of animals. Even the smallest animal is important in a faunal assemblage, because it may reveal characteristics of the environment and methods employed in exploitation. When many individuals of small-sized animals are represented they may indicate an important food resource.

Faunal samples were chosen from proveniences located in different areas of the site from different time ranges of the site's occupation. They include material from Areas 1, 4, 8, and 9N, 9S, and 9W, augmented by faunal data from the Main Street and Magens Bay sites. A list of the proveniences from which the faunal remains were identified and analyzed is presented in Table 4.1. Two-sigma ranges for early occupation midden levels sampled for faunal remains range between approximately cal. AD 15 and cal. AD 885 (Beta 108888, 62569), while those for the late occupation range between approximately cal. AD 1035 and *c.* cal. AD 1535 (Beta 51355, 51354). The C^{14} dates associated with the analyzed material are presented on Table 4.2.

When a single provenience is not large enough adequately to sample a deposit, a combination of data from other proveniences that are believed to represent the same episode of deposit is required. For the purpose of this analysis we compare the data from five subsamples grouped according to approximate 200-year blocks of time from the Tutu site. Each of these subsamples is adequate by the measure described below. The subsamples upon which this study is based are as follows. The earliest faunal remains analyzed from the Tutu site are associated with Area 1 and have a radiocarbon dated time range of approximately cal. AD 65 through cal. AD 350 (2-sigma) (Lundberg's comparative ceramic analysis refines the dates to between approximately cal. AD 65–100 through cal. AD 400; see Chapter 5). This is followed in time by the deposits studied from Area 4, Area 8, and Area 9N, dated approximately between cal. AD 400 and cal. AD 630 (2-sigma). The faunal assemblages from Areas 4 and 8 differ from Area 9N, and will be considered separately as variants for the time period. The largest analyzed faunal sample, that from Area 9W, was deposited at the end of the early occupation, during the time period between approximately cal. AD 420 through cal. AD 885 (2-sigma). The final period, dated between approximately cal. AD 1035 and cal. AD 1535 (2-sigma) is represented by the sample from Area 9S. Comparisons of faunal remains can be grouped

Table 4.1 List of proveniences analyzed from the Tutu, Main Street and Magens Bay sites

North coordinate	*East coordinate*	*Level*	*Bag; float number*	*Liters of matrix*
Area 1				
2096	1825	B	509	8
2097	1821.5	B	750, 752, 929	13.5
2097	1822.5	B	800, 801	10
2097	1823.5	B	747, 806	10
2097	1828	B	518	5
Area 4				
2087	1952	B zone 2C	3023, 3024, 3025, 3026	20
2090	1948	D	3766, 3767, 3769, 3770; 161, 162, 188, 189	23
Area 8				
2115.5	1838.5	B	3192, 3193, 3196, 3197, 3382; 107, 108, 151, 157	36
2115.5	1838.5	15–19 cm combined	3383, 3386, 3387; 137, 138, 139	>11
Area 9N				
2075	1810	B_2	1694, 1695, 1697, 1699, 1702, 1703, 1722	40
Area 9W				
2044	1837	D stratum 3	363, 364, 365, 366; 23, 31, 32, 37, 38, 39, 40	34
2044	1837	F	371, 628, 1185, 1186, 1263, 1265; 55, 71, 82	17
2044	1837	I	1289, 1290, 1291, 1292, 1293, 1294, 1295; 89, 90, 92, 95	25
2044	1837	P and PP	1657, 3619; 252, 255	10
Area 9S				
2033.5	1843.5	C 26–32 cm	3884; 148, 177	>9
2034	1842	C/E 34–42 cm	3881	n.a.
2036	1842	B-mid	5088; 265	10
2036	1842	B-base	5105, 5107; 269, 271	20
2037	1842	C 67–73 cm	5050, 5051; 226	10
Main Street				
trench		3'– 4' 3" bd	5995, 5996; 297, 298	40
Magens Bay				
test unit 2	sec. E	E	Feature 2	n.a.
test unit 3	sec. E	B and C		29

Note
bd = below datum.

according to deposits associated with early occupations at Tutu, which include Areas 1, 4, 8, 9N, and 9W, and contrasted with the late deposits from Area 9S. Faunal material from the early occupation at Tutu also may be compared with a sample from the Main Street site, which yielded 2-sigma calibrated dates of between cal. 360 BC and cal. AD 695 (between cal. AD 10 and cal. AD 550 at

Table 4.2 Chronology of components of the Tutu, Main Street and Magens Bay sites

Provenience[a]	*C^{14} lab number*	*C^{14} age BP*[b]	*Median uncalibrated date*
Area 1			
2096N/1827E, B	Beta 65474	1800±80	AD 150±80
Area 4			
2087N/1952E, B	Beta 50066	1610±70	AD 340±70
2090N/1948E, D	Beta 54646	1560±90	AD 390±90
Area 8			
2113N/1840E, B	Beta 65473	1570±60	AD 380±60
Area 9N			
2075N/1810E, B2	CAMS 10696	1550±50	AD 400±50
Area 9W			
2044N/1837E, D	Beta 62568	1430±90	AD 520±90
2044N/1837E, F	Beta 62569	1400±120	AD 550±120
2044N/1837E, I	Beta 62570	1380±90	AD 570±90
Area 9S			
2036N/1842E, B base	Beta 51355	720±120	AD 1230±120
2036N/1842E, B top	Beta 51354	560±120	AD 1390±120
Main Street			
lowest stratum	Kreuger Ent.	1770±235	AD 182±235
Magens Bay			
unit 3, level B	Beta 49751	1040±150	AD 910±150

Notes

[a] The provenience is noted as north and east coordinates followed by the level.

[b] BP = "before present" where the present is AD 1950.

1-sigma, Beta unassigned), most comparable to the first two time periods at Tutu. Tutu late occupation material may be compared with the Magens Bay sample which had a calibrated date range of between AD 1175 and AD 1405 (2-sigma, Beta unassigned). These time period groupings are used because no demonstrable faunal changes can be detected in groups of shorter duration.

Standard zooarchaeological methods are used. Identifications are made by comparison with comparative or reference specimens in the collections of the Florida Museum of Natural History. Identifications are made to the lowest taxon possible; however, our policy is to be conservative and not carry identifications further than can be demonstrated on anatomical grounds.

Three methods of quantification are applied to characterize the importance of each taxon. These are the number and weight (in grams) of identified bone or shell specimens of each taxon and a calculation of minimum numbers of individuals (MNI). All methods of quantification are normalized for comparisons between samples of different sizes. Estimates of MNI are the number of individuals that can account for all of the specimens identified to each taxon in a sample. These estimates are augmented by the remains that are different in size. For example, four right dentaries and one left dentary of a particular species would indicate four MNI; however, if the left dentary is larger than all of the right ones, an MNI of five would be indicated. Estimates of MNI should not be interpreted as the actual number of individuals present but rather as a method of evaluating the relative proportions of different taxa in a sample. It is entirely possible to find, for example, a single shark's tooth and record it as one MNI from a site where no whole shark was ever deposited. The tooth might have been acquired through trade and served as a tool. The widespread practice of animal carcass distribution throughout a community would also result in a portion of an animal being recorded as one MNI. Subdivision of carcasses is less likely when the animals in a catch are all small, in which case the catch might be divided among the fishermen participating in landing it. Therefore, in evaluating MNI, it is also important to compare these values with the other methods of quantification that might give a clue to the completeness of the skeleton of an individual.

The analyses of these faunas are based primarily on the calculated MNI, although this calculation has come under some criticism by zooarchaeologists working primarily on mammalian remains. However, in faunal assemblages composed of animals from classes as diverse as mammals and gastropods, it is essential to have some mechanism to put their remains in perspective and to diminish biases that result from the widely different numbers of skeletal or shell elements that could contribute to the deposits of the diverse Virgin Islands fauna. The calculation of MNI is the best way we know to do this.

The other important basic parameter of zooarchaeology is the adequacy of the sample size. One measure of adequacy is whether the full range of the most common taxa is represented and few new taxa are added with further identifications (Wing & Brown, 1979). When richness (the number of taxa) and sample size based on MNI are plotted, the curve rises quickly as new individuals and new taxa are added to the sample. New species are added less frequently as sample size increases and, consequently, the curve levels off reaching a point of diminishing returns. This is known as a rarefaction curve (Figure 4.1). If the sample size falls on the portion of the curve where new taxa are added at an ever-diminishing rate with the increase in the sample size, we consider that it includes the common taxa and is adequate at least by this measure. Based on other sites in the Caribbean, we have determined that 125 MNI in a sample is sufficiently large to include all of the numerically most important species in the deposit (Wing & Wing, 1995).

To understand the environmental focus of prehistoric exploitation, the faunal assemblage of each subsample is divided according to the major habitat in which each taxon is typically found (Tables 4.3 and 4.4; Figure 4.2). The presence or absence of a particular species may not be significant because it may be from a catch in which chance played a large part. However, the accumulation of individuals from one habitat indicates the focus of the catch or gathering activity. The general habitat categories we use are land vertebrates and crabs, intertidal mollusks, inshore and estuarine vertebrates and invertebrates, reef-dwelling fishes, and pelagic fishes. Terrestrial animals include two introduced mammals, the insectivore and hutia, as well as birds, lizards, snakes, and land crabs (Gecarcinidae) as well as the less abundant land hermit crabs (Coenobitidae) (Wing, 1995). The other habitat or niche groupings are all marine and include: a great diversity of reef fishes; inshore and estuarine animals, such as sea turtles (Cheloniidae); fishes including herring (Clupeidae), needlefishes

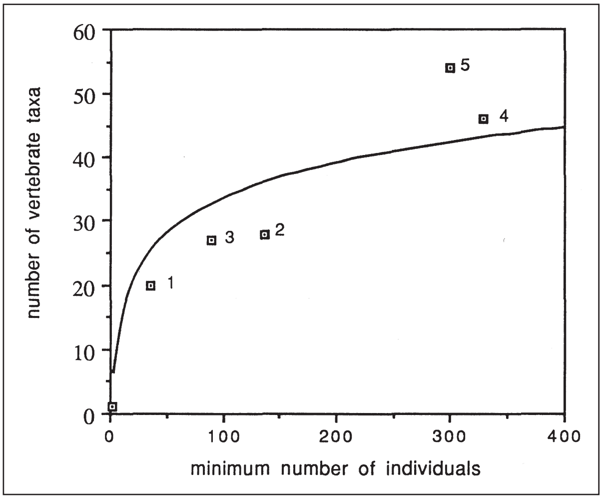


Figure 4.1 A comparison of the numbers of the taxa and MNI for each excavation area at the Tutu site. The curve is the best fit for this comparison. It can be used to evaluate the adequacy of sample size. The numbers beside the points designate excavation areas of the site: 1 is Area 1; 2 is Areas 4 and 8; 3 is Area 9N; 4 is Area 9W; and 5 is Area 9S.

Table 4.3 Species list and habitat information for animals identified from Tutu, Main Street and Magens Bay sites. The list is organized in conventional taxonomic order

Scientific name	*Common name*	*Habitat*
BIRDS (Bond, 1985)		
Ardeidae		
Nyctanassa violacea	night heron	swamps and marshes
Anatidae		
cf. *Branta* sp.	goose	swamps, lagoons
Rallidae	duck	lakes, lagoons
Fulica sp.	coot	fresh-water lakes and ponds
Scolopacidae	sandpiper	seacoast, inland rivers
Columbidae	pigeon	woodland, open lowlands
Passeriformes	song bird	land, cosmopolitan
Turdidae		
cf. *Turdus* sp.	thrush	land, wooded hills
Mimidae	mockingbird, thrasher	land, cosmopolitan
REPTILES (Schwartz & Henderson, 1991)		
Emydidae		
Trachemys sp.	pond turtle	introduced on some islands
Cheloniidae	sea turtle	marine waters, beaches
Dermochelydae		
Dermochelys coriacea	leatherback	marine waters, beaches
Iguanidae		
Anolis spp.	anole	land, arboreal
Cyclura pinguis	rock iguana	land, xeric limestone areas
Iguana iguana	common iguana	land, xeric limestone areas
Leiocephalus sp.	curly-tailed lizard	land, rocky coast, beach, scrub
Teiidae		
Ameiva exul	ground lizard	land, open grassy areas
Colubridae	non-poisonous snake	land, terrestrial
CARTILAGINOUS FISHES (Randall, 1983; Robins *et al.*, 1991)		
Carcharhinidae		
Negaprion brevirostris	lemon shark	shallow inshore marine
Rajiformes	skates and ray	inshore, marine
Dasyatidae		
Dasyatis spp.	stingray	shallow inshore marine, sandy
BONY FISHES (Randall, 1983; Robins *et al.*, 1991)		
Elopidae		
Elops saurus	ladyfish	inshore estuarine
Muraenidae		
Gymnothorax spp.	moray	shallow reef, carnivore
Clupeidae		
Harengula spp.	sardine	school near shore
Ophidiidae	cuskeel	marine various depths

(continued on next page)

Table 4.3 (cont.)

Scientific name	*Common name*	*Habitat*
Exocoetidae		
Cypselurus spp.	flyingfish	pelagic
Hemiramphus spp.	halfbeak	surface water
Belonidae		
Strongylura spp.	needlefish	surface water, inshore
Tylosurus crocodilus	houndfish	surface water, inshore
Cyprinodontidae		
Fundulus sp.	killifish	shallow water estuarine
Atherinidae	silversides	school in inshore water
Holocentridae		
Holocentrus spp.	squirrelfish	reef, feed on crustacea
Centropomidae		
Centropomus spp.	snook	inshore/estuarine near mangroves
Serranidae		
Diplectrum formosum	sand perch	inshore sea grass meadows
Epinephelus spp.	grouper	reef, carnivore
Hypoplectus unicolor	butter hamlet	reef, carnivore
Mycteroperca spp.	grouper	reef, carnivore
Malacanthidae		
Malacanthus plumieri	sand tilefish	inshore near reefs
Pomatomidae		
Pomatomus saltatrix	bluefish	inshore in cool months
Carangidae		
Alectis ciliaris	African pompano	pelagic or inshore
Caranx crysos	blue runner	inshore over reefs and open bottom
C. latus	horse-eye crevally	along sandy beaches
C. ruber	bar jack	shallow water over reefs
C. spp.	jacks	
Chloroscomberus chrysurus	Atlantic bumper	shallow inshore water
Decapterus punctatus	round scad	inshore, outer shelf
Selar crumenophthalmus	bigeye scad	inshore over reefs
Selene vomer	lookdown	inshore
Seriola spp.	amberjack	offshore
Trachinotus spp.	pompano	inshore
Lutjanidae		
Lutjanus apodus	snapper	reef, estuarine mangroves
Ocyurus chrysurus	yellowtail snapper	shallow reef
Gerreidae		
Diapterus sp.	mojarra	inshore estuarine
Eucinostomus spp.	mojarra	inshore estuarine
Gerres cinereus	mojarra	inshore
Haemulidae		
Anisotremus virginicus.	porkfish	reef carnivore
Haemulon album	margate	reef carnivore
Haemulon spp.	grunt	reef carnivore
Orthopristis chrysoptera	pigfish	inshore

(continued on next page)

Table 4.3 (cont.)

Scientific name	*Common name*	*Habitat*
Sparidae		
Calamus bajonado	jolthead porgy	inshore sea grass meadows
Calamus penna	sheaphead porgy	inshore sea grass meadows
Sciaenidae		
Bairdiella spp.	croaker	inshore estuarine
Mullidae		
Mulloidichthys martinicus	yellow goatfish	reef, sand areas
Mullus auratus	red goatfish	reef
Pseudupeneus maculatus	spotted goatfish	reef
Kyphosidae		
Kyphosus spp.	chub	inshore
Pomacentridae		
Abudefduf saxatilis	sergeant major	reef herbivore
Microspathodon chrysurus	yellowtail damselfish	reef omnivore
Labridae		
Bodianus rufus	Spanish hogfish	reef carnivore
Halichoeres spp.	reef wrasse	reef carnivore
Scaridae		
Scarus spp.	parrotfish	reef herbivore
Sparisoma viride	stoplight parrotfish	reef herbivore
Sparisoma spp.	parrotfish	reef herbivore
Mugilidae		
Mugil spp.	mullet	inshore estuarine
Sphyraena		
Sphyraena spp.	barracuda	reef carnivore, open water
Eleotridae		
Dormitator maculatus	fat sleeper	inshore estuarine
Gobiomorus dormitor	bigmouth sleeper	inshore estuarine
Acanthuridae		
Acanthurus spp.	surgeonfish	reef herbivore
Scombridae		
Euthynnus spp.	little tunny	pelagic
Scomberomorus spp.	mackerel	pelagic
Balistidae		
Balistes vetula	queen triggerfish	reef carnivore
Cantherhines spp.	filefish	reef carnivore
Melichthys niger	black durgon	reef carnivore
Ostraciidae		
Lactophrys spp.	boxfish	inshore bottom
Diodontidae		
Diodon hystrix	porcupinefish	reef carnivore
LAND CRABS (Walcott 1988; Williams *et al.*, 1989)		
Coenobitidae		
Coenobita clypeatus	land hermit crab	land
Gecarcinidae		
Cardisoma guanhumi	blue land crab	land

(continued on next page)

Table 4.3 (cont.)

Scientific name	*Common name*	*Habitat*
Gecarcinus spp.	land crab	land
Callianassidae		
Callianassa spp.	ghost shrimp	intertidal, commensal
Parthenopidae		
Parthenope spp.	elbow crab	sandy bottom, commensal
Majidae	spider crab	reefs, commensal
Portunidae	swimming crab	inshore, commensal
Balanidae		
Tetraclita squamosa	ribbed barnacle	intertidal, commensal
Coronulidae		
cf. *Chelonibia* sp.	sea turtle barnacle	commensal, attached to turtles
BIVALVES (Abbott, 1974; Turgeon *et al.*, 1988)		
Mytilidae		
Brachidontes spp.	mussel	shallow marine, intertidal
Archidae		
Arca zebra	turkey wing	inshore, rocky
Barbatia cancellaria	red-brown ark	inshore, rocky
Isognomonidae		
Isognomon spp.	tree-oyster	inshore, tree roots
Pectinidae		
Pecten ziczac	zigzag scallop	shallow inshore
Lucinidae		
Codakia costata	costate lucine	shallow inshore
C. orbicularis	tiger lucine	shallow inshore
Divaricella spp.	lucine	shallow inshore
Chamidae		
Chama sarda	cherry jewelbox	reef attached to coral or shell
Tellinidae		
Tellina laevigata	smooth tellin	sandy inshore
Donacidae		
Donax denticulatum	coquina	sandy intertidal, inshore
Psammobiidae		
Asaphis deflorata	gaudy sanguin	inshore
Veneridae		
Chione cancellata	cross-barred venus	inshore
Pitar spp.	pitar	inshore
Transennella spp.	transennella	inshore
GASTROPODS (Abbott, 1974; Turgeon *et al.*, 1988; van der Schalie, 1948)		
Fissurellidae		
Fissurella nodosa	knobby keyhole limpet	rocky intertidal
Acmaeidae		
Acmaea leucopleura	dwarf suck-on limpet	rocky intertidal
A. pustulata	spotted limpet	rocky intertidal
Trochidae		
Calliostoma spp.	topsnail	rocky intertidal

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Table 4.3 (cont.)

Scientific name	*Common name*	*Habitat*
Cittarium pica	West Indian topsnail	rocky intertidal
Turbinidae		
Astraea caelata	carved star-shell	inshore, intertidal
A. tuber	green star-shell	inshore, intertidal
Phasianellidae		
Tricolia spp.	pheasant	inshore turtle grass
Neritidae		
Nerita fulgurans	Antillean nerite	rocky intertidal
N. peloronta	bleeding tooth nerite	rocky intertidal
N. versicolor	four-tooth nerite	rocky intertidal
Neritina spp.	nerite	rocky intertidal
Annulariidae		
Chondropoma antacruzense	horn snail	land, commensal
C. tortolensis	horn snail	land, commensal
Littorinidae		
Littorina meleagris	white-spot periwinkle	rocky intertidal
Nodolittorina tuberculata	common periwinkle	rocky intertidal
Tectarius muricatus	beaded periwinkle	rocky intertidal
Rissoidae		
Zebina browniana	smooth risso	inshore
Vitrinellidae	vitrinella	commensal, incidental
Vermatidae	wormsnail	commensal, incidental
Planaxidae		
Planaxis lineatus	dwarf planaxis	inshore
Modulidae		
Modulus modulus	buttonsnail	inshore sea grass meadows
Cerithiidae		
Cerithium lutosum	variable cerith	rocky intertidal
Diastoma varium	grass cerith	inshore eel grass
Strombidae		
Strombus spp.	conch	inshore
Cypraeidae		
Cypraea zebra	cowrie	rocky intertidal
Naticidae		
Natica spp.	moonsnail	intertidal
Cassidae		
Cypraecassis testiculus	reticulated cowrie-helmet	reef, inshore
Cymatiidae		
Cymatium spp.	triton	inshore
Muricidae		
Thais deltoidea	deltoid rocksnail	rocky intertidal
Columbellidae		
Nitidella nitida	glossy dovesnail	rocky intertidal
Fasciolariidae		
Leucozonia nassa	chestnut latirus	rocky intertidal
Olividae		
Oliva spp.	olive	inshore sandy

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Table 4.3 (cont.)

Scientific name	*Common name*	*Habitat*
Marginellidae		
Hyalina spp.	marginella	rocky intertidal
Conidae	cones	inshore shallow marine
Subulinidae		
Leptinaria salleana		land, commensal
Opeas pyrgula	sharp awlsnail	land, commensal
Spiraxidae	wolfsnail	land, commensal
Bulimulidae		
Bulimulus guadalupensis	West Indian bulimulus	land, commensal
Drymaeus virgulatus	tree snail	land, commensal
Sagdidae		
Hojeda spp.	mudcloak	land, commensal
Camaenidae		
Polydontes incerta		land, commensal
Neocyclotidae		
Megalomastoma spp.		land, commensal
Xanthonycidae		
Hemitrochus musicola		land, commensal
CHITONS AND TUSK SHELLS (Abbott, 1974; Turgeon *et al.*, 1988)		
Chitonidae		
Acanthopleura granulata	West Indian fuzzy chiton	rocky intertidal
Chiton marmoratus	marbled chiton	rocky intertidal
C. squamosus	squamosus chiton	rocky intertidal
Dentiliidae		
Dentalium spp.	tusk shell	inshore incidental

(Belonidae), mojarra (Gerreidae), porgy (Sparidae), mullet (Mugilidae), and sleepers (Eleotridae); and pelagic fishes such as halfbeaks and flyingfishes (Exocoetidae) and tuna (Scombridae). Reef fishes can be further subdivided by trophic levels (Sale, 1991). Predatory fishes at a high trophic level are carnivorous fishes such as groupers (Serranidae), jacks (Carangidae), snappers (Lutjanidae), and grunts (Haemulidae) that are often encountered on reefs. These include residents of reefs, such as the groupers, as well as transients such as the jacks which regularly swim and feed over reefs. At a lower trophic level are omnivorous and herbivorous fishes such as the wrasses (Labridae), parrotfishes (Scaridae), surgeonfishes (Acanthuridae), and damselfishes (Pomacentridae) that are residents of reefs, although they also feed in the surrounding seagrass beds. Mollusks fall into two major groups:

1. those, such as the West Indian topsnail (*Cittarium pica*) and nerites (Neritidae), that are found on wave-washed rocks in the intertidal zone, and sandy intertidal or subtidal bivalves, such as donax (Donacidae); and
2. commensal land snails such as the awlsnail (Subulinidae).

These habitat categories indicate the sources of the resources used, while the faunal list gives the species targeted by the human occupants of the listed archaeological sites.

Omitted from consideration of the pre-Columbian economy are commensal animals, which include primarily small land snails that are attracted to human occupation sites by their moisture and

Table 4.4 Frequencies of animals based on percentage MNI by habitat

Site/area	*Land*	*Intertidal*	*Inshore*	*Reef*	*Pelagic*	*Total*
Area 1						
MNI	41	27	10	17	6	101
%	41	27	10	17	6	101
Area 4 and 8						
MNI	167	22	19	91	11	310
%	54	7	6	29	4	100
Area 9N						
MNI	69	70	17	58	10	224
%	31	31	8	26	5	101
Area 9W						
MNI	248	73	55	215	45	636
%	39	12	9	34	7	101
Early deposits combined						
MNI	525	192	101	381	72	1271
%	41	15	8	30	6	100
Area 9S						
MNI	99	143	152	178	8	580
%	17	25	26	31	1	100
Main Street site						
MNI	77	89	19	24	3	212
%	36	42	9	11	1	99
Magens Bay site, TU-2, Section E, Level E						
MNI	27	310	26	34	5	402
%	7	77	7	9	1	101

Notes
Commensals and animals with undetermined habitat preference are omitted. See Table 4.1 for proveniences included within each site and excavation area.
MNI = minimum numbers of individuals.

organic materials. The most abundant of these is the subulinid snail, *Opeas pyrgula.* It is minute and can have no economic value. However, their abundance can be used as a guide to the speed with which a deposit was covered. A similar logic was used in a study by Reitz (1994) of commensal animals in wells of Spanish Florida. Few commensal animals were represented among the remains excavated from wells that were filled during one quick episode of deposit, while commensals were abundant in wells that were open for a longer time period during which the wells acted as traps. The commensals in the faunal remains from Tutu are not the mice and shrews found in wells but are small snails that died and were incorporated in the midden refuse. They are particularly abundant in some subsamples, Area 9N (N2075/1810E, Level B_2), Area 9W (N2044/1837E, Levels P and PP), and Area 8 (N2115.5/1838.50E, Level 15–19 cm), suggesting that these deposits may have accumulated more slowly than other subsamples.

Evidences of changes in the faunal assemblages grouped according to habitat can be examined in terms of the relative abundance of species in the different habitats. An objective method for evaluating the significance of these comparisons is percentage similarity, which is one of the best quantitative similarity coefficients available (Krebs, 1989). It uses the formula as follows:

$$P = \Sigma \text{ minimum}(p^{1i}, p^{2i}) \quad [1]$$

where P = percentage similarity between samples 1 and 2

p^{1i} = percentage of species i in community 1
p^{2i} = percentage of species i in community 2

The percentage similarity between the five subsamples from the Tutu site and the faunal assemblages from Main Street and Magens Bay is presented in Table 4.5.

Comparison of specific pairs of resources found in early and late deposits allows examination of particular changes in relative abundances of species and groups of species (Table 4.6). The groups compared, based on MNI, are reef carnivores such as groupers, snappers, and grunts with reef omnivore and herbivores such as parrotfishes and surgeonfishes; total vertebrates and crabs and then the more restrictive comparison between land vertebrates and land crabs; and the two kinds of land crabs, those belonging to the family Gecarcinidae, which has two genera, and the monotypic land hermit crabs belonging to the family Coenobitidae. These comparisons are made between the faunal assemblage from the early period, prior to *c.* cal. AD 885 and later deposits, after *c.* cal. AD 1040 (2-sigma ranges), at Tutu (Table 4.2). This comparison also is made

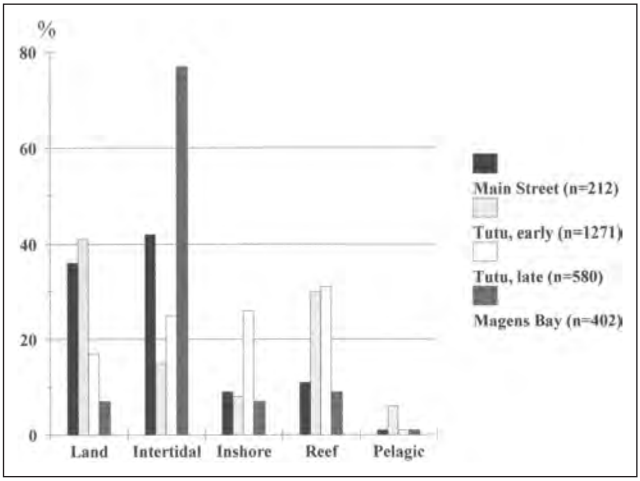

Figure 4.2 The percentage of MNI in major habitats by analytical units: Main Street; Tutu site, early and late occupation; and Magens Bay.

Table 4.5 Percentage similarity indices between the deposits at the Tutu site (divided by area), Main Street and Magens Bay sites using the data presented in Table 4.4

	Percentage					
	Area 4, 8	*Area 9N*	*Area 9W*	*Area 9S*	*Main Street*	*Magens Bay*
Area 1	75	88	83	70	84	51
Area 4, 8	—	74	85	60	61	30
Area 9N	—	—	82	77	82	55
Area 9W	—	—	—	70	69	36
Area 9S	—	—	—	—	63	49
Main Street	—	—	—	—	—	66

Table 4.6 Comparison between groups of animals in early and late deposits

	Early deposits		*Late deposits*		
Group	*MNI*	*%*	*MNI*	*%*	*Chi^2*
Tutu					
Vertebrates	438	55	149	73	>0.99
Crabs	362	45	55	27	
Total	800		204		
Magens Bay					
Vertebrates	72	81	155	96	>0.99
Crabs	17	19	6	4	
Total	89		161		
Tutu					
Land vertebrates	45	11	22	29	>0.99
Land crabs	362	89	55	71	
Total	407		77		
Magens Bay					
Land vertebrates	5	23	16	73	>0.99
Land crabs	17	77	6	27	
Total	22		22		
Tutu					
Gecarcinid crabs	244	98	62	63	>0.99
Coenobitid crabs	5	2	36	37	
Total	249		98		
Magens Bay					
Gecarcinid crabs	10	59	2	33	not significant
Coenobitid crabs	7	41	4	67	
Total	17		6		
Tutu					
Reef carnivores	245	86	58	66	>0.99
Reef omnivores	39	13	30	34	
Total	285		88		
Magens Bay					
Reef carnivores	28	58	44	39	>0.97
Reef omnivores	20	42	69	61	
Total	48		113		

Note
These are based on vertebrates and crabs from the deposits prior to AD 600 and after AD 1000 at the Tutu site and deposits in levels D and E compared with B and C at the Magens Bay site. The significance in the difference between the groups of animals in early and late deposits is expressed by chi^2 probability.

between deeper levels (D and E) and more superficial levels (B and C) in the Magens Bay site. The significance of the difference between these earlier and later deposits was tested with chi-square.

Table 4.7 Summary of measurements of fish vertebral centra, gecarcinid crab mandibles (merus height of the maxillaped), and shell height of the West Indian topshell from early and late deposits

	Early deposits				*Late deposits*			
Site/taxa	*no.*	*mean*	*range*	*SD*	*no.*	*mean*	*range*	*SD*
Tutu								
Herring	59	1.8	1.1–2.4	0.23	38	1.6	1.3–3.2	0.38
Jack	254	4.97	2.6–10.3	1.25	25	5.4	1.8–12.4	1.22
Grouper	37	7.3	1.6–21.6	2.79	16	3.2	2.0–8.2	1.42
Snapper	35	4.7	1.1–21.8	4.01	18	2.96	1.3–5.6	1.35
Parrotfish	21	5.3	2.3–8.9	1.52	53	2.5	1.3–4.9	0.85
Unidentified fish	314	3.7	1.3–11.7	1.78	313	2.6	1.0–8.9	1.19
Crabs	139	10.8	7.5–13.5	1.23	21	8.5	4.2–10.7	1.52
Main Street: Tutu								
W.I. topsnail	44	80.6	30.8–96.5	11.39	7	45.8	30.5–61.7	9.37

Notes
All measurements are in mm.
SD = standard deviation.
The early deposits are from Area 1, 4, 8, and 9N and 9W, and the late deposits are from Area 9S, all from the Tutu site as indicated on Table 4.1. The measurements from early period West Indian topsnails come from the Main Street site as there were too few to measure in the early Tutu deposits.

The sizes of animals, determined by sets of measurements of their skeletal or shell remains, provide information about the size classes of animals that were used, have implications about fishing technology, and are a guide to the potential amount of meat that different animals might have contributed to the prehistoric diet. A gauge of the relative sizes of the represented animals can also be made by comparisons of the actual measurements (Table 4.7).

Basic biological relationships exist between the size of an animal (for example its whole body weight) and dimensions of its skeleton or shell. This relationship is usually known as allometric because the two measurements, body weight and skeletal dimension, do not increase at the same rate. These relationships are widely used to describe variables such as whole-body size based on lengths or weights of body parts. Once a relationship between body weight and shell or skeletal dimension is established using comparative or reference specimens, the formula that is generated to describe this relationship can be used to estimate body weight when only a shell or skeletal dimension is known (Schmidt-Nielsen, 1984).

Allometric relationships were established between measurements (mm) of femur head depth and body weight (g) in mammals, the width (mm) of vertebral centra in fishes and corresponding body weight (g), and the height (mm) of the merus of the maxillaped in land crabs and their body weight (g). These relationships can be described by the following formulas:

1. $\log Y = 0.867 + 2.5569(\log X)$ where Y is body weight (g) and X is the greatest depth (mm) of the femur head of a mammal (Wing & Brown, 1979);
2. $\log Y = 1.162 + 2.047(\log X)$ where Y is body weight (g) and X is the width (mm) of the vertebral centrum of bony fishes (Wing & Brown, 1979);
3. $\log Y = 0.508 + 1.842(\log X)$ where Y is body weight (g) and X is the merus height (mm) of the maxillaped (deFrance, 1988).

Predictions of potential meat weight require a further conversion which can be done by a simple percentage derived from comparative specimens. The percentages of body weight that is usable meat are about 66 percent for mammals, 84 percent for fishes, and 60 percent for crabs (deFrance, 1988:50; Wing & Brown, 1979). Estimates of potential contribution of meat to the prehistoric diet using these allometric formulas will provide information only about the possible relative importance of different taxa in the diet, not about the actual diet of the people who deposited the refuse nor the size of the human population that could be sustained.

RESULTS

A total of 4,239 MNI vertebrates and invertebrates were identified from Tutu, with 2,103 MNI from components that date prior to AD 885, and 2,136 from components that date after AD 1040. A total of 62,370 specimens was identified from the Tutu site, making this one of the largest faunal samples studied from the zooarchaeological perspective in the entire Caribbean. The sample size of the Main Street fauna is 259 MNI (7,643 identified specimens), which includes vertebrates and invertebrates. The sample size of the Magens Bay fauna is 201 MNI (3,615 identified specimens), vertebrates and crabs only, for Test Units 2 and 3, Levels B and C; and 419 MNI (3,032 identified specimens), vertebrates and invertebrates, for Test Unit 2, Level E, Feature 2. By any measure these are adequate for comparisons that can be made of animal exploitation through time and space.

The sizes of the faunal samples excavated from different parts of the Tutu site and from the two coastal sites, Main Street and Magens Bay, are all adequate even though all samples are not equally large (Figure 4.1). The samples are large enough to include all targeted species. Even with the extensive sampling at the Tutu site, all of the activities that took place in the village were not recovered and studied. However, multiple samples allow examination of the deposit of animal remains associated with a range of activities. The importance of the adequacy of the samples is that it insures that the differences and similarities seen in comparisons between these samples are not due to chance alone.

The diversity of species is large at the Tutu site, with 158 species identified (Table 4.3). The majority of these species are fishes (63) and mollusks (63), supplemented by smaller numbers of mammals (5), birds (8), reptiles (9), crustaceans (9), and echinoids (1).

The patterns exhibited by the faunal assemblages associated with each deposit at Tutu are repeatedly replicated, which gives one confidence that they reflect traditions of resource use with fluctuations between deposits representative of different activities and changes through time. Analysis by habitat exploitation is accompanied by analysis of key species and, together, they point to the zones in which exploitation efforts were concentrated, the species or group of species that was targeted, and how this changed through time and differed according to the location of the site (Tables 4.4, 4.5, and 4.6). In subsamples that we examined (Table 4.4), MNI of terrestrial animals and animals that inhabit coral reefs predominate, while those living in rocky intertidal zones are second in abundance. At Tutu, the relative abundance of land animals (41% MNI, with a range of between 31% and 54%) is greater in early deposits than in the later deposit, where there are 17 percent MNI. The exploitation of reef fishes throughout the occupation at Tutu is relatively stable, as indicated by MNI percentages (30% MNI of the fauna with a range from 17% in the earliest subsample, Area 1, to 34% at the end of the early period, Area 9W). The relative abundance of the rocky intertidal mollusks (which are primarily marine gastropods), chitons, and limpets averages 18 percent MNI for the site as a whole, with ranges of between 7 percent and 31 percent. Rocky and beach intertidal animals predominate in the faunal assemblages from the two coastal sites.

To view objectively the similarity in the distribution of individual (MNI) animals in the five major habitats, we used the percentage similarity. These indices are presented in a matrix in Table 4.5. The percentage similarity indices are the highest, over 80, in the following compared pairs: Area 1 compared with Areas 9N and 9W and Main Street; Areas 4 and 8 compared with Area 9W; and Area 9N compared with Area 9W and Main Street. The subsample from Areas 4 and 8 has the lowest indices among the early deposits, 75 and 74, in comparisons with Area 1 and Area 9N respectively. Indices between 60 and 77 result from comparisons between the late deposit in Area 9S with all early deposits. Indices of comparisons between Main Street and Tutu deposits are generally higher, 61 to 84, than comparisons between Magens Bay and Tutu, which range between 30 and 55. The high indices, 82 to 88, in comparisons between Area 1, Area 9N, and Main Street are owing to a relatively even and high number of animals associated with land, intertidal, and reef habitats.

In addition to examining the relative abundance of species found in major habitats, further understanding of changes in the faunal assemblages can be gained by comparing groups of animals in early and late deposits (Table 4.6). The first two of these comparisons present data relevant for documenting the change through time in the presence of land crabs first discussed by Rainey (1940). In both comparisons (vertebrates with crabs, and land vertebrates with land crabs), a significant increase in the abundance of vertebrates and a corresponding decrease in crabs is seen in the deposits from Tutu and Magens Bay (Table 4.6). This demonstrates that the numbers of crabs decline relative to the numbers of vertebrates and that this decline is in later deposits. Whether they are a decline from Saladoid to post-Saladoid, as first thought, or a decline within the post-Saladoid period is not known.

A closer examination of the land crabs compares the large gecarcinid land crab with the smaller land hermit crab. These crabs belong to two families and, although the gecarcinid land crabs are always more abundant, the relative numbers of land hermit crabs increase through time. This increase is significant in the Tutu deposits. Although the same trend is seen in the Magens Bay deposits, these samples are too small to be significant.

A final comparison is between reef fishes of different trophic levels: those that prey on other fishes and those that consume plants and invertebrates or plants alone. The change in the relative abundance of reef fishes of different trophic levels is significant at both Tutu and Magens Bay. In both pairs of deposits the numbers of reef omnivores and herbivores increase relative to reef carnivores in the later time period. The key species in the early deposits at Tutu are jacks, which swim over reefs and feed on resident fishes but are also in the inshore habitats. In addition to jacks, territorial reef carnivores (such as grouper, snapper, and grunts) are less abundant in the later deposits, where they are replaced by parrotfishes, which are territorial reef dwellers.

The potential importance of an animal to the prehistoric diet is reflected in its abundance and size. Measurements of the fragmentary remains provide a guide to the size of the animals represented in the deposits (Table 4.7). One measurement that correlates particularly well with body weight is the width of fish vertebrae. However, many fish vertebrae are difficult to identify even to the family level. We assume the unidentified vertebrae are from a cross-section of fishes in the site with the exception of species such as herring, eels, flyingfishes, ladyfishes, needlefishes, and tuna, which have distinctive vertebrae that can usually be identified. The vertebrae of other fishes that are possible to identify usually have only a few vertebrae in the column which are distinctive enough to identify with confidence.

The sizes of animals estimated from measurements of their skeletal or shell remains have implications for the types of equipment that were used to catch them and the contribution they may have made to the prehistoric diet. The primary resources, fishes, crabs, and topsnails, caught or gathered by the early occupants of Tutu were generally small, estimated to weigh less than 250 g

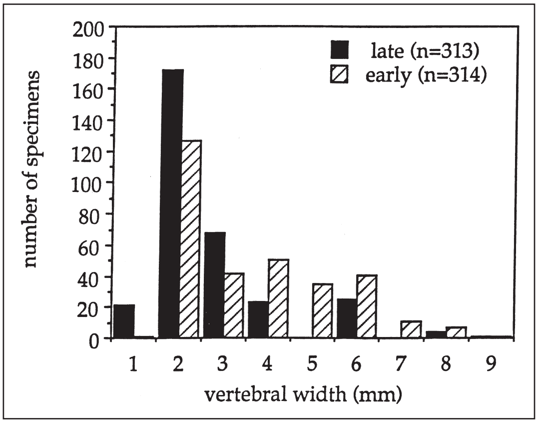

Figure 4.3 The size frequency distribution of unidentified fish vertebrae from early and late deposits at the Tutu site.

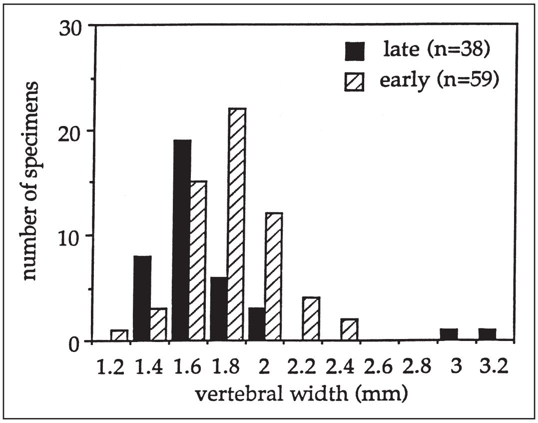

Figure 4.4 The size frequency distribution of Clupeidae (herring) vertebrae from early and late deposits at the Tutu site.

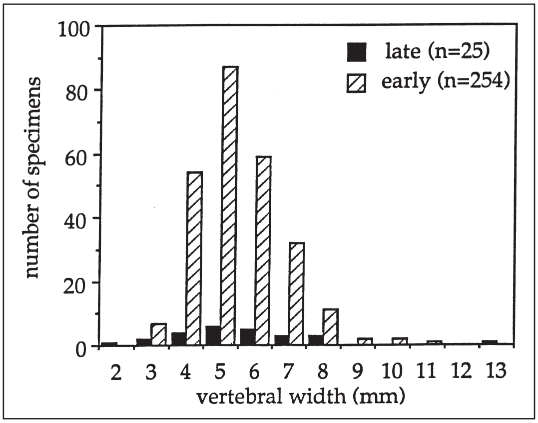

Figure 4.5 The size requency distribution of Carangidae (jack) vertebrae from early and late deposits at the Tutu site.

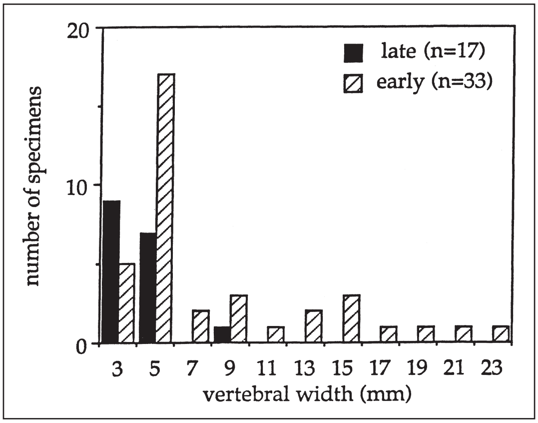

Figure 4.6 The size frequency distribution of Serranidae (grouper) vertebrae from early and late deposits at the Tutu site.

(Figure 4.3). Occasionally fishes were caught that were much larger: in the neighborhood of 2,700 g. Most of the larger fishes were either grouper (one grouper is estimated to have weighed as much as 7,355 g) or tuna fish. Other large animals that were caught are sea turtles and manatees. Monk seal, represented by a single perforated tooth, also may have been caught. Of these, the sea turtles were the most abundant and represented in both early and late deposits. The presence of the remains of large animals in a sample need not represent the prehistoric use of an entire animal. However, the complete shell of a large sea turtle straddled N2115.50/1838.70E (Elizabeth Righter, personal communication, 22 April 1992; Figure 1.19).

These same primary resources acquired by the later people were substantially smaller; the average fish weight is estimated to be less than 190 g (Figure 4.3). Furthermore, the largest measurement of a fish caught by later occupants at Tutu is a jack that weighed approximately 2,500 g. Gecarcinid crabs were smaller; the average weight is estimated to be 188 g. West Indian topsnails were only about half as

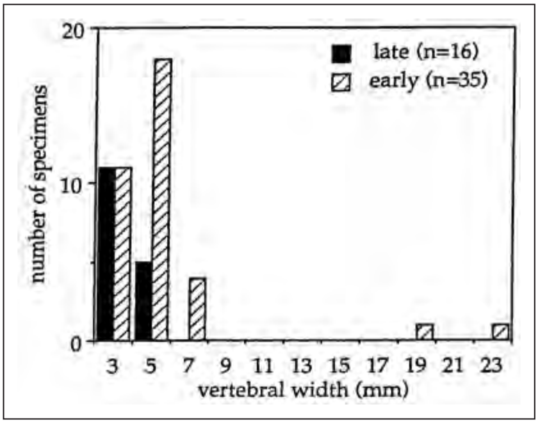

Figure 4.7 The size frequency distribution of Lutjanidae (snapper) vertebrae from early and late deposits at the Tutu site.

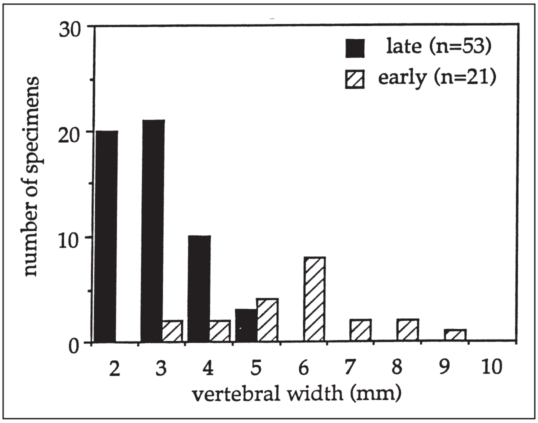

Figure 4.8 The size frequency distribution of Scaridae (parrotfish) vertebrae from early and late deposits at the Tutu site.

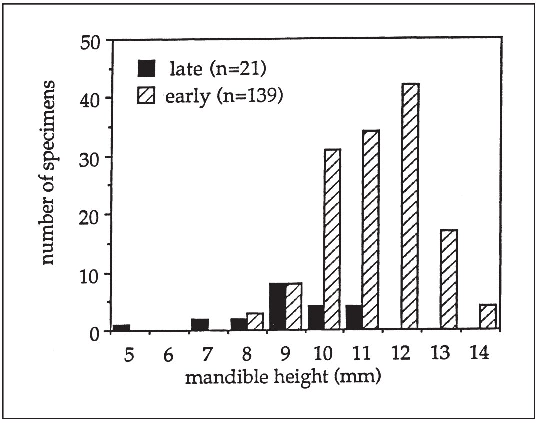

Figure 4.9 The size frequency distribution of Gecarcinidae (land crab) mandibles from early and late deposits at the Tutu site.

large in the later deposits at Tutu as those gathered by the early occupants of Main Street. These are clear and consistent decreases in sizes of many of the animals caught by the later occupants at Tutu.

Predictions of the weights of these animals and their potential contribution to the prehistoric diet from the two time periods differ in accordance with the observed size differences. Estimated mean weights of unidentified fishes and crabs in the early deposits are 220 g and 245 g respectively, while in the later deposits estimates of the weights of these same animals are 100 g and 188 g (Table 4.7). If these estimates are further converted to meat weight, the mean estimated meat weights of unidentified fishes and crabs in the early deposits are 185 g and 147 g respectively, while the estimated meat weights in the later deposits are 84 g and 113 g respectively. A comparison of the numbers of specimens identified as key animals compared with the weights of these specimens provides another measurement of the potential contribution of these animals to prehistoric diets.

The size distribution of some of the animals represented in early and late deposits at Tutu changes while others do not (Table 4.7). The sizes of herrings and jacks do not change significantly through time (Figures 4.4 and 4.5). Although the size distribution of jack vertebrae is the same through time, more jack vertebrae were identified and measured in the early deposits than in later ones. Number of identified vertebrae reflects abundance but is not the same as MNI. The species of jacks most frequently identified is the blue runner (*Caranx crysos*). The mean size of these fishes, based on a vertebral width of approximately 5 mm, is estimated to represent a live weight of almost 400 g. Herrings, with a mean vertebral width of 1.7 mm, are estimated to weigh 43 g.

The means and ranges of the sizes and the numbers of identified vertebrae of some territorial reef fishes do differ between the early and late deposits. Two predatory fishes (grouper and snapper) have a smaller mean size and range in the later deposits than in the earlier ones (Figures 4.6 and 4.7). This same pattern is seen in the comparison of the size distribution of the reef omnivores, the parrotfishes (Figure 4.8). The numbers of vertebrae that could be identified from early and late deposits also reveal the changes in relative abundances of these fishes. Fewer vertebrae of the predatory fishes were identified and measured in the late deposits, whereas more vertebrae of parrotfishes were identified and measured in the late deposits. As with the jacks and herrings, numbers of identified vertebrae are a measure of abundance but one that is different from MNI which takes into account all skeletal elements and excludes the count of bones that could come from the same individual.

Change in the size distribution of land crabs exhibits the same pattern as that of the predatory fishes exemplified by groupers and snappers (Figure 4.9). The height of the merus, which also correlates with body size, is smaller in the later deposits, and far fewer could be measured. The sizes and abundances of all of these animals have important implications for the prehistoric uses of these resources through time.

DISCUSSION

The faunal samples that were studied from St Thomas are large, and, as a result of a recovery strategy using fine-gauge screen, have a wide size range. Subsamples come from different locations at the Tutu site, and, augmented by faunal remains from two coastal sites, they represent deposits from a 1,400-year time span. These attributes permit us to characterize the past exploitation of resources and the way in which it differed between inland and coastal locations, as well as between early and late occupations of the Ceramic Age period. For St Thomas, this also gives us a better understanding of the exploitation of animals (one aspect of the human economy) than is available for most other islands in the Caribbean.

Commensal animals and their implications

Among archaeological faunal remains, commensal animals are species that live in association with people and the environments modified by people. The commensals typically found in West Indian sites are snails attracted to the organic rich, moist conditions of refuse. When the refuse is exposed long enough for these snails to come to the site and die there, some of them will become incorporated in the faunal sample. The relative abundance of commensal land snails in the invertebrate component of the faunal assemblages varies between 0 and 83 percent. If, as we believe, they are more abundant in those deposits that accumulated slowly, their abundance could be used as a gauge for the speed of the deposition, indicating whether refuse was deposited in one episode and covered, or gradually accumulated and left exposed. Those proveniences in which commensals constitute more than 50 percent of the invertebrate MNI are Area 8, Area 9N, and Area 9W (deep levels). The later deposits at Tutu (Area 9S) have the fewest commensal snails, less than 6 percent of the invertebrate MNI. Whether refuse was deposited quickly or slowly might be related to the nature of the refuse and the numbers of people producing it. Inedible remains from animals, such as mollusks and crabs, which have a low proportion of meat to body weight, would produce refuse more quickly than fishes. Abundant molluscan and crustacean remains do not seem to correlate with the greatest numbers of commensals. Those proveniences with or without many commensals have equally high proportions of mollusks and crabs. Therefore, it may simply be related to the production of refuse. The increased amount of charcoal noted by Pearsall (see Chapter 2) in later deposits may indicate behavior that accounts for speedier refuse accumulation that precluded the incorporation of many commensals. Whatever the conditions are that promote the inclusion of abundant commensal gastropods in a deposit, they are clearly not a component of the diet and were not intentionally gathered and, therefore, we exclude them from further analysis. Most of the animals, other than commensals represented at the sites, are assumed to have been a part of the prehistoric diet or used by people in some way.

Fishing and gathering practices and management of animals

The choices made by people living on St Thomas were determined to some extent by the location in which they chose to settle and by the resilience of the natural resources. A whole array of animal resources was used at each site, indicating that no one resource provided sufficient food for the population. Resources are normally exploited closest to the home site within what is called the catchment area (Higgs & Vita-Finzi, 1972), and people living along the shores of bays gathered more invertebrates, particularly mollusks, compared with the people living as far inland as the Tutu site. The predominance of terrestrial resources, both land crabs and vertebrates, in the early deposits at Tutu conforms to this expectation. Likewise, the intensive use of donax by the people living beside the long sandy shores of Magens Bay shows a reliance on a local resource. Donax are a seasonal resource in most places and are scooped with sieves in great numbers from the sand in the receding tide.

Equipment used for gathering food, whether plant or mollusk, consisted of baskets or bags. Fishing for marine species on St Thomas probably involved the use of nets or traps. Nets can be used to sweep a swath, recovering animals in their paths, while traps are passive in capturing targeted species. Both types of equipment, however, usually result in selective fish sizes (controlled by the net mesh or the trap opening), and in catches of a complex of species that frequent specific water depths and swim over or among habitats where the equipment is used. Nets are typically used to catch herring, halfbeaks and flyingfishes (Exocoetidae), and blue runner today, and may well have been used to catch them in the past. Of these, halfbeaks and blue runners are particularly abundant in the early deposits. Both of these species swim in large schools over inshore waters. The halfbeaks swim on the surface and feed on sea grasses and small fishes. Blue runners school inshore, swimming rapidly over open bottom and occasionally over reefs, and feed on fishes, usually silvery species, and invertebrates. Reef fishes are typically caught with traps. The catch from traps includes a variety of fishes that are both carnivores and herbivores. Parrotfishes, which are particularly abundant in the later occupation at Tutu, are usually caught in this manner.

If the reef fishes were caught in traps, the actual composition of the catch would be expected to fluctuate from day to day, and some of this would be related to chance. The size of the trap and its placement in the reef would influence the size range and the species composition of the fishes caught. However, over the time represented by the archaeological deposits, the day-to-day fluctuations would average out, and changes in the composition of the reef populations as revealed by trap catches, human selection, and bone preservation can be documented.

Fully domestic and managed animals are not abundant in the faunal assemblages. Guinea pigs are one of the two fully domestic animals found in the West Indies, and they are absent from these faunal samples. The other is the dog. Most West Indian dogs were given the special ritual of burial and not associated with midden refuse, thus they are seldom encountered in studies of midden remains. At least 22 dogs accompanied human burials in an early Ceramic Age site on the nearby island of Vieques (Wing, 1991). Dog remains were expected at Tutu because of the close proximity of St Thomas to Vieques Island, occupations during the same time period, and excavations of human burials at both sites. Thirty-seven human burial pits were excavated at Tutu, and none included dog burials. Only two dog skeletal elements (auditory bulla and scapula) were identified from Magens Bay. The absence of dog remains from the Tutu and Main Street deposits does not mean that dogs were absent from these economies. The very large size of the Tutu excavations, however, suggests that they were very rare, if they were present.

Two animals are not abundantly represented but are important because they were introduced by people into the Virgin Islands from the Greater Antilles (Morgan & Woods, 1986). These animals are the hutia and the large insectivore. The occurrence of these animals in the early deposits documents their early introduction and use. The hutia evolved in Hispaniola and was introduced by people into Puerto Rico, and, presumably, from there to the Virgin Islands. It may be viewed as a managed animal and represents some degree of human control over a resource. Although these animals were introduced and managed, they are not abundant at the Tutu site. They are only slightly more abundant (representing between 4% and 6% of the vertebrate MNI) in the later deposits at Tutu than in the early deposits where they are absent or constitute only 1 percent of the vertebrate MNI. They were expected to be more abundantly represented at Tutu because they are abundant in some later occupations, particularly in sites located inland from the coast on Puerto Rico (Wing, 1993).

Those managed animals that are present at Tutu indicate a prehistoric connection with islands to the west. There is no evidence of introductions from the Lesser Antilles. However, in contrast with some sites on Vieques Island and Puerto Rico, introduced and managed animals are less abundant at Tutu, and both dogs and guinea pigs are absent. Guinea pigs might have been present in the later time periods, as they are in Puerto Rico, Vieques Island, and Antigua in the Lesser Antilles. The rarity of managed animals and the absence of domestic ones suggest that the Tutu people were engaged more in exploiting wild resources than in managing captive and domestic animals. Their control of resources apparently was concerned more with cultivating plants than with nurturing animals (see Chapter 2).

Habitat exploitation

As seen in the animal remains at Tutu, much about the exploitation of resources is consistent throughout the site's occupation, and those animals that were a part of the prehistoric economy were intentionally procured from several different ecological zones. Relative abundances indicate that land dwelling animals and reef fishes were important. Intertidal organisms, primarily those mollusks that cling to rocks in the splash zone, were generally also abundant. Inshore fishes gain in numerical importance in the later occupation of Tutu.

The abundance of intertidal mollusks at the coastal Main Street and Magens Bay sites contrasts to the faunal distributions at Tutu, and suggests that the animals assumed a greater importance among people living adjacent to St Thomas Harbor and Magens Bay. These two coastal locations differ ecologically from the inland site and this difference is reflected in the exploited species. The Magens Bay people gathered great numbers of donax which are usually found burrowing in the sand after a retreating wave. The people living at the Main Street site gathered those mollusks that cling to rocks. The complex of animals used by the people depositing refuse in Area 1 and Area 9N at Tutu is similar to the Main Street deposit. This suggests that these people gathered mollusks and fished under conditions similar to those found in prehistoric St Thomas Harbor. The later occupants at Tutu intensified exploitation of intertidal, inshore, and reef habitats.

Changes in exploitation as seen in the faunal assemblage through time

The faunal composition of the Tutu samples does not differ greatly; however, the relative abundance of representatives of different habitat groups and the relative abundance of species do change. The two components that are important because they change in predictable ways in many sites are:

1. the relative abundance of terrestrial and marine animals, and
2. the relative importance of the carnivorous reef fishes at the top of the food chain and reef herbivores and omnivores at the base of the food chain.

One much discussed change in Caribbean faunal assemblages is a shift from abundant land crab remains to greater abundance of marine mollusks through time (Rainey, 1940; Rouse, 1992; Wing, 1995). At the Tutu site the importance of terrestrial animals (vertebrates and land crabs) decreases relative to marine vertebrates, and this change between early and late occupations is significant (Table 4.4). With the decline in the use of land crabs, in the context of the overall shift to greater use of marine resources, we see a relatively greater use of land vertebrates and land hermit crabs (Table 4.6). This change follows an intense period of exploitation both between early and late deposits at Tutu, and during the shorter span of occupation of Magens Bay.

Land crabs and land hermit crabs produce larvae that develop in the plankton stream (Wolcott, 1988). Although crabs produce many thousands of eggs, young crabs that are at the mercy of the ocean currents may not be washed back to the island from which they came. Spawning migrations of female crabs occur periodically when conditions are suitable. Masses of crabs can be caught during these migrations. Catching gravid crabs would reduce the numbers of eggs thrown to the waves to form the core of the next generation. Sustained and protracted predation of the crab population would be expected to have an effect on its size (Wing, 1995).

The other trend that can be examined is a relative decrease in the abundance of territorial carnivorous reef fishes and increase in the herbivores and omnivores. At both Tutu and Magens Bay a decline of about 20 percent in the MNI of predatory reef fishes relative to reef herbivores and omnivores can be seen, and this change is significant. At least two explanations could account for this change. It is possible that, during the early occupations at both Magens Bay and Tutu, a hook-and-line method was used more often to catch reef fishes. This would select for predatory fishes in addition to those caught with traps, which would include fishes at all trophic levels. No remains of hooks were recovered from any of these sites. This, of course, does not mean they were not used. Hooks may have been made of plant material that did not preserve at a site or they may have been too fragmentary to recognize. Alternatively, prolonged intensive exploitation would reduce populations, such as predatory fishes at the top of the trophic pyramid, more quickly than those primary consumers near the bottom of the pyramid. Reduction of the numbers of predators in an ecosystem allows the primary consumers, free from this predation, to flourish. We believe that some sort of a trap was used, because the cross-section of reef fishes represented in the deposits is similar to the range of fish species caught by traps set in reefs today.

Sizes of shell and skeletal elements

Most of the animals in the St Thomas sites are small individuals, but a few are large. The most abundant of the large species are sea turtles, which can be caught while they feed on the sea grass meadows or while the females come up on sandy shores to lay eggs. Because of the difficulty of bringing such a large carcass to the Tutu site, the remains of these animals may be an under-representation of the numbers that were actually caught. The widespread practice of butchering sea turtles and sharing the carcasses among different members of the community would distribute their parts throughout the Tutu settlement including, finally, in their refuse deposits about the site. The large shell of the sea turtle has many purposes, one of which is use as a large container. One whole turtle shell was excavated in Area 8 at Tutu.

Fishing gear can determine the size range of the fishes caught. A hook has to fit in the fish's mouth in order for it to be effective in catching the fish. The line has to be strong enough to hold a fish once it is hooked. Hook and line will only catch a fish that is lured by the bait and willing to bite. Similarly netting must have fine gauge if small fishes are to be caught. Nets must also be long enough to surround a school of fishes or gather the individual fishes swimming independently in a habitat. Traps also limit the size of the fishes that can be caught. The size of the weave (more precisely, the size of the holes in the fabric) of the trap body allows small fishes to escape, while the size of the opening limits the sizes of fishes that can enter. Usually fishermen design their gear to catch a desired spectrum of fishes that are available. We would not expect traps or nets to be made with mesh so large that all of the fishes in the local waters could escape.

Where a trap is set or a net is swept also influences the suite of fishes caught and the range in their sizes. Juvenile fishes of many species inhabit inshore nursery grounds such as seagrass beds and waters around mangroves (Heck & Weinstein, 1989). The difficulty in determining whether the focus of the fishing strategy is in inshore waters or over reefs is that it is not always possible to distinguish between juveniles and adults of a small-sized species.

The great majority of animals represented in the Tutu samples are small individuals. Size of individuals in some species does not change during the span of occupations, but, in general, in the collection, individuals of most species are smaller in the later occupation than they were in the earlier one. Those fishes with large population reservoirs offshore tend to remain the same size in both early and late occupations. Intensive fishing close to shore would not greatly impact these wide-ranging fishes, and we would not expect to see a reduction in their size through time.

Territorial and moderately long-lived reef fishes can respond in two ways to intensive predation: by growth overfishing or by recruitment overfishing. Growth overfishing, when applied to modern fisheries, occurs when the size distributions of the harvested fishes goes from a growth dominated state to a mortality-dominated state. The slope of a size distribution is defined by two terms:

1 the rate at which individuals accumulate in a size class due to slowing of the growth rate, and
2 the rate of attrition from a size class due to mortality.

When the size distribution of a population is plotted and results in a normal curve, growth and mortality are equal. This can be seen in the curves for herrings, jacks, and the parrotfishes from early deposits (Figures 4.4, 4.5 and 4.8). When growth dominates, young individuals in the smaller size classes enter the community at a faster rate than large individuals are lost. The resulting size distribution producing a curve that is skewed to the right, since the class with the highest frequency is above the middle class. On the other hand, when mortality dominates and attrition is greater than recruitment, the resulting curve of the size distribution is skewed to the left, since the class with the highest frequency is below the middle-size class. When mortality is increased through harvest, a fish population can shift from a growth-dominated to a mortality-dominated condition. Mortality-dominated curves can be seen in the size distributions of grouper remains from early and late deposits, and snapper and parrotfish remains from late deposits (Figures 4.6–4.8).

The other pattern, called recruitment overfishing, is recognized when population size declines and recruitment of the young is depressed. When predatory fishes in the upper trophic levels decline in numbers, prey species lower in the trophic pyramid are released from predation pressures and may increase in abundance. Such a demographic decline in population numbers is seen in many modern fisheries, and is often accompanied by populations with a decreased age at maturity and decline in viability of the succeeding generations (Sutherland, 1990; Trippel, 1995).

The same pattern of decrease in size and numbers, apparent in predatory fishes, also is seen in the land crabs. The decline in numbers of land crabs conforms to the early observations of Rainey (1940) and subsequent studies of decline in the abundances of land crabs in later deposits. The measurements reported here show a decline in the sizes of land crabs in the later occupation. Land crabs from the Maisabel site on the north coast of Puerto Rico show a decrease in their abundance in later deposits, but do not show the decline in size seen at Tutu (deFrance, 1988). However, the sizes of the land crabs in the site at Maisabel are approximately the size range of those from the early deposits at Tutu and are larger than those that can be caught around the site of Maisabel today (deFrance, 1988).

Overexploitation

We believe that these changes in abundance and size show the effects of overexploitation. The decline in sizes and numbers of land crabs, relative increase in the numbers of land hermit crabs, decline in numbers and sizes of reef carnivores, decline in sizes but increase in numbers of reef herbivores and omnivores, and the decline in sizes of the West Indian topsnail all point to stress in the exploited species. With the decline in capture of crabs came a shift to greater concentration on aquatic resources. This greater concentration on fishing and shell fishing did not come about as the result of increased exploitation of new zones, such as pelagic waters, or the addition of new groups of species, such as birds from coastal rookeries. Instead, most of the same species of fish were caught, and shellfish were gathered, but, either by design (through the size of the fishing equipment) or necessity (because only small individuals were available), smaller individuals were acquired to sustain the apparently growing human populations.

Terrestrial faunas on islands are by nature fragile (Steadman, 1995). Many non-human island residents have evolved free from predators, and are, therefore, more vulnerable to human and domestic dog and cat predators. Most small islands do not have a reservoir of species to repopulate overexploited parts, and, once an animal population is reduced below economic levels, it is slow to recover, if recovery is even possible. Human modification of the island environment by cutting trees and other vegetation also has its effect on animal populations. This island vulnerability can be extended to the animals that live on the island shelf. Many fishes enter coastal waters from oceanic reserves and, once there, some become territorial residents of near-shore and reef habitats. Overexploitation at the top of the food chain reduces this segment of the fauna, whether it is marine or terrestrial, and releases prey populations lower on the food chain from some level of predation pressure. This allows the populations of species at lower trophic levels to grow and become more available for further human exploitation. This is what appears to have happened at Tutu and Magens Bay, as well as at other sites in the Caribbean.

CONCLUSIONS

Life does not appear to have been easy on St Thomas during prehistoric times. There is evidence from the human remains of stress, as seen in the Harris lines and enamel hypoplasia, iron deficiency, substantial tooth wear, tooth loss, and caries (see Chapter 7). Caries may be the result of a diet that includes sweet fruits and sticky starches and both are presumed to be part of the Tutu diet (see Chapter 2). The great upper body development observed among some of the deceased adult male population at Tutu results from heavy work which may have been the efforts involved in cutting lignum vitae trees, paddling canoes, pulling seines, transporting marine resources to the inland site, and all of the other hard physical work needed to maintain life at Tutu. The human food quest for the animal protein portion of the diet concentrated on land animals and fishes living on the reefs and, secondarily, on those animals living in inshore and intertidal waters. The populations of many of these animals appear to have been affected by intensive exploitation. Some animals declined in numbers and individual sizes. As a response to these changes, the Tutu inhabitants more intensively exploited all three aquatic habitats (intertidal, inshore, and reef), and fewer animal resources from the land were used. This greater breadth in the quest for animals of generally smaller size may be further evidence for increased stress on the Tutu population. Despite this greater diversification in fishing and gathering, new resources were not incorporated into the food quest. Birds remain a minor component of the fauna. Pelagic fishes, such as tuna, do not become more important numerically. The introduced and managed animal, the hutia, is slightly more abundant in later times than in earlier ones but could not be considered a major resource. Thus, in the face of declining animal resources, effort was put into intensifying rather than expanding fishing and gathering resources or managing more domestic or captive animals.

Chapter Five

Tutu pottery and ceramic chronology

Emily R. Lundberg

The pottery of the Tutu site is a useful class of remains for estimating its periods of use and its relationships to other sites in the region. This chapter focuses on ceramic contexts and stylistic description, which provide relative chronological information helpful in the interpretation of multiple data sets from the site and which, in broader scope, add detail to the ceramic chronology for the island.

From the point of the site's discovery in 1990, after its surface had been scraped by heavy machinery preparing for construction of a shopping mall, it was apparent from the pottery fragments on the new ground surface that the site had multiple cultural components. The study of pottery recovered from the site has attempted to deal with the ceramic remains from each of these several components individually in order to decrease the level of generality for issues of the site's utilization and local cultural chronology.

A cultural chronology is essentially a classification of archaeological assemblages representing cultures that vary through time and space. As with many classifications, the classes of a cultural chronology may artificially segment a continuum of related phenomena. The classes themselves are viewed by this author as heuristic devices that reduce a myriad of detail to descriptive synopses useful for comparative purposes. The scale of the classification – in this case the length of time and the geographical breadth of local cultural complexes (or "local periods") in the cultural chronology – determines the scale of the cultural questions that can be addressed through such comparisons. Reducing that scale to a finer-grained classification, as was pursued in the earlier work of Vescelius (1979, and personal communications, 1978–80; Tronolone, Cinquino & Vandrei, 1984: Figure 4-1), is one of the ongoing aims of Virgin Islands' archaeology to which this study may contribute.

A hierarchical approach to Caribbean cultural chronology has been steadily advanced through the research of Rouse (e.g. 1972: 92–94, 1992: 33) and others who have used his models. In the pursuit of his objective regionally to trace lines of cultural development, Rouse's interpretations of archaeological evidence from the Caribbean islands and northern South America have resulted in a region-wide cultural chronology that is ever-improving. Many have adopted his system of classifying assemblages within local cultural complexes (or "local periods"), classifying complexes within subseries, and classifying subseries within series that have considerable extent in time and space.

In Rouse's Ceramic Age classification for the Virgin Islands area, the division between manifestations of the Saladoid and Ostionoid series coincides with a two-part classification formulated by Hatt (1924) early in the twentieth century. The sequence of local complexes within those series parallels the sequence for eastern Puerto Rico (e.g. Rouse, 1992: Figure 14; Rouse & Faber Morse, 1995). Because few radiocarbon dates have been available from the Virgin Islands, that temporal alignment largely reflects stylistic comparisons, such as those that resulted from the findings of Vescelius (1952) and Bullen (1962). In Rouse's chronology, two consecutive cultural complexes of the Cedrosan Saladoid subseries are estimated to span between 200 BC and AD 600. From AD 600 until European conquest, three more local complexes are classified in the Ostionoid series. Modifications to this chronology for the local area were developed by Vescelius, who extended the Saladoid series to *c.* AD 800 and attempted additional subdivision (Tronolone *et al.*, 1984: Figure 4-1; Vescelius, 1979). There is still a lack, however, of comprehensive description of delimited and dated assemblages that are necessary to substantiate and characterize the proposed local sequence. Descriptions of Tutu site pottery are offered as one step toward filling that need.

Although pottery is a valuable classificatory tool, a true cultural chronology is developed from a basis broader than pottery alone. The current chapter, however, is concerned only with ceramic remains and thus only with that aspect of the cultural chronology that concerns ceramic classification. Accordingly the classification to be discussed here is more appropriately termed a "ceramic chronology," and its basic units are "ceramic styles" rather than "cultural complexes."

METHODOLOGY

In order to address a ceramic chronology, ceramic remains related to various periods of use of the Tutu site were dealt with according to ceramic assemblages, or specifically defined groupings of collected samples. The ceramic assemblages were not defined with reference to pre-existing type descriptions of ceramic style classes but instead were defined by field context. During excavation at the site, one focus of field efforts was to identify vertically bounded strata that could yield artifactual assemblages with relatively secure association within a usefully limited depositional period. The primary focus of the ceramic analysis has been concerned with the pottery from such defined contexts, which in most cases was excavated by natural stratigraphic layers. For the objectives of ceramic chronology, it has been important to avoid contextually mixed assemblages such as result from arbitrary excavation levels.

Through this approach, stratigraphically segregated collections of remains were recovered from several deposits of the site. The integrity of each of these collections was later evaluated based on the field conditions, the nature of the pottery as compared to the existing chronology, and the results from associated radiocarbon samples. These evaluations resulted in the identification of four ceramic assemblages, each of which could best represent an example of a ceramic style associated with a specified time period (as estimated from the radiocarbon results). The four defined ceramic assemblages that are described in this chapter derived from midden deposits that were below the level of the extensive machine scraping on the site (Figure 5.1). Three of the assemblages consist of pottery of the Saladoid series, and one assemblage consists of pottery of the late Ostionoid series.

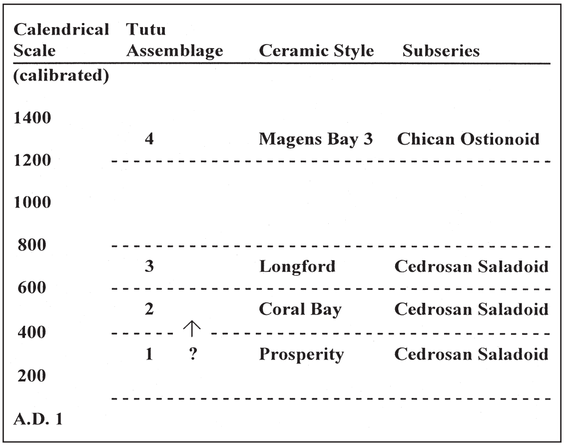

Figure 5.1 Ceramic sequence represented in midden excavations at the Tutu site.

The descriptions of these assemblages must serve, for now, as descriptions of ceramic styles for St Thomas, inasmuch as there are no other descriptions of temporally limited ceramic assemblages with which they might be compared.

Although they are considered to be relatively reliable representatives of local ceramic styles, it also is recognized that each is only one sample of a style. That sample may not be representative of the whole site during any one period of time, let alone representative of the pottery in use in various settlements on the island. Furthermore, even if the fieldwork perfectly separated material from different depositional strata, which is highly unlikely, the site's occupants might have mixed pottery sherds prior to their deposition in the midden, or rooting and burrowing animals might have disturbed potsherds after their deposition. For all of these reasons, assemblage descriptions must be considered an initial contribution to a continuing process of building a local ceramic chronology.

Ceramic assemblages in this study have been described in terms of modes, or types of ceramic features, using, generally, Rouse's scheme (e.g., 1972) and other successful examples in Caribbean ceramic analysis (e.g. Hofman, 1993; Oliver, 1990, 1992). Not only individual modes but also their patterns of co-occurrence on vessels have been examined.

Tutu site pottery was analyzed at different levels, according to the reliability of various contexts. A sampling of pottery in defined ceramic assemblages underwent very detailed analysis, employing numerous ceramic features. Ceramic features, which are elements or qualities of ceramic artifacts, are defined by the analyst and thus are potentially limitless in number. Because motivations for this study included promotion of detail in ceramic style descriptions that may be applied to the Virgin Islands, as well as identification of new modes that may be useful for comparing site components, the detailed analysis of assemblage samples included many recorded individual feature attributes and consciously avoided, in the recording stage, the use of combined feature types that may have been determined from classifications elsewhere. Many feature and attribute definitions were based on the superbly objective and thorough attribute definitions of Shepard (1956).

For all contexts studied in detail and most of the others as well, sherd collections were first examined at length for joins. The resultant mendable sherd groups were enumerated in assemblage samples as "sherd-units" (meaning groups of joining sherds, including groups of one). For the detailed analysis of selected samples, recorded observations were entered into computerized data bases. Pottery sherd-units of selected samples were recorded no matter how small or non-descript. Observations included measurements, contours, edge abrasion, coiling evidence, Munsell colors, attributes of core, several attributes of surface finishing and coating (including slip), and several attributes for each decorative technique. Many of these observations were made with a low-power binocular microscope (at 30×), without which they could not have been determined correctly.

Also aided by the microscope were observations of fabric, particularly aplastic inclusions that were recorded by type, size range, and comparative amount. These observations of fabric were augmented by point-counts of eleven thin-section samples of prehistoric sherds, reported by Spectrum Petrographics Inc. (DePangher, 1996, 1997). The point-count information provides identifications of fabric constituents at up to 200 points of the thin section, quantifying matrix/void/aplastic proportions and petrographically identifying the aplastics (Stoltman, 1989). The study of sherd fabric has yielded a wide range of information that cannot be accommodated here, but will be the subject of future reports.

In the assemblage samples for detailed analysis, vessel-rim lots were identified for purposes of morphological observations, loosely based on prior examples such as that of Petersen & Watters (1991). Vessel-rim lots were defined as consisting of at least one rim sherd together with any other sherds of certain or highly likely derivation from the same vessel. (Cases of possible but questionable association were not united, so that these lots represent a maximum number rather than a minimum number. The word "vessel" in this chapter has no special definition limiting its general sense.) These were linked to the records of their individual sherds. Observations for the vessel-rim lots included attributes of vessel shape such as contour, orifice, upper wall, and corner point (angle in contour); attributes of dimension such as diameter and height; and attributes of the rim such as angle, thickening, and lip (edge). Attributes of form were recorded by geometric reference types (Shepard, 1956: 224–36) instead of by previously recognized ceramic types in order to ensure that new information would not be subsumed by prior categories.

From these observations and records, modes were identified in terms comparable to those that have previously been used to describe pottery of the area. Such summary information is presented in this chapter for each of the four ceramic assemblages.

For each assemblage, material from other, slightly less reliable site contexts was examined in order potentially to enlarge the sample of modes associated with it. That type of information is associated with each assemblage only provisionally. The modal descriptions of assemblages and related material allow comparison with defined ceramic styles and possibly adjustments to their definitions for the local St Thomas area. Finally, in order to facilitate interpretation of some of the site's other archaeological evidence, material from various other site contexts was examined for estimated association with any of the ceramic styles represented by the site's ceramic assemblages. The Tutu site's ceramic assemblages and related ceramic material are discussed, in chronological order, in the remainder of this chapter.[1]

ASSEMBLAGE 1: INITIAL SALADOID OF TUTU

Samples

Material that constitutes the Tutu site's earliest studied assemblage was excavated in Area 1, in the northwestern part of the site. In Area 1, artifactual material in a midden layer was exposed on the machine-scraped surface at the start of the investigation. This midden layer was sampled with several excavation units, representing the most concentrated midden excavation effort on the site (see Figures 1.7a–d).

The following seven excavation units (EUs) (numbered 3–7, 10, 11) contribute the core of Assemblage 1 for analysis:

EU 3: N2097/1821.50E, 1.0 m^2, Levels B, BI, BIII
EU 4: N2097/1823.50E, 1.5 m^2, Level B
EU 5: N2096/1825E, 1.0 m^2, Level B
EU 6: N2096/1827E, 1.5 m^2, Level B
EU 7: N2097/1822.50E, 1.0 m^2, Level B
EU 10: N2098/1822.50E, 0.5 m^2, Levels B, C
EU 11: N2098.5/1821.50E, 1.0 m^2, Levels B, C, D

(Grid locations mark the northwest corners of the excavation units.)

During excavation, material from the midden layer was segregated from the disturbed surface and from underlying strata. This midden layer was not obviously internally stratified in horizontal layers, and its material from the selected units was aggregated for analysis.

There are 2,104 pottery sherds in the ceramic Assemblage 1 sample studied from the seven selected units. All the rims and associated sherds from the midden levels of EUs 3, 4, and 6 were analyzed in detail as 101 vessel-rim lots. With the inclusion of a sampling of body sherds, the sherds analyzed in detail totaled 286, in 153 sherd-units (4,030 g in total weight). Sherd-unit maximum length ranges between 1.40 cm and 24.30 cm. Because of the shallow depth of this midden layer under a surface traversed by heavy machinery, the pottery collection from it is extremely fragmented.

Supplemental material for this assemblage is provided by sherds recovered from other adjacent proveniences that were part of rescue and profiling operations intended to confirm the nature of this midden layer prior to site destruction. Although recovery methods for those contexts may not have been as precise, the material is still fairly reliably associated with this assemblage because there were no strata recognized as belonging to any substantially later occupation in the immediate vicinity.

Table 5.1 Radiocarbon results for charcoal associated with ceramic Assemblage 1 of the Tutu site

Unit and level	*Beta no.*	*Conventional age*	*Cal. 2-sigma results*	*Cal. 1-sigma results*
10-D	108917	2090±50 BP	200 BC to AD 25	175–35 BC
3-BIII	111462	1980±50 BP	60 BC to AD 130	20 BC to AD 85
6-B	65474	1800±80 BP	AD 65–420	AD 130–350
4-B	108888	1720±140 BP	AD 15–635	AD 145–465, 475–515
3-BI	108889	1500±50 BP	AD 440–650	AD 540–630

Dating

Radiocarbon dating results for five samples from the Area 1 midden layer have been obtained from Beta Analytic Inc. by project director Elizabeth Righter (Table 5.1). The interpretation of these results is the most difficult of all the midden areas, however. Charred material was scarce among the midden contents, and multiple tiny fragments had to be combined for all but the sample from EU 10.

The results for EU 10 have the earliest range on a calibrated calendrical scale, but that sample was collected in an excavation level that recovered only the very base of the midden, at its interface with the underlying stratum. It thus is possible that the charred material dates the top of the underlying stratum. The results for this sample are much earlier than the range that might be estimated for the associated pottery on the basis of dating of comparative material elsewhere. The sample from Level BIII in EU 3, which was the lowest subdivision of the midden in that unit, should have valid association with the ceramic sample. At least the younger end of its range, *c.* AD 100, is less difficult to reconcile with the level's ceramic assemblage. The results for the EU 6 radiocarbon sample correspond well to the stylistic dating for the associated pottery, based on the working chronology for the area. The EU 4 results can be seen as supportive of those results, although the error range is large and the upper end of the calendrical estimate extends approximately 200 years later. The results from Level BI in EU 3, on the other hand, also are within a later range and could be seen as supporting the later end of the range of the EU 4 sample. In that case, deposition of this midden may have been more prolonged than was anticipated on the basis of stratigraphy and artifacts. This remains a possibility, due to the absence of much firm data to corroborate the estimated dating of particular ceramic styles or modes from Virgin Islands and eastern Puerto Rico contexts. In the judgment of this author, however, these latest results from the Level BI sample probably do not reflect the age of most of the midden, although midden deposition could have extended into the early portion of the date range.

Ceramic style and modes

The disparate radiocarbon results associated with Assemblage 1 place it in the time range of the Prosperity style and/or the Coral Bay–Longford style as they have been aligned on a calendrical scale by Rouse (1992: Figure 14; cf. early and late Coral Bay of Bullen, 1962: Table 6). These styles have never been differentiated in detailed ceramic descriptions of Virgin Islands assemblages, but they are considered to be very similar, respectively, to the contemporaneous Hacienda Grande and Cuevas styles of Puerto Rico. From the available information, it appears that Assemblage 1 does not represent early Prosperity style, but it might represent what could be called late Prosperity style. Such identifications, of course, depend on the definitions of the styles. Like the radiocarbon evidence, the ceramic evidence is not entirely unequivocal, and much similarity to Assemblage 2 leaves open the question of a somewhat later association. On the other hand, it is possible to recognize certain modes of the Assemblage 1 sample that perhaps can serve as temporal distinctions in a ceramic tradition with overall stability throughout long duration.

Shape

The pottery of Assemblage 1 displays wide variety in decoration and morphological elements added to the basic vessel forms, as well as in variations (and variable combinations) of certain elements. General vessel forms that could be estimated from the sample are quite limited, however (Figure 5.2). Among the 101 vessel-rim lots, only one has a demonstrably inward sloping, or restricted, upper wall. Among the 44 vessel-rim lots that could be reliably estimated to have vertical or outward sloping (from mid-wall to orifice) upper walls, only one has a strongly convex contour (from the exterior view), and it is a shallow open bowl. Of the taller vessels, upper walls seem always to be straight or concave. The concave and outsloping upper wall comprises the majority of vessel-rim lots, indicating that the "inverted bell" shape is the most common in this assemblage. Vessel rims outside the lots analyzed in detail support the same results, and body sherds with vessel wall angles, or corner points of contour, are common. Because the sherds of this assemblage were very fragmented, the lower walls of vessels could rarely be reconstructed.

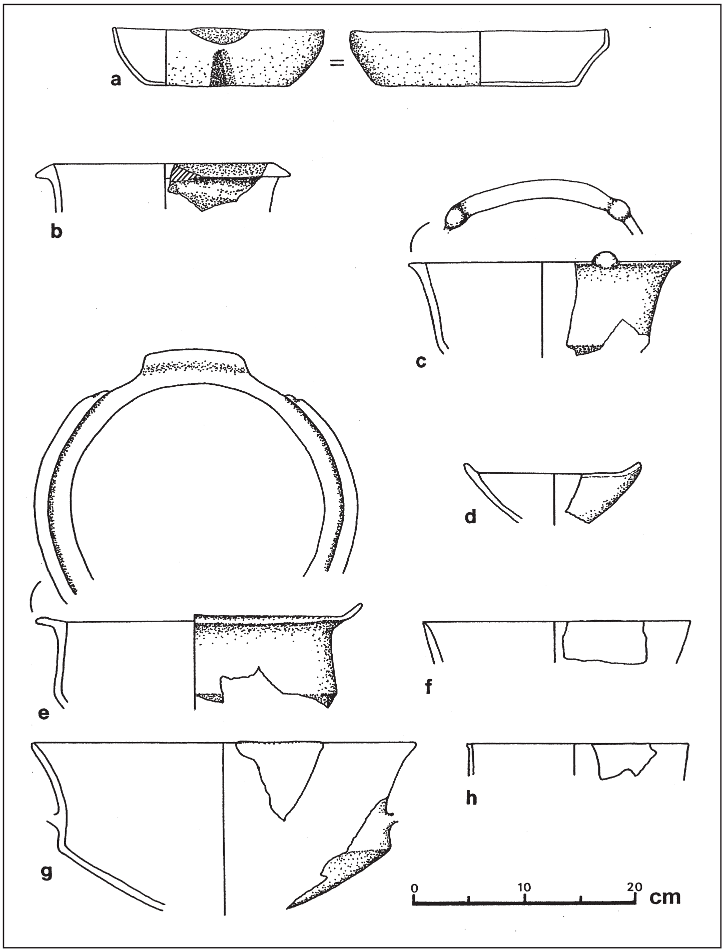

Figure 5.2 Selected vessels of Assemblage 1 and related supplemental material (e) from the Tutu site.

Outsloping or vertical upper walls may have attached D-shaped strap handles of various sizes (Figures 5.3a, 5.3c). The upper handle join may be at the edge of the rim or may be attached to the vessel wall below a vertically rising "scallop" or undulation of the rim. Vertically undulating rims appear elsewhere, as well, and orifices are frequently elliptical or irregular in plan. Among the few recovered vessels, bases are flat.

The assemblage includes griddles with and without raised rims. They were not abundant, however, and only two occurred among the 101 vessel-rim lots from three units. Also recovered in Assemblage 1 were sherds of three very thick-walled and small-diametered cylindrical artifacts similar to those that have been termed "incense burners" (Figures 5.4a, 5.4c). A fourth example (Figure 5.4d) was recovered in surface collection, but none was found with other assemblages.

These artifacts typically are found in early Saladoid styles of the Antilles, including Hacienda Grande (Pons Alegría, 1976; Rouse & Alegría, 1990: 41; cf. Versteeg, 1992: Figures 37–8).

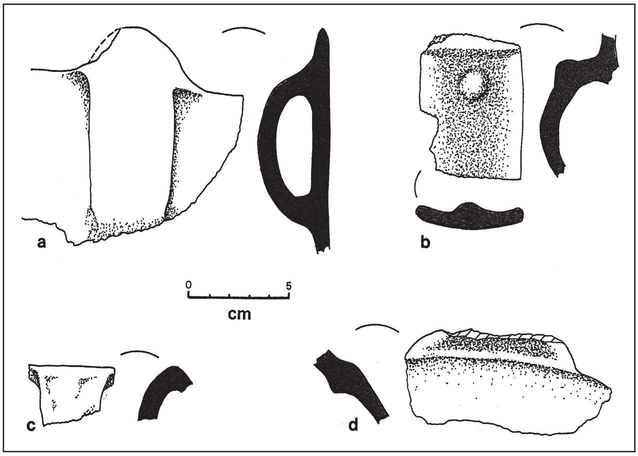

Figure 5.3a–d Sherds representing handles (a–c) and a tabular lug (d) of Assemblage 1 and related supplemental material (c) from the Tutu site.

Modes of vessel shape do not distinguish Assemblage 1 from the subsequent Assemblage 2. Modes of rim and lip form (Figure 5.5), however, may have been subject to some temporal change. In Assemblage 1, unthickened vessel orifices are commonly flattened in some way. The results vary from a simply squarish lip to a totally flat lip, and even to a lip that retains a linear indentation, concavity, or step created by the tool used to cut or scrape the lip (Figure 5.5f). Clay commonly spills slightly over the edge to one or both vessel surfaces, and bulges may be created at the edges of the rim from the pressure of the lip-flattening process (Figure 5.5h). Often the lip is flattened at a slant, sometimes with one edge sharp (usually the interior) and the other rounded (Figure 5.5e). Although these traits may also be found in Assemblage 2, they are less frequent there.

Many rims are thickened to the exterior or angled towards the exterior, creating a relatively flat upper surface that usually is decorated. Those traits continue through Assemblage 2. Also common in Assemblage 1, but rare among the analyzed vessels of Assemblage 2, are rims that are thickened only towards the interior of the vessel, with a flattened or slightly rounded bevel slanting towards the interior and a relatively straight exterior profile from wall to lip (Figure 5.5m). Interestingly, that rim-lip form occurs again in Assemblage 3, where it serves the same purpose of displaying red paint as it does in Assemblage 1.

Rim elaborations are not uncommon. One low bowl has a semi-circular area of inwardly "bent" rim above a vertical indentation of the wall (Figure 5.2a). From Area 1 there are several examples of rim lugs and partial rim flanges. Most are simple extensions at an angle to a direct rim (Figure 5.2c), but one vessel exhibits both partial double flanges and a secondarily upward-angled tabular lug (Figure 5.2e), traits that are characteristic of Hacienda Grande style (cf. Rouse & Alegría, 1990: 42, Figure 10).

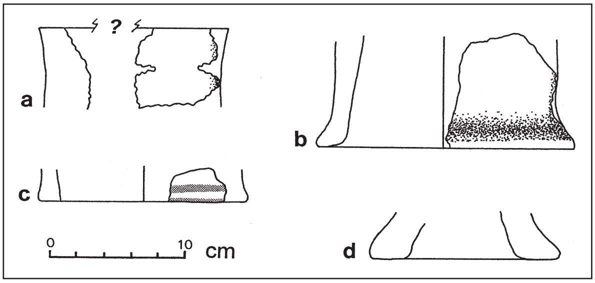

Figure 5.4a–d Rims of thick-walled, small-diameter objects of Assemblage 1 (a–b), related supplemental material (c), and surface collection (d) from the Tutu site: (a) is more than 3 cm thick and has no interior surface; (c) has white-on-red banded design; (d) has different rim shapes on opposing sides, as shown. Any or all might be drawn upside down.

Decoration

Vessel decorations occur on 14 percent of Assemblage 1 vessel rim lots (not including sherds that exhibit slip alone), and are diverse. Zoned incised crosshatching occurs on three sherd-units of the assemblage, which may represent only two vessels (from EUs 3 and 6, Figures 5.6, e–f). Another example was collected from the surface in the same area and appears to have remnant white paint in the incisions (Figure 5.6d). On these specimens the crosshatching is located on the interior vessel surfaces; in one case, visible in a large hyperboloid-sided, or wide hourglass-shaped, zone. The incised crosshatching is unlike that confined to narrow bands that is typical, for example, of the Hacienda Grande component of the type site (Rouse & Alegría, 1990: Plate 4, S–V), the La Hueca component on Vieques and at Punta Candelero (Chanlatte Baik & Narganes Storde, 1983: fo. 11; Rodríguez & Rivera, 1991: Figures 2, 3), and the Prosperity component of St Croix (Faber Morse, 1995: Figure 5b). It has more resemblance to the use of crosshatching pictured for St Eustatius, for example (Versteeg, 1992: Figure 21). The crosshatching incisions are extremely narrow, shallow, and imprecise. The crosshatched zone is bounded by wider, deeper incised lines and by double (parallel) lines. Although double-line incision occurs on the interior surfaces of other Assemblage 1 open bowls without evidence of crosshatching (Figure 5.6j), it evidently is a motif associated with crosshatched incision (cf. examples from St Martin and Martinique: Haviser, 1988: Figure 4; Mattioni & Nicolas, 1972: facing Figure 8). On one sherd, an incised line separates the crosshatched design area from an adjacent red-painted zone (Figure 5.6f).

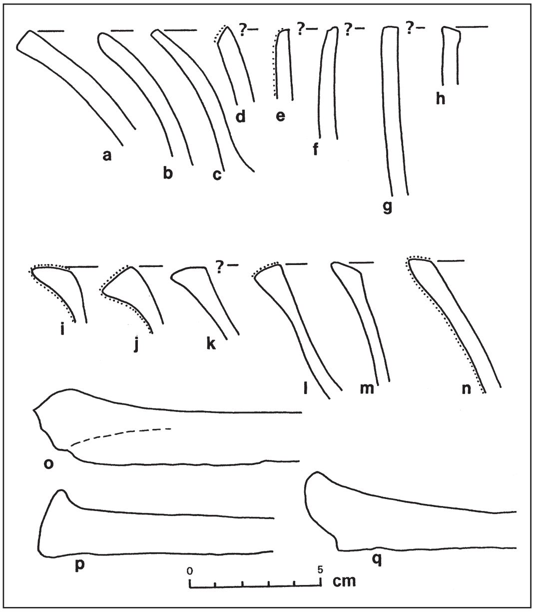

Figure 5.5 Rim variations of Assemblage 1 from the Tutu site. Dotted lines along profiles indicate red surface coatings.

Neither of these incised motifs was found in other controlled excavations of midden contexts at the Tutu site. A sherd with zoned-incised-crosshatching was among material disturbed by machine trenching in Area 9S (where lowermost strata contained Saladoid material like Assemblages 1 and 2). Interior-surface double-line incision combined with a small exterior-perforated lump occurs on a bowl section recovered with Burial 13 in Area 1 (discussed below with Assemblage 3). Part of a vessel with the same combination of traits was collected from the surface of Area 5, in the south central part of the site, and other double-line examples are found in unprovenienced surface collections. The perforated lump on the exterior surface is associated with other forms of interior incision, as well (Figure 5.6g).

Zoned red paint bounded by incision occurs on several specimens of Assemblage 1, on both interior and exterior walls (Figure 5.6c). Incision also may separate zones of red paint from white paint (both on unslipped surfaces). White-on-red painted designs are executed on exterior concave surfaces but are very rare in Assemblage 1. Most abundant among decorative techniques is red paint on rim lips that have been widened and flattened by thickening or by an angle (flange) toward the exterior (Figures 5.5, i–j, l–n, 5.6d).

Modeled elements include clay lumps (“nubbins,” “pegs,” or “buttons”) of various forms on handle tops (Figure 5.3b) and at the ends of partial rim flanges, where, in one case, hemispherical knobs appear to create four “corners” on the vessel rim (Figure 5.2c; cf. Versteeg, 1992: Figure 21). Small triangular projections of the rim (Figures 5.7, a–b) are like those characteristic of early Saladoid styles such as Hacienda Grande (e.g. Rouse & Alegría, 1990: pl. 3H, M–O). Also on vessel walls there are examples of red-painted low-relief modeling, notably incorporating small circular (papule-like), centrally punctated elements with other curvilinear incision (Figures 5.7, c–h; cf. Mattioni & Nicolas, 1972: Figure 57; Rouse & Alegría, 1990: pl. 4H). The small fourlegged animal models associated with La Hueca style narrow-band crosshatched incision (e.g. Rodríguez & Rivera, 1991: Figure 5) were not found at the Tutu site.

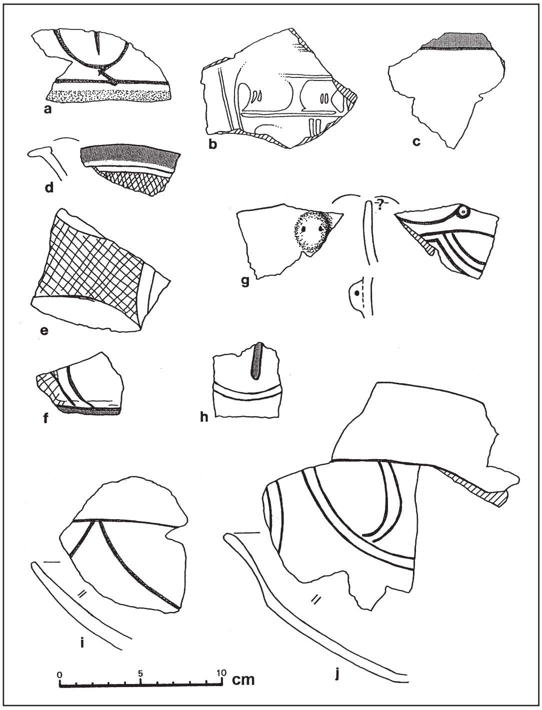

Figure 5.6 Incised and/or painted decorations on the exteriors (a–c) and interiors (d–j) of sherds of Assemblage 1 and related supplemental material (a, d, h) from the Tutu site. Shaded areas on (c), (d), (f), and (h) indicate red paint; item (b) has heavy red slip on which a design visible by contrasting light reflection may indicate the former presence of white paint.

Manufacture

Non-griddle sherd-units analyzed in detail from Assemblage 1 average 6.10 mm in wall thickness. Typical thickness of sherd-units ranges between 3.50 mm and 9 mm.

The temper of Assemblage 1 sherds is of igneous rock, which was used throughout all the assemblages recovered from the Tutu site. Microscope observations of aplastic inclusions in all sherds of the detailed-analysis samples identified two general sub classes of primary inclusions, which are basically the same for all assemblages. The most common is a diverse mixture of igneous rock grains, termed here "mixed igneous sands," which occurs in 76 percent of the Assemblage 1 sample. Grains most often extend to coarse sizes larger than 1 mm and frequently larger than 2 mm. The larger sizes of these grains have rounded and altered surfaces. Although colors of these grains are a mixture ranging from light to dark, a common variant is a mixture of predominantly white/transparent colors reflecting quartz/plagioclase rocks. The second major sub class of primary inclusions used in Tutu pottery is one of essentially uniformly felsic igneous rock. (Other fine grains present in minor amounts may have been natural to the clay.) These light-colored grains are white and/or colorless (transparent) and are petrographically identified as feldspar and quartz. Occurring naturally with them are secondary or minor amounts of black-appearing hornblende. Inasmuch as the island is composed of predominantly mafic volcanic rock, this material may have been specially sought from limited exposures. Because of its angular unweathered surfaces, it is obviously distinguishable from the mixed sands, and grains sometimes are limited to relatively small and uniform size ranges. These grains appear to represent a selectively collected, crushed, and sieved temper material. This temper category occurs in 24 percent of the Assemblage 1 sample and was not found to correspond with recognized variables of decoration, thickness, or form.

Surface compaction typically has been thorough enough to submerge completely all temper grains (76% of surfaces) and to remove traces of tool use (84% of surfaces). The attention to thorough evening (the leveling of surface humps and dips) and compaction of surfaces, on undecorated and thick vessel walls as well as on finer ware, gives this assemblage the feel of well-made pottery. The qualities of "hard" and "well-fired" fabrics that often have been ascribed to early Saladoid pottery, however, are not confirmed by observations here. Many Assemblage 1 sherds, in fact, yield easily to fracturing for an edge sample (31%), and most have wide dark cores. Sherds amounting to another 27 percent of the sample are friable on fracture edges, probably due to the coarse and rounded shape of aplastic inclusions in most sherds.

Slip coatings with color contrast to the sherd body are very rare except in the same red colors as the zoned painting. Although some red-coated sherd surfaces may represent a slip on the entire vessel surface, recovered vessel sections are not large enough to show that the added color is not zoned painting confined to certain vessel elements such as the upper wall.

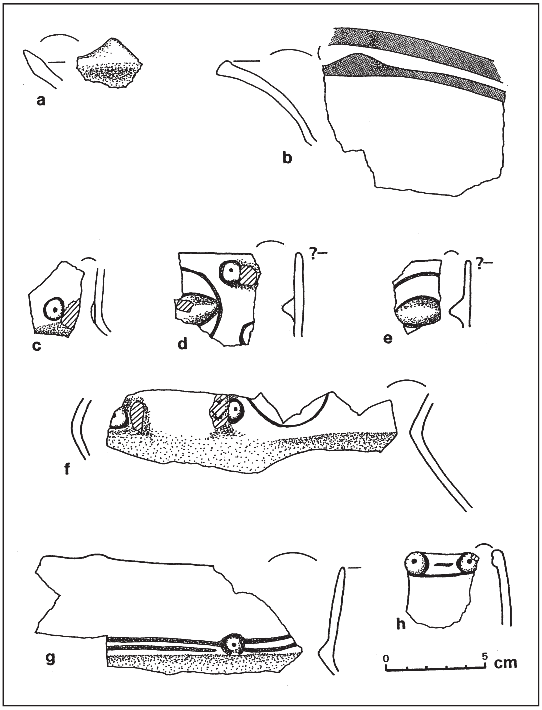

Figure 5.7 Rim points (a–b) and low-relief modeled-incised exterior decoration (c–h) on sherds of Assemblage 1 (b–c), related supplemental material (a, d), and surface collections in the same area of the Tutu site (e–h). The low-relief modeling is red slipped above the angle of vessel wall contour.

Additional related material

Excavation units and trenches in southern areas of the site produced samples of early Saladoid material in lowermost cultural levels. This material occurred sparsely in strata that may have been redeposited. A thick rim of a small-diameter cylinder and diagnostic decorations (single examples of painted low-relief modeling, zoned incised crosshatching, and double-line incision) were encountered in Area 9W and Area 9S. Area 13 also preserved strata with Saladoid material that relates to Assemblage 1 or 2.

ASSEMBLAGE 2: MIDDLE SALADOID OF TUTU

Samples

A Cuevas-like Saladoid component of the Tutu site was well represented by ceramic remains in excavation units and in disturbed soils in several areas. One extremely good context that produced much material apparently free of intrusive artifacts and associated with two corroborating radiocarbon samples was the source of pottery analyzed in detail as Assemblage 2. Supportive information is also available from other contexts. This material probably is generally later than Assemblage 1, but it has many similarities to it.

The materials that constitute Assemblage 2 derive from Area 4 on the sloping northeastern edge of the site. Cedrosan Saladoid sherds were exposed on the machine-scraped sloping surface, with no artifacts of later date. Material from the principal and lowermost midden layer yielded the sample analyzed for Assemblage 2 in two excavation units:

EU 28: N2090/1948E, 1.0 m^2, Levels D, E
EU 31: N2087/1952E, 2.0 m^2, Levels BIIC, BIID

The Area 4 sample analyzed in detail for this assemblage comprises 552 sherds, in 240 mendable sherd-units (8,699 g in total weight). In addition, the assemblage includes two nearly whole bowls that were reconstructed by Margaret and Phillip Caesar and were not examined in the same manner as the other sherds (Figure 5.8, Figure 1.17, a and b). They are, however, included in the vessel-rim lot sample, which totals 51 for this assemblage. Upper levels of the EUs contained sherds of similar character and contributed supplemental material (1,126 sherds).

Figure 5.8a–b Reconstructed undecorated partial vessels (a and b) of Assemblage 2 from the Tutu site (photographs by Robert Coates). Item (a) is also shown in Figure 5.9e.

Sherd-units of this sample range in maximum measurement from 1.20 cm to 25.50 cm (not including the two reconstructed vessels), with an average of 5.60 cm. They generally have not suffered from much edge abrasion, which was noted as extreme in the case of only one sherd and as obviously present in only 9 percent of the sample. This suggests that the midden deposit was covered by soil relatively quickly and was not an area highly utilized by later inhabitants.

Another excavation context for similar Saladoid remains was in Area 8, on high ground at the northwestern edge of the site. There the pertinent midden layer surviving below the machine scraping was thin, and it included an entire sea turtle skeleton set among rocks interpreted as a possible hearth (Figure 1.19). This Area 8 midden was sampled by a cluster of excavation units within a 5.50 m by 4.50 m area. Sherds examined from the midden layer totaled 810, which are considered supplemental to Assemblage 2. Strata that once existed above this exposed midden layer possibly contained pottery from one or more later components, as is suggested by some of the surface material. Post-Saladoid pottery was present in excavation units placed just 7 m to the east. Cultural deposition in this area also may have begun earlier than indicated by the one radiocarbon date, which due to the longevity of many Saladoid traits, would be difficult to detect in the ceramic remains. The Area 8 context, therefore, is considered to have slightly greater possibility of intermixing of sherds from different periods than does Area 4. Most of the diagnostic material, though, conformed with the modes identified for Assemblage 2 from Area 4.

Dating

Two charcoal samples from the lower midden in Area 4 excavation units provide a temporal estimate for Assemblage 2, as shown in Table 5.2. Those results, from Beta Analytic Inc., are consistent with the ceramic sample's Cedrosan Saladoid affiliation as indicated by the artifactual evidence. The two radiocarbon samples also conform well with each other.

The results for a radiocarbon sample from the Area 8 midden are essentially equivalent to the results from Area 4 (cal. AD 390 to cal. AD 630, 2-sigma, Beta 65473). That finding is not contradicted by the Area 8 midden pottery, which is much like the Assemblage 2 pottery from Area 4.

Although the radiocarbon results for Assemblage 2 form a relatively tight pair that indicates a possibly brief span of time for that assemblage, they do overlap considerably with some of the radiocarbon results associated with material defined as Assemblage 1 in Area 1. Three samples associated with Assemblage 1 have ranges that overlap at 2-sigma statistics with those associated with Assemblage 2. At 1-sigma statistics, two samples of Assemblage 1 still overlap those associated with Assemblage 2. The radiocarbon results thus do not clarify the question of whether these two assemblages may be temporally differentiated, and ceramic evidence must be carefully compared.

Table 5.2 Radiocarbon results for charcoal associated with ceramic Assemblage 2 of the Tutu site

Unit and level	*Beta no.*	*Conventional age*	*Cal. 2-sigma results*	*Cal. 1-sigma results*
31-BIIC	50066	1610±70 BP	AD 265–290, 320-615	AD 395–550
28-D	54646	1560±90 BP	AD 330–660	AD 415–615

Ceramic style and modes

The pottery of Assemblage 2 and its related material is representative of what has been called the Coral Bay–Longford style of the Cedrosan Saladoid subseries (e.g. Rouse, 1992: Figure 14; nomenclature from Hatt, 1924). The Coral Bay–Longford style has been considered similar to the Cuevas style of Puerto Rico, and it has been estimated to be generally contemporaneous with Cuevas, as in Rouse's scale.

The Tutu site sample now provides an opportunity to describe in detail a Virgin Islands occurrence of such material and to associate it with an approximate time range based on radiocarbon results. Furthermore, the Tutu site allows discrimination between two sequential assemblages, here numbered 2 and 3. With that discrimination, the Coral Bay–Longford period can be temporally divided (Lundberg & Righter, 1997). The result is a refinement of the classification of local ceramic styles, whereby two distinct and more specifically defined Saladoid styles are recognized in place of one, at least for their occurrence on St Thomas. It is suggested that the name 'Coral Bay' be reserved for the earlier of the two, which is represented by Tutu's Assemblage 2, and that the name 'Longford' be applied to the subsequent style, which is represented by Assemblage 3 (agreeing with the prior usage by Vescelius, 1979, which restricts 'Longfordian' to the late Saladoid period).

Shape

Among the Assemblage 2 vessel-rim lots for which aspects of shape could be estimated, outward flaring (from wall to orifice) and concave (from exterior view) upper walls are common. This form, which reflects the typically Saladoid "inverted bell" shape, occurs both in evidently utilitarian, poorly executed bowls and in embellished, superbly finished fine-ware vessels (Figures 5.8b, 5.9a, 5.9c). More often than other open vessel forms, the inverted bell vessel tends to be circular in plan shape. Size of vessel varies widely. The plain vessels of this form usually have direct rims, while the decorated or fine-ware examples commonly have rims that are thickened or angled toward the exterior (between 1.50 cm and 2.10 cm in width; Figures 5.9, b and c). Closely related outward flaring vessels have straight upper-wall profiles (Figures 5.8a, 5.9e).

Another related vessel form is one with relatively upright upper walls that may be either concave or straight (to slightly convex) in profile (Figure 5.9d). Vessels may be elliptical in plan. As with the outward flaring vessels, the rim may be thickened or angled toward the exterior. The same concept of vessel contour is carried over to the few recovered vessels with slightly convex upper walls. These also have angles in the vessel wall profile (or corner points of contour), but only weak ones. Irregular rims and orifice shapes are not uncommon for shallow open bowls of this sort.

The assemblage also includes three examples of wide-necked jars (Figure 5.9f). Like all the estimated vessel contours, the contour of the jar that is sufficiently represented to estimate shape also has a corner point, or angle, in it (cf. Chanlatte Baik, 1976: 149). Figure 5.9g illustrates a unique vessel contour in the supplemental material for this assemblage, but one that occurs with early Saladoid material elsewhere (e.g. Mattioni & Nicolas, 1972: Figure 47). One rim of this assemblage possibly represents a restricted vessel with direct rim, the only potential evidence for orifice restriction. Among the Area 4 supplemental specimens are two convex restricted rims.

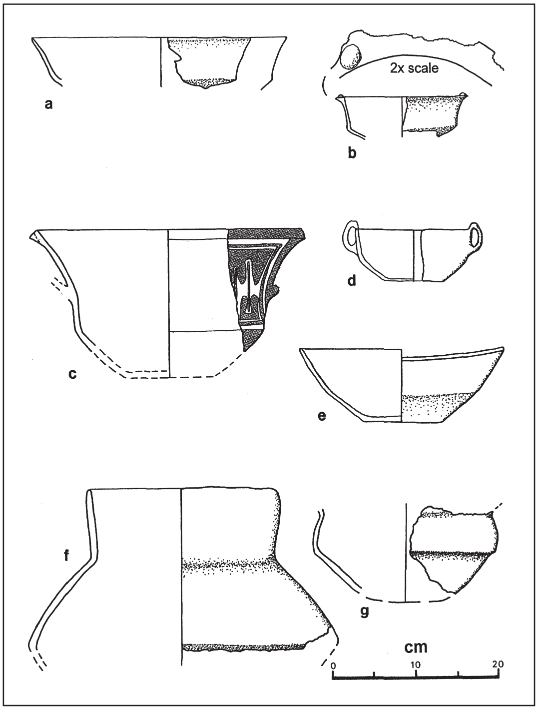

Figure 5.9 Selected vessels of Assemblage 2 and related supplemental material (b, g) from the Tutu site. Item (e) is also shown in Figure 5.8 (a).

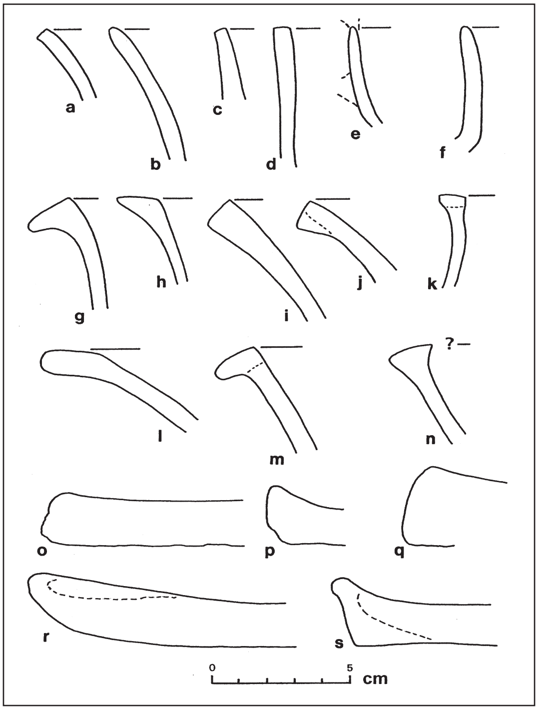

Figure 5.10 Rim variations of Assemblage 2 and related supplemental material (l–n, r, s) from the Tutu site. Dotted lines along profiles indicate red surface coatings, and (i), (j), and (l) also have white paint on the exterior red slip.

Three griddles are represented by rim sections in Assemblage 2 (Figure 5.10, o–q). Two of them are triangularly thickened at the lip to create a raised rim, and one is unthickened but has a very slight upward tilt at the rim. Griddle thickness ranges between 8.50 mm and 20 mm. Griddle bottoms are unfinished. (Figures 5.10, r and s show two additional griddle rims in the supplemental material.)

The bases of other types of vessels are finished on the exterior. All are flat or very slightly concave (from the exterior), with distinct but not emphasized edges where the base meets the vessel wall.

There are eight handle fragments in the assemblage. All are of flattish "strap" handle form, although one is slightly concave on its outer surface (Figure 5.11a). The loop form is "D" shaped (Figure 5.11c) or vertically elongated, at the rim height or rising slightly above it (Figure 5.9d). Upper joins are at the lip edge or on the exterior rim at the lip, and lower joins are on the upper wall or at the angle in the wall contour. Handle sizes vary widely, with represented widths of between 1.90 cm and 4.80 cm. Thickness usually is close to 1 cm. Some handles are surmounted by modeled lumps or nubbins (Figures 5.11a and b), and one handle appears on a white-on-red painted vessel (Figure 5.9c). Semi-circular tabular lugs (Figure 5.11f) and partial flanges on simple rims are associated with this assemblage, as with Assemblage 1. Here also, perforated modeled lumps may be attached to exterior walls, and one such lump is unperforated. An attachment area for what could be a leg or a horizontal handle/lug occurs on one unique, very thick, specimen (Figure 5.11e).

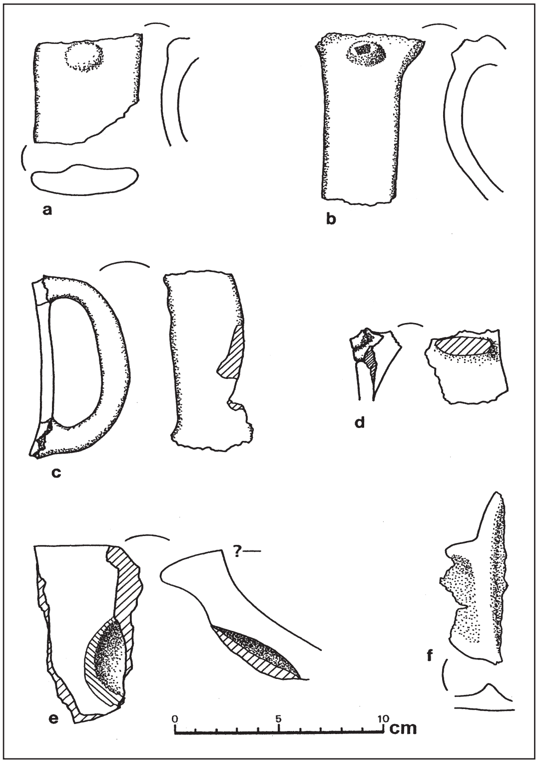

Figure 5.11 Sherds of Assemblage 2 and related supplemental material (b, e, f) from the Tutu site, showing various handle treatments (a–d), a unique thick rim with a missing attachment (e), and a concave tabular lug (f).

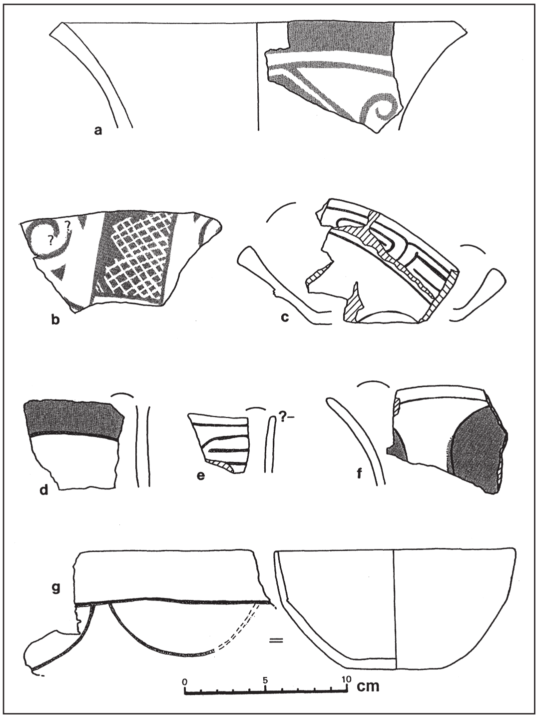

Figure 5.12 Examples of decoration in Assemblage 2 and related supplemental material (c, e–g) from the Tutu site: (a) and (b) have white-on-red painting; (c) has incision only; (d) and (f) have red paint outlined with incision; (e) has red slip over exterior incision, probably white-filled; and (g) has red slip over interior incision.

Decoration

On 13 percent of the sherd-units in Assemblage 2, decoration occurs in a variety of techniques. (This figure does not include sherds exhibiting only overall slip and thus probably under-represents zoned painting.) White-on-red painted designs occur on the exteriors of "inverted bell" shaped bowls (Figure 5.12a) and on a jar from the supplemental context in Area 8. The painted design on one sherd includes a crosshatch motif (Figure 5.12b). Precise narrow incisions on red-slipped exterior surfaces probably were filled with white paint, now vestigial (Figure 5.12e). Red paint also occurs as zoned decoration confined to particular vessel parts such as angled rims, and it may occur in zones of the interior or exterior surface, sometimes outlined by incision (e.g. Figure 5.12d). Circle or half-circle design motifs may be executed with red paint and/or incision (Figures 5.12f and g). Figure 5.12c illustrates a rare incised design on an interior surface of a small irregular vessel.

Modeling ranges from a finely executed zoomorphic head overlooking a bowl rim (Figures 5.13a, 5.14b) to rounded lumps of clay, all commonly accompanied by incising and red paint. Reminiscent of Assemblage 1 (Figures 5.9b, 5.13a), flattened clay pellets may be applied to the upper surface of a thickened rim or angled partial rim flange.

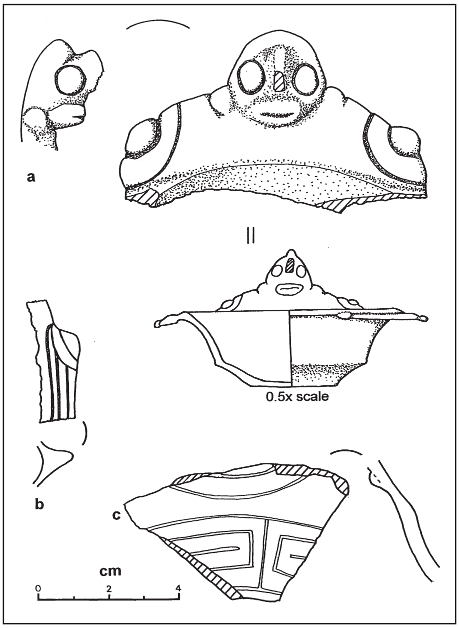

Figure 5.13 Red-painted modeled-incised decoration of Assemblage 2 (a–b) and a modeled and red-slipped sherd with white-filled incisions (c) from the surface of the same area of the Tutu site. Item (a) is also shown in Figure 5.14b.

Manufacture

The aplastic inclusions in the sherds of Assemblage 2 are most commonly mixed igneous sands, which occur in 83 percent of the sample. Usually the largest abundant grains are rounded, altered, and larger than 1 mm in length. A frequent variant (16% of the sample) is characterized by bimodal size range, with principal grains of relatively small size and low amount, and a secondary component of relatively much larger grains present in very low amounts. Slightly less common is a variant characterized by a high proportion of felsic minerals. A very few sherds of this assemblage sample contain grains of calcareous material as a secondary constituent occurring with igneous rock, and three contain appreciable amounts of shell.

Inclusions described as primarily felsic minerals occur in 16 percent of the sample sherds. These may be quartz, feldspar, or both, with these variants represented about equally. Maximum linear measurements for these inclusions vary widely, from less than 0.25 mm to more than 2 mm. Hornblende is frequently present as a secondary inclusion type, and other very minor inclusions may be mica, calcareous sand, or ferric material. In a few examples, coarse mixed sand is present in a low amount, as if extra temper were added to the original paste mixture. The same sort of practice may have resulted in the mixed-sand tempered sherds with bimodal size ranges.

There is no correlation between temper type and finely finished surfaces or decorated vessels. Thin-walled decorated vessels may be primarily tempered with coarse mixed igneous sands. Even decorated sherds with fine-sized primary inclusions also contain some coarse grains. The decorated vessel surfaces, however, are very well compacted to submerge the grains completely. In contrast, the same types of temper grains often protrude out of the surfaces of utilitarian vessels.

Vessel wall thickness (omitting griddles) has an average of 6.20 mm, with a range from between 2 mm and 13 mm. The size range of the primary inclusions has slight correlation with wall thickness, but the amount of primary inclusions does not. As in Assemblage 1, sherds estimated to have comparatively good fracture strength comprise only 59 percent of the sample, which is surprisingly lower than expected.

Well-evened surfaces for both vessel interior and exterior occur on 60 percent of the sample, and partially evened surfaces appear on most of the other sample sherds. Only 10 sherd-units were observed to have an uneven surface. Surface finishing is less thorough than in Assemblage 1; slightly more than half of all recordable surfaces are well compacted, and striations or compaction bevels left by finishing tools are observable on 35 percent of surfaces. Surface color that can be confidently estimated as overall slip (as opposed to limited painted decoration) is very rare, and all potential slip is limited to only one side of the sherd. An appreciable number of interior surfaces (30%) are totally eroded, which probably may be ascribed to use-wear, inasmuch as exterior surfaces are not similarly affected.

Vessels with evidence of forming technique were made by coiling and exhibit common fracture parallel to coil surfaces. There are 10 examples of clear coil separation. Handle attachments reveal a construction technique that is unique to this assemblage and its supplemental material. On 7 handle attachments, both upper and lower joins, the handle strap is placed completely through the vessel wall to the interior surface (Figures 5.11c andd). On the exterior surface, clay is added in strips or simply smoothed from the handle to make a gradual contour between handle and vessel wall. Of handles with evidence for attachment, only one upper handle join appears merely to abut the rim exterior.

Figure 5.14a Modeled ceramic head with red-painted elements and a pronounced concavity in the flat back side, from the surface in the area of Assemblage 2 from the Tutu site. Photographs by Robert Coates.

Additional related material

In addition to the Assemblage 2 and supplemental samples from the northeastern and northwestern edges of the site, sherds like those of Assemblage 2 occur in samples from southern edges of the site as well. Excavation units and trenches in Areas 9W, 9S, and 13 all sampled strata containing sherds with the concave contours and rim forms typical of Assemblage 2. Artifacts were sparse in these strata of the test units, however, and discrimination from earlier material related to Assemblage 1, which was also present, is not accomplished with high confidence.

Vessels in burials

Bone collagen of skeletons in three adult burials were AMS dated to the time range of Assemblage 2. These graves also contained ceramic vessels interpreted as grave goods. (Skeletal identifications are by Sandford, Bogdan & Kissling; see Chapter 7.) One is Burial 21 (N2062/1877.50E), a male adult found with a bowl positioned on its side over the skull. This bowl is of painted fine ware, in an “inverted bell” shape. The exterior upper wall of the vessel is painted in white-on-red, while the lower wall displays a polychrome design created by spaces of orange paint separating areas of white-on-red. The upper wall is 6 mm thick, the lower wall is only 4 mm thick, and both are well compacted. Vessels with similar form and two-part color scheme are found in Saladoid sites of the Lesser Antilles (Mattioni & Nicolas, 1972: Figure 63; Olsen, 1974: Figure 64).

The radiocarbon results for this burial place it in the range of between cal. AD 450 and cal. AD 640 (2-sigma, Beta 83011). Based on its estimated dating elsewhere, however, polychrome paint on the bowl suggests an earlier date. If the bone collagen dates are comparable to the Assemblage 2 charcoal results, then this burial seems to indicate it may be necessary to consider the persistence of polychrome painting into the middle Saladoid time range, if only for special vessels.

The remains of a second adult with pottery vessels also were dated to the

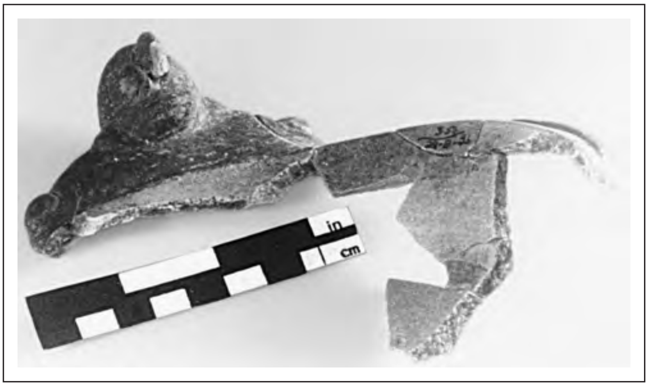

Figure 5.14b Red-painted modeled-incised head with concave back surface, attached to the rim of a small, thin, red-rimmed bowl in Assemblage 2 from the Tutu site (also shown in Figure 5.13 (a). Photographs by Robert Coates.

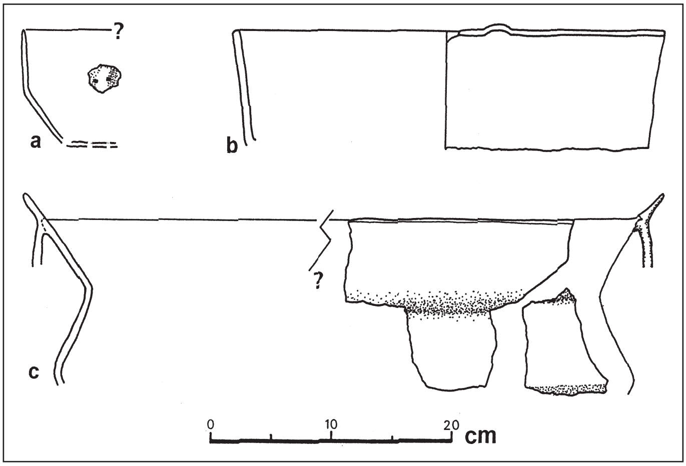

Figure 5.15 Three of the partial vessels recovered with Burial 36 of the Tutu site: (a) is non-circular and well finished, with a perforated lump that does not join the rim sherds; (b) is smudged and plain except for the small raised section of rim lip; (c) has an elliptical plan shape of undetermined size, with tool marks and unsubmerged temper grains that impart a utilitarian look.

time range of between cal. AD 450 and cal. AD 615 (2-sigma, Beta 83003). This burial, Burial 36 (N2060/1884E), was severely disturbed by earth-moving machinery, with the result that the original position of the vessels in relation to the skeleton is unknown. Portions of several vessels were collected, three of which are shown in Figure 5.15. These resemble forms of either Assemblage 1 or Assemblage 2.

A third adult, in Burial 10 (N2097/1858E), was identified by Sandford and coworkers as a female. This burial also was severely damaged by earth-moving equipment so that both the bones and the ceramic vessel were very fragmented when discovered. The vessel remains include thin base and wall sherds with interior red slip. Bone collagen returned a radiocarbon result of between cal. AD 450 and cal. AD 640 (Beta 88345).

A fourth burial vessel stylistically associated with the early to middle Saladoid period at the site is a painted bowl holding the remains of an infant in Burial 24 (N2087.50/1845E, no bone collagen date). Rim sherds of this large “inverted bell” shaped bowl are painted white-on-red on the exterior surface and painted black on the interior surface. A similar paint combination is reported as a minor part of the Trants site samples associated with dates of approximately the first century AD, uncalibrated (Petersen & Watters, 1995). Securely identified black paint such as that on this bowl was not represented in the Tutu site analyzed assemblages, and white-on-red painting could relate to either Assemblage 1 or Assemblage 2.

ASSEMBLAGE 3: LATE SALADOID OF TUTU

Samples

Saladoid artifacts were abundant at the Tutu site, but many of them seemed to represent a later time period than indicated by the two assemblages discussed above. Ceramic artifacts from several areas exhibited characteristic Saladoid contours while lacking the range of modes, especially those of decoration, apparent in the first two assemblages. This sort of material was encountered in apparently undisturbed strata, in Area 9W, where it was carefully excavated for a ceramic sample that is defined as Assemblage 3.

The samples comprising Assemblage 3 derive from EU 1 at N2044/1837E, 1 m^2, where deposits remaining below a machine-scraped surface were of two general types: an upper section of distinct thin midden strata; and a lower section of indistinct strata containing far less cultural material. The upper section of the unit, which received extremely careful attention during its stratigraphic excavation, yielded Assemblage 3 (from Levels D–I). Diagnostic sherds in the lower levels appear to be significantly earlier than those of the upper levels, including a painted, low-relief modeled rim that would not be out of place in Assemblage 1.

The number of sherds pertaining to Assemblage 3 is small, and all were recorded in detail. The selected excavated levels in the upper part of the unit yielded 200 sherds, which mended to 117 sherd-units (3,840 g in total weight). The sample includes 31 vessel-rim lots.

The sherds of this sample are in relatively good condition. Abrasion of sherd edges is obvious to extreme in 26.50 percent of the sample, suggesting that those sherds had not been immediately buried in the midden. The sizes of sherd-units (averaging 5.30 cm) range between 1.50 cm and 30.50 cm in maximum dimension, which includes one of the largest sherd units of any of the assemblages.

Dating

Three charred wood samples from EU 1 were submitted to Beta Analytic Inc. by project director Elizabeth Righter for radiocarbon dating analysis. They were collected in each of the three main midden strata of the upper section of the unit, Levels D, F, and I, as shown in Table 5.3. The results from these three samples form a tight group. It is very likely that the deposition of these three strata occurred within a relatively brief span of time. That likelihood, coupled with the general similarity of all the types of materials from these strata, led to the decision to treat the sherds recovered from the upper levels as a single ceramic assemblage. The radiocarbon results for Assemblage 3 are mostly, but not completely, segregated from those for Assemblage 2 at the level of 1-sigma statistics, or 68 percent probability. With 2-sigma statistics, or 95 percent probability, there is considerable overlap, due to long statistical error ranges in the results. The uniformity of the three radiocarbon samples for Assemblage 3, and their clustering within and beyond the later portions of the Assemblage 2 date ranges, however, lend credibility to the differentiation of these two assemblages. The ceramic evidence serves to support that differentiation.

Ceramic styles and modes

Based on characteristics such as outward flaring vessel orifices, red-painted rim bevels, and well-finished surfaces on fine ware, the Assemblage 3 ceramic material should be classified in the Cedrosan Saladoid subseries. In widely-used chronology, the last Saladoid ceramic style in the Virgin Islands has been called Coral Bay–Longford, customarily dated at approximately between AD 400 and AD 600 (e.g. Rouse, 1992: Figure 14). The evidence from the Tutu site, however, suggests that this style is temporally divisible into two different styles (Lundberg & Righter, 1997). Assemblage 3 represents the later style, and its associated radiocarbon results extend the Saladoid duration in the Virgin Islands by some 150 to 250 years, lending support to temporal estimates by Vescelius and others. Based on the late Saladoid application of “Longfordian” by Vescelius (1979), we have retained the name “Coral Bay” for the earlier style (as discussed with Assemblage 2) and have called this late Saladoid style “Longford.”

Comparative information from neighboring Culebra Island is available from Oliver’s (1992, 1995) analysis of the Lower Camp site, which yielded a single component very similar to Assemblage 3 and a radiocarbon result of between cal. AD 576 and cal. AD 666 (1-sigma range) from the bottom of the cultural stratum. The much larger ceramic sample from Lower Camp provides good evidence for a distinct ceramic style as represented at Tutu by Assemblage 3 (Lundberg &

Table 5.3 Radiocarbon results for charcoal associated with ceramic Assemblage 3 of the Tutu site

Unit and level	*Beta no.*	*Conventional age*	*Cal. 2-sigma results*	*Cal. 1-sigma results*
1-D	62568	1430±90 BP	AD 435–780	AD 560–675
1-F	62569	1400±120 BP	AD 420–885	AD 560–720, 735–760
1-I	62570	1380±90 BP	AD 535–865	AD 615–705

Righter, 1997). Detailed data from the Aklis site on St Croix also enlarge the perspective on this time period (Hayward & Cinquino, 1997; Hayward, Cinquino, Scheippati, Narganes Storde, Newsom & Stanley, 1997), although Aklis occupation appears, to this author, to have also continued into a subsequent period not represented in the Tutu middens.

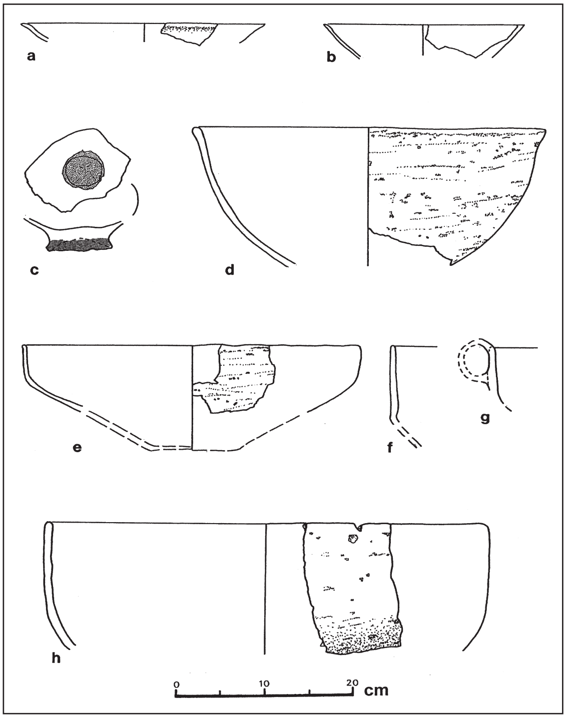

Figure 5.16 Selected vessels of Assemblage 3 from the Tutu site.

Shape

In contrast to Assemblages 1 and 2, the Assemblage 3 sample does not contain clear evidence of the "inverted bell" vessel shape. Among the 17 upper vessel wall profiles recorded, outward sloping straight contours are most common. Concave outsloping contours are not confirmed in any instance, although several small rim specimens offer that possibility. Even among body sherds with evidence of contour, only 6 percent exhibit concave exterior surfaces, compared to 66 percent that exhibit convex surfaces. Upper wall contours recorded uncommonly in the assemblage were convexly outward sloping, vertical, or inward sloping.

The most common estimated vessel form for the 31 vessel-rim lots of this assemblage is a medium–deep bowl of various shapes and sizes (Figures 5.16b–h). Two vessel-rim lots appear to represent shallow bowls, and one may represent a necked jar with outward angled rim. Although angles in vessel wall contour are present, one lot provides evidence of a hemispherical bowl (Figure 5.16d). Vessels with angled contours have relatively short, upright upper walls. (One example may vary from upright to inward sloping.) In plan view, vessels most commonly seem to be circular but also may be elliptical (or possibly navicular). A rim "corner" of approximately 90° may represent a rectanguloid vessel or tabular lug.

The assemblage includes evidence for three strap handles just under 3 cm wide. The one example associated with a vessel rim is attached at the rim lip, rising slightly above the rim level but generally preserving a "D" shape (Figure 5.16g), similar to an example in Assemblage 2. Other embellishments of vessel form were not found.

Bases in this assemblage are more varied than evidenced in the prior assemblages. Their exterior contours are flat or slightly concave, and one possibly is convex. An annular base occurs on a decorated vessel (Figure 5.16c).

Rims are commonly either direct (unthickened and undifferentiated from the vessel wall) for upright upper vessel walls, or thickened towards the vessel interior for outward flaring walls (Figure, 5.17f and h). Most of the direct rims in the sample have rounded edges (lips), although some have squarish edges and one has a very flat edge. Thickened rims are rounded or triangular in contour, with the interior lip bevel slightly rounded. The assemblage includes only one flat beveled rim (Figure 5.17f) similar to those of Assemblages 1 and 2. This bevel and other, rounded, bevels are painted red. A minor rim treatment is slight thickening towards both sides.

Rims that curve very slightly toward the exterior of the vessel also occur in the assemblage, and there is one strongly curved rim on a possible jar (Figure 5.17a). In contrast to Assemblages 1 and 2, angled or flanged rims are not present in the sample.

Four griddles are represented in the vessel-rim lots for this assemblage. Two have raised rim edges with different profiles (Figures 5.17i and j), and two have lost rim coils that probably formed raised edges.

Decoration

Red painting is the only form of decoration in Assemblage 3, and it is limited to particular vessel elements. Evidence of the painted/non-painted interface indicates that 5 sherd-units (4.30%) (three lip bevels, one exterior rim, and one annular base) are definitely painted. Other small sherds show some evidence of remnant red pigment that may be from either painted zones or slip.

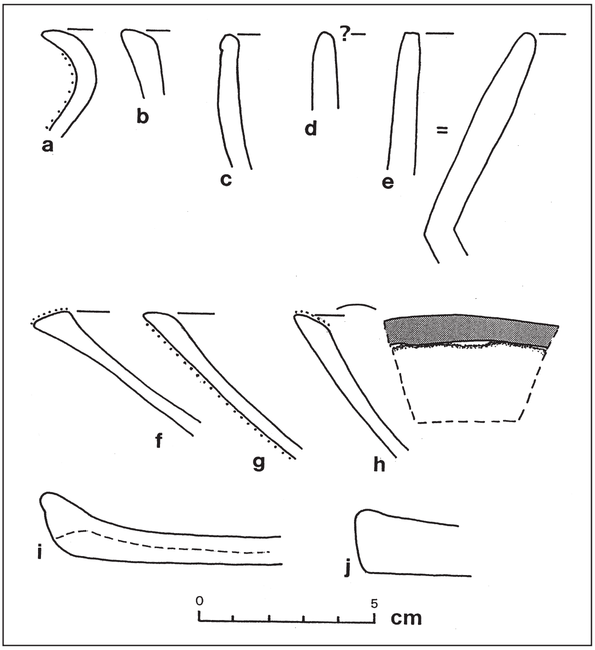

Figure 5.17 Rim variations of Assemblage 3 from the Tutu site. Dotted lines along profiles indicate red surface coatings, and (h) has interior smudge that is darkest against the resist-painted lip edge as shown.

One of the red-painted beveled rims has evidence of a smudge-resist technique in which the painted bevel was covered with a coating material that extended slightly over the paint in some places (Figure 5.17h). When the vessel was then smudged on the interior, the paint was protected. This rim also contrasts with those of Assemblage 2 in that the red-painted zone of the rim is not strongly demarcated from the interior vessel wall by an angle in contour.

The zone-painted annular base is also of special interest (Figure 5.16c). In addition to its unique shape, it also has two different paint colors. Encircling the exterior of the base is a strong red band similar to the red rim bands of other sherds. Coinciding with the slightly convex interior of the base is a filled circle of weak, greyish red color.

Manufacture

Evidence for construction technique is uncommon, but coiling is indicated by several fractures. Griddles apparently were constructed with a second clay slab added at least at the rim to thicken it. Most sherds are well evened, although exterior surfaces can be very uneven. Thorough compaction occurs on 59 percent of recordable surfaces. Slipped surfaces with color contrast to the sherd fabric are very rare in the assemblage.

Vessel wall thickness in this assemblage is slightly greater than in the earlier assemblages, averaging 6.40 mm, and ranging between 2.50 mm and 12 mm. Sherd thickness is correlated with temper size, increasing as temper size increases. It also is correlated with temper material, although individual sherds provide exceptions to the general pattern.

As in Assemblages 1 and 2, the aplastic inclusions in sherds of this assemblage can be categorized. Most abundant are fabrics containing mixed igneous sands of rounded shape and usually coarse size, comprising 68 percent of the sherd-unit sample. Fabrics with these inclusions commonly include pebblesized (larger than 4 mm) rocks and large voids. Calcareous sand may be present as a secondary inclusion type.

Selectively felsic inclusions that are largely quartz, plagioclase, or a combination of the two, comprise 26 percent of the sample. In fabrics with mostly plagioclase inclusions, the aplastic material is abundant, angular, and usually fine. In fabrics having mostly quartz inclusions or quartz and plagioclase mixtures (often with hornblende as a secondary inclusion type), grain size varies but can be less than 0.25 mm. No fabrics with primarily felsic inclusions included pebbles. For grain size, then, these fabrics contrast with fabrics containing mixed sands.

A dichotomy between fabrics with different categories of inclusions persists in generalizations applicable to other modes as well. Sherds with felsic inclusions have a smaller average thickness than do sherds with mixed inclusions. They do not have uneven surfaces, and they are most likely to have well-compacted, smoothed, and polished surfaces. The 5 decorated specimens described above all have felsic primary inclusions, and they are well-evened and compacted. In contrast to Assemblages 1 and 2, the choice of materials and production process leading to fine ware appears to generally differ from that for utilitarian ware.

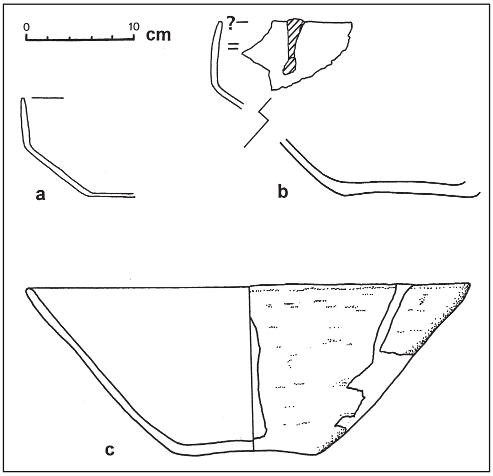

Figure 5.18 Three of the four partial vessels recovered with Burial 13 and Burial 13A of the Tutu site: (a) has elliptical plan shape and even, compact surfaces affected by smudge and completely eroded on the interior below the corner point; (b) is unusual in containing shell as a secondary temper component in the lower section (the rim with missing attachment is not proven to join this vessel but appears very similar); (c) has uneven and streakily compacted light brown surfaces.

Additional related material

Although EU 1 tested only a very small sample of preserved late Saladoid midden, such material was not uncommon on the site. Its main deposits probably received severe impacts from machine scraping and topsoil mounds. In Trench 10, near EU 1, and in excavation units of Area 9S, small samples contained evidence for similar material, including red circles painted on the interiors of fine bases, comparable to the example in Assemblage 3.

Late Saladoid material also appears to have been included in a mixed deposit in Area 9N, where two large excavation units tested a shallow, midden-like concentration. Many sherds from that sample are highly eroded on all surfaces, and mixed stylistic evidence also suggests a secondary deposit. Included are sherds like those of Assemblage 2 (which correspond to results from the one associated radiocarbon sample), Assemblage 3, and Assemblage 4. The sherds distinctly related to Assemblage 3 include a band-painted annular base and a red rim band on the rounded surface of a rim thickened towards the interior. A rim of a shallow bowl of similar ware bears evidence of an interior red-painted design or zone, the only possible instance of a "painted plate" among the site's analyzed samples. Farther north at the western edge of Area 1, a surface collection recovered another painted annular base.

Vessels in burials

Four burials with significant ceramic grave goods are dated to approximately the seventh century AD by AMS radiocarbon results on bone collagen. Burials 13A and 13 (N2087/1844E) were overlapping, with the former intruding upon the latter. Both possibly were female adults. Major portions of 4 vessels were recovered from the combined burial pits. Figure 5.18 illustrates three that appear to be utilitarian. The fourth bowl is an "inverted bell" shape of thin, well-finished ware; its interior is incised in curvilinear parallel lines below the angle of contour and its exterior has a small perforated lump.

The inclusion of that incised bowl in these combined burial features associates certain ceramic modes with a later date range than is indicated by the midden assemblages. Burial 13A returned a range of between cal. AD 560 and cal. AD 665 (2-sigma, Beta 83006), and Burial 13 returned a range of between cal. AD 605 and cal. AD 665 (Beta 83009). These dates are near the estimated temporal boundary between Assemblage 2 and Assemblage 3. Other specimens of double-line incision were not found with Assemblage 2, however (being limited, in midden contexts, to Assemblage 1), while the "inverted bell" shape and incised decoration were not demonstrated in the Assemblage 3 sample. If the dating of both context types is compared at face value, then these burials show a continuity of earlier Saladoid modes into a later Saladoid time period.

Burial 4/7 would appear to support that suggestion. In Burial 4/7 (N2016/1854.50E), the skeleton of a female adult was associated with a small, deep, misshapen, poorly finished bowl with two semicircular tab lugs attached to the lip of the rim at an oblique outward angle (Figure 5.19a). At the bottom of the grave, partially beneath the human bones, were the fragments of an essentially complete but upside-down tall, large, "inverted bell" shaped vessel with a plain, uneven finish (Figure 5.19b). The radiocarbon results for this burial returned a range of between cal. AD 620 and cal. AD 675 (2-sigma, Beta 83001). Again, the ceramic vessels are more typical of a style represented by Assemblage 2 than of one represented by Assemblage 3. This might suggest that Assemblage 3 is incompletely representative of the time period of its associated dates, or that grave goods preserved traditional styles not in common daily use. On the other hand, the vessels associated with the female adult skeletons appear to be mostly utilitarian vessels that saw usage, not fancy goods created for burial purposes.

Of the burial vessels discussed to this point, associated by their dating with Assemblages 2 and 3, several seem, on the basis of midden comparisons, to be earlier in style than implied by the bone collagen results. There is no obvious explanation for this, but it may simply reflect the imprecise nature of radiocarbon dating or non-correspondence of results from differing materials with current correction methods. Nevertheless, the bone collagen dating suggests, at the least, that the duration of midden-represented assemblages into the later parts of their estimated date ranges must be considered a strong possibility.

Another burial with included pottery provides inconclusive results. In Burial 23B (N2074/1874.50E), the elliptical base and lower wall of a thick, smudged vessel was found between the forearms of the adult skeleton, which was disturbed by machinery. The recovered vessel portion is undiagnostic for comparison to the bone collagen date of between cal. AD 655 and cal. AD 770 (2-sigma, Beta 83000).

ASSEMBLAGE 4: LATE OSTIONOID OF TUTU

Sample

Because of the topsoil disturbance prior to site discovery, in situ Ostionoid remains were relatively rare on the site compared to Saladoid remains. The best context for late pottery was in Area 9S, where excavation units were located beside a very large soil mound (Figure 1.7c). Here late Ostionoid pottery that is defined as Assemblage 4 was recovered from a localized upper stratum (immediately below disturbed overburden) of two adjacent excavation units:

EU 25: N2037/1842E, 1.0 m^2, Level C
EU 26: N2036/1842E, 1.0 x 0.5 m, Level B (subdivided as top, mid, base)

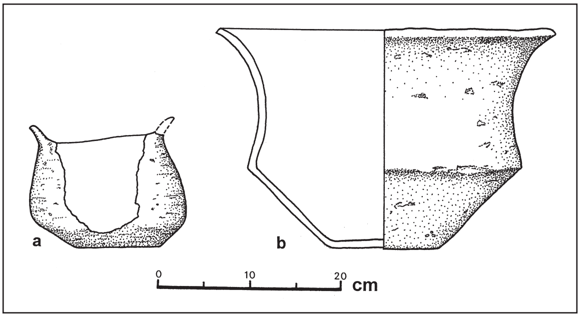

Figure 5.19 The vessels of Burials 4/7 of the Tutu site. Drawing (b) is reconstructed from records.

Underlying strata consisted of layers or lenses containing Saladoid cultural material interspersed among layers of soil and gravel essentially lacking cultural material. The late Ostionoid midden lay immediately above layers with Saladoid material, with no intervening strata to represent an earlier Ostionoid time period.

The context for this assemblage is interpreted as acceptably reliable. The description of the ceramic assemblage, however, should be viewed as provisional simply because of a lack of comparative ceramic material by which to verify a late and limited time span, in the range of between cal. AD 1200 and cal. AD 1500, as suggested by the radiocarbon results discussed below. The assemblage does include two rim sherds with Saladoid traits, which are easily noted. One is very eroded on all surfaces, and these sherds may have been incorporated into the late midden during its prehistoric accumulation. If, however, the midden also incorporated some Ostionoid pottery from an earlier period, this would be difficult to detect in the absence of well-defined comparative assemblages from either Tutu or other Virgin Islands sites.

The Assemblage 4 sample examined from selected levels of EUs 25 and 26 totals 246 sherds (in 162 sherd-units). The EU 26 (Level B) sample underwent detailed analysis. It comprised 170 potsherds (1,705 g in total weight) in 92 sherd-units and 20 vessel-rim lots. Maximum sherd-unit length ranged from 1.40 cm to 21.50 cm, with an average of 4.70 cm. Only 13 percent of those sherd-units exhibited any obvious edge abrasion suggestive of long or damaging exposure before burial.

Supplemental ceramic materials for Assemblage 4 are available in collections from Trench 9, a backhoe-dug trench adjacent to EU 26. The late midden stratum that appears in EUs 25 and 26 appears also in the sides of that trench. Small areas beside the trench were sampled in order to enlarge the collection from this layer. Other supplemental material derives from EU 27, located approximately 1 m to the south of Trench 9. Here the lower portion of a localized and thin late Ostionoid midden layer seemed to be undisturbed. Although there are some residual questions about this excavation unit, obviously aberrant sherds are not found in the sample from this level. Starting immediately below this midden, lower levels of this unit again contained earlier Saladoid material that may have been subject to redepositional processes.

Dating

Four radiocarbon samples provide a basis for estimating the dating of Assemblage 4. They were collected from the late midden layer in EUs 25 and 26, and are listed in Table 5.4. These radiocarbon results are relatively uncomplicated: they show good consistency among the group, and they also are consistent with expectations for the associated pottery.

Two of these samples have a large statistical error range (EU 26, Level B, top and base), which results in long estimated calendrical ranges. The sample for EU 26, Level C, which was a level segregated at the very bottom of the midden, probably provides a better estimate for the early end of the range (and agrees well with the sample from the adjacent excavation, EU 25, Level C). In this author's opinion it is unlikely that the late midden stratum dates to either the early or late ends of the calendrical ranges for the two EU 26, Level B samples. It probably dates somewhere within

Table 5.4 Radiocarbon results for charcoal associated with ceramic Assemblage 4 of the Tutu site

Unit and level	*Beta no.*	*Conventional age*	*Cal. 2-sigma results*	*Cal. 1-sigma results*
26-B, base	51355	720±120 BP	AD 1035–1435	AD 1220–1395
25-C	111461	650±50 BP	AD 1275–1410	AD 1290–1395
26-C	11452	560±80 BP	AD 1285–1470	AD 1310–65, 1375–1435
26-B, top	51354	560±120 BP	AD 1250–1535, 1545–1635	AD 1295–1450

the range of overlap for all four samples, which is between cal. AD 1285 and cal. AD 1410 at 2-sigma probability.

Ceramic style and modes

In the current chronology of the eastern Puerto Rico and Virgin Islands area as summarized by Rouse (1992: Figure 14; Rouse & Faber Morse, 1995; Introduction, this volume: Figures 1, 2), styles of the Chican Ostionoid subseries are estimated in the time period of between AD 1200 and AD 1500. The eastern Puerto Rico style is termed "Esperanza," while the Virgin Islands style is termed "Magens Bay–Salt River III" in the earlier terminology of Hatt (1924). For the Virgin Islands specifically, the Ostionoid styles are not well described or securely dated.

The Assemblage 4 pottery of the Tutu site relates to the Chican Ostionoid subseries both by radiocarbon dating and by ceramic modes. It has clear similarities to the Esperanza style, with the most obvious diagnostic decorative motifs being bands of incised designs around restricted orifices. Decorative traits ascribed to Capá and Boca Chica styles are also present. Following established terminology, we refer to the St Thomas manifestation of the Chican Ostionoid subseries as the "Magens Bay III" style. The Tutu site offers an opportunity to describe one representative of it.

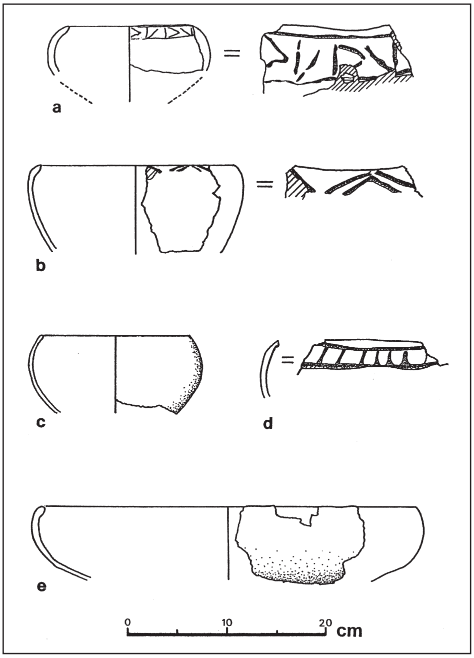

Figure 5.20 Selected vessels of Assemblage 4 of the Tutu site, with incised decorations shown at twice the figure scale.

Shape

Within the small sample of vessel-rim lots in Assemblage 4, as well as the supplemental material from other fairly good contexts, the uniformity of vessel shape is striking. Excluding one rim suspected to be an intrusive Saladoid specimen, all of the upper walls that can be identified to contour are convex (Figure 5.20). The stance of the convex upper wall most commonly is inward sloping (from mid-wall to orifice). In some cases it is vertical (upright) at the rim (unrestricted), and one case is possibly outward sloping. Among all the sherd-units of the assemblage, more than half have convex contours. A minor number have a straight contour, which may include flat-based sherds. Many are too small or uneven reliably to show wall contour, but none exhibits a concave contour. No exterior angles in vessel wall contour (corner points of contour) could be clearly identified. These characteristics contrast sharply with the Saladoid assemblages.

It is particularly difficult to determine modes of vessel shape in this assemblage, because, in addition to the small size of many recovered rim sherds, the sherds are very uneven on surfaces and on rim edges. Even when the rim fragment is fairly large, the unevenness of the edge prevents a secure determination of the upper wall stance or the shape of the orifice in plan. The orifice shape in plan apparently can be either circular or non-circular in this assemblage, but most are undetermined.

No thick griddle sherds were found in the assemblage sample. One griddle rim with a single encircling incised line was collected from an excavation level that provides supplemental material but has a potential for stratigraphic disturbance. In the assemblage itself, there are two rim sherds of what seems to be a flat but very thin griddle-like or plate-like object. The rims are slightly thickened, the bottom surfaces are unfinished, and the thickness apart from the rim is 5 mm (Figure

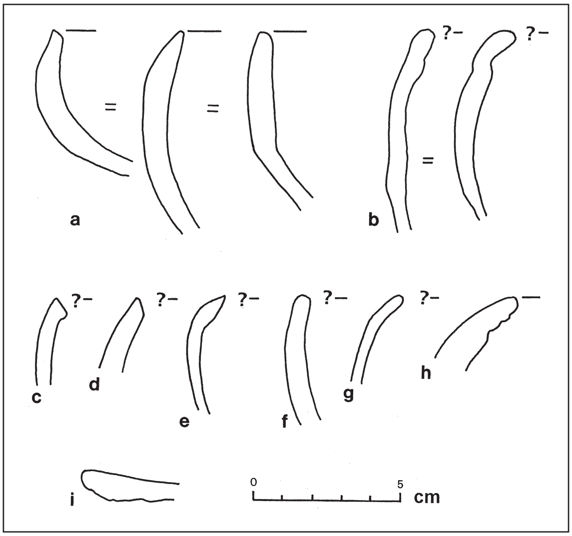

Figure 5.21 Rim variation in Assemblage 4 and related supplemental material (h) from the Tutu site: (a) and (b) show variation within individual sherd-units.

5.21i). In the supplemental collection there is a similarly thin (8 mm-thick) flat sherd with raised rim and unfinished bottom, providing some support for the inclusion of a thin, planar form in this assemblage. Two additional flat rim sherds of similar thickness and with one unfinished surface but no raised rim are in an unprovenienced sample from Trench 9. Nothing similar is associated with Assemblages 1, 2, or 3.

The small-diameter rim of a probable bottle or jar is one of two suspected as possibly intrusive Saladoid sherds. It is relatively thin, light brown, and slightly outward sloping above an interior corner point. If a valid part of this assemblage, it is a unique representative of a vessel form.

Vessel rims of Assemblage 4 most commonly are direct (unchanged in thickness or angle in relation to the vessel wall) with rounded edges. Other rim edge (lip) shapes are tapered or flatly beveled towards interior surfaces (Figures 5.21, a, c–e). The tapering of rims is pronounced at their edges, in contrast to the long tapers of earlier assemblages. Some rims can be classified as inward curving rather than direct, if the vessel's convex contour changes noticeably near the rim (Figure 5.21e). Thickened rims also occur, as in the final unflattened coil of the vessel in Figure 5.20e. No rims were found to be curving or angled towards the exterior of the vessel.

Assemblage 4 includes only one, very indistinct, probable base edge. A supplemental context yielded a base edge with an emphasized angle at the wall join. No loop handles were identified.

Decoration

Decoration associated with this assemblage is limited to exteriors of inward curving upper walls, near vessel rims. Among sherd-units of the defined assemblage, only 5 (3%) are decorated. Three exhibit rectilinear incised motifs in bands around the rim (Figures 5.20, a, b, d; cf. Rouse 1952: Plate 7J). The incision is imprecisely executed, with lines of variable cross-section, depth and width (ranging between 1 mm and 2 mm). One decorated vessel exhibits part of a modeled motif that may be a biomorphic limb (Figure 5.22a). Another combines modeling and incision in the decoration of an irregular inward-angled rim that may be a zoomorphic motif (Figure 5.22b).

Among the supplemental sherds that have a less secure contextual association with the assemblage there is an example of a single, sloppily incised line around an exterior surface just below the rim edge. The oblique lines and gashes of Figure 5.22c probably were associated with a circular motif, as is common in late assemblages of Puerto Rico (e.g. Rainey, 1940: Plate 7; Rouse, 1992: Figure 27) and appears as far away as Barbados (Harris, 1991: Figure 52–177).

The only specimen with painted decoration occurs in the supplemental collection from Trench 9. It has pinkish red paint applied to the top of a triangular rim on a convex, outward sloping, uneven vessel wall. This painted decoration possibly may be associated with Assemblage 4 or it may represent an earlier Ostionoid form.

Red coating is evident on three sherds in the assemblage sample that underwent detailed analysis. All are rims, with the red pigment on the interior surfaces; one also has red pigment on the exterior. The pigments are classified as slip because the observable sherds do not evidence a design;

however, the red pigment could be part of a painted decoration limited to a particular vessel zone, such as a band around the rim or upper wall. Although the rims of two sherds are inward curving, they appear to be from unrestricted vessels. The possibility that these are earlier sherds and intrusive in the assemblage was considered. One has uneven surfaces typical of this assemblage, however, and none is severely eroded as are other suspected intrusive sherds. In sum there is no compelling reason to conclude that red slip/paint is not a trait attributable to this assemblage.

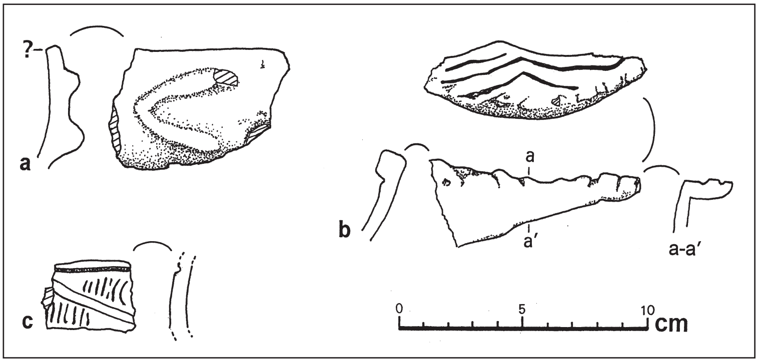

Figure 5.22 Examples of decoration in Assemblage 4 and related supplemental material (c) from the Tutu site.

Manufacture

Notwithstanding the crude appearance and thickness of many sherds, Assemblage 4 includes a high proportion of very thin sherds. Vessel wall thickness averages 6.40 mm (the same as the late Saladoid assemblage), with a range of between 3 mm and 11 mm. (This includes convex sherds that possibly could be convex bases, and it excludes the many cases that were unmeasurable due to a typical variation of more than 2 mm.) These figures for vessel wall thickness do not distinguish this assemblage from the Saladoid assemblages.

In surface finishing, however, the assemblage is very distinctive. Only a minority of exterior surfaces (less than 40%) are well evened. The remainder, if not undeterminable, have partially or very uneven surfaces, some undulating with the pattern of construction coils. Many of the uneven exterior surfaces also are not well compacted; and either temper grains protrude from the clay or they are filmed by clay but still rise out of the vessel wall surface. Some exterior surfaces have had no finishing treatment at all, while many others preserve evidence of incomplete finishing in the form of ridges from finger-smoothing, striations from scraping tools, and bevels from compacting tools. Unscraped and uncompacted exterior surfaces even occur in conjunction with exterior upper-wall decoration.

Interior vessel surfaces are more often well evened (68%). Compared to exterior surfaces, they also are more often well compacted, which is the condition of the majority of interior surfaces. Marks left from smoothing and compacting treatments are more rare on interior surfaces. It is not uncommon for a crudely uneven exterior to occur with a superbly finished interior surface, showing that the exterior treatment is intentional and not attributable to lack of craftsmanship. Further, despite the crudely finished aspect of many specimens, this assemblage also includes sherds that are extremely thin, hard, and very well smoothed and compacted on both surfaces.

Slip coatings apparently were an option for the makers of the vessels in this assemblage but were not much utilized. Six sherds were observed to have a slip other than the red pigment discussed above, with a few more having the possibility of slip. Slip colors are brown to reddish brown, and they occur on either surface or on both surfaces.

Black smudge or fire clouding is very common, occurring in moderate to heavy deposits on 61 percent of exterior surfaces and on 48 percent of interior surfaces. This imparts a darkened appearance to many sherds, which otherwise are usually reddish brown in surface color.

Although the aplastic inclusions in sherds are generally similar to those of the Saladoid assemblages, there are specific differences. As in the earlier assemblages, inclusion mixtures still are classifiable within two general types, either a mixture of various rounded igneous sands or a more specific type that is composed largely of angular felsic grains. The latter is more common in Assemblage 4, however, comprising 43 percent of the sample. Within it there also are variations that are new: secondary black hornblende sometimes is much more abundant and much larger in grain size, the maximum size range of felsic grains exceeds 1 mm more commonly than not, and large rounded inclusions may occur in angular felsic mixtures. Chican Ostionoid sherds examined from the Magens Bay site also have this pattern of crushed temper, and at the Robin Bay site on St Croix, as well, Payne (1995) found a marked increase in crushed rock temper in the latest excavation levels.

Temper mixtures of large round igneous sands, in abundant amounts, make up 57 percent of the assemblage sample. Included pebbles can be as much as 1 cm in length. Shell as a secondary temper constituent in the fabric was observed in only one sherd-unit.

Seven sherd-units exhibit carbonate fragments on the exterior surface in a thin layer unique to this assemblage. Among these examples the carbonate layer varies from a dispersed single layer to an obvious continuous layer several grains thick. In one vessel, a well-defined layer lies in places on the surface and in other places just below the surface, covered by a thin clay layer. Typical size ranges for the carbonate fragments can extend to as large as 1 mm. A number of additional sherd-units in the assemblage have sparsely scattered carbonate or shell fragments on the exterior surface.

Ceramic disk

The context that yielded the vessel sherds of ceramic Assemblage 4 also yielded a perforated ceramic disc fragment. The disc originally may have been approximately 7 cm in diameter, with a perforation of 1 cm in diameter drilled from both sides. It preserves a slight convex–concave contour of the sherd from which it may have been derived, and, for the most part, is 8 mm thick. It has felsic (quartz/plagioclase) and hornblende temper, with one eroded surface and one well-compacted surface (originally the interior).

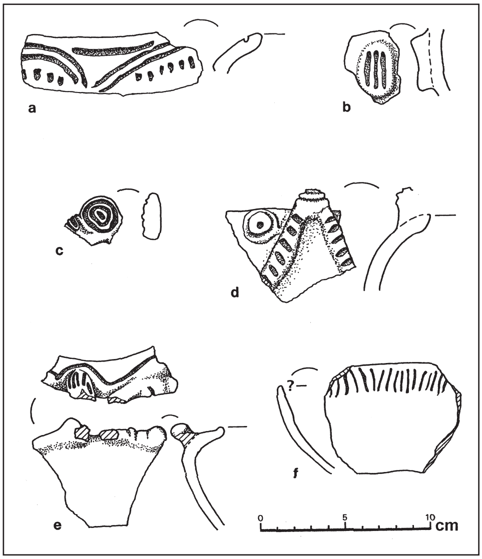

Figure 5.23 Examples of decorative motifs that, like Assemblage 4, probably pertain to the Magens Bay III style but occur on sherds from poor contexts of the Tutu site.

Three other perforated disc specimens were included in the ceramic material examined from the site, two from post feature P-278 and one from Trench 9. These have similar form but are smaller in overall diameter (between 5 cm and 6 cm).

Additional late material

Pottery stylistically similar to Assemblage 4 and to Puerto Rican late Ostionoid pottery was recovered from various surface areas of the site. Because the Assemblage 4 sample is extremely small, this material is useful in revealing a wider range of ceramic modes that can be tentatively assigned to the late Ostionoid period.

Several sherds recovered from various poor contexts have wide-lined curvilinear incisions and gashes. The example shown in Figure 5.23a closely resembles specimens recovered during Elizabeth Righter's investigation of the Magens Bay site on St Thomas (although differing in temper). Variations on this arched line motif, often with gashes below, were relatively abundant in the Tutu site late material. They also are common in assemblages designated as Esperanza or Capá style on Vieques Island (as at El Destino; Rodríguez López & Rivera, 1983: Figures 1, 3) and Puerto Rico (e.g. Alegría, 1983: Plate 5; Rouse, 1952: Plates 6M, 6P, 7B; Rouse & Alegría, 1990: 7W–X).

Other rims are decorated with notched-strip appliqué (Figure 5.23d), which often takes the form of zoomorphic limb motifs and occurs in many examples from the Virgin Islands and Puerto Rico (e.g. Rouse, 1952: Plates 6G, 6N), as well as examples eastward to Saba (Hofman, 1993: Figure 67) and St Martin (Henocq, 1995). Although not included in the Assemblage 4 sample, such appliqué surely pertains to the Magens Bay III style.

Pottery like Assemblage 4 was excavated in Area 8 (EUs 19 and 70). A sample from a shallow layer under the scraped surface consists of 651 sherds of mostly small size. Present are examples of wide and narrow exterior incision, notched-strip appliqué, and rims that are tapered, folded, or thickened by round coils that easily become detached. Plain sherds with the finishing characteristics of Assemblage 4 also were found in mixed contexts of Area 9N.

Vessels in burials

Bowls of clearly Ostionoid style were recovered with Burials 39 and 18. Neither represents decorated or fine ware. In Burial 39 (N2084/1838.50E) a major portion of a large hemispherical bowl was associated with a child. Its exterior surface has an uneven, unsmoothed surface undulating over coils, but its interior surface is well evened and compacted. The rim is thickened by a coil larger than the adjoining wall. The AMS radiocarbon results for the collagen of bones from this burial are problematical, at between cal. AD 1660 and cal. AD 1950 (2-sigma discontinuous, Beta 83002).

Another convex-walled, plain utilitarian bowl was possibly in association with the machine-damaged burial of an infant (undated) designated Burial 18 (N2118/1850E). Like the bowl of Burial 39, the exterior surface is undulating and unsmoothed but the interior is well finished. This bowl is somewhat smaller and thinner, however.

OTHER CONTEXTS

In addition to the material already discussed, pottery derived from various minor excavations and other recovery procedures was examined. Most of that material was unremarkable. Some of the features with characteristics of post holes contained unusually abundant pottery. The pottery always consisted of diverse normal sherds, however, with no special items to suggest any sort of intentional cache. Such sherds may have been trash incorporated in backfill of a hole and thus provide questionable evidence for an assemblage or even for a related structure.

Surface collections and other miscellaneous proveniences were the sources of some unusual items (Figures 5.24, 5.25, 5.26). Among the collections from such contexts were several modeled heads, lugs and adornos, crafted in both Saladoid and Ostionoid style (Figures 5.25–5.28a, 5.28b).

SUMMARY AND CONCLUSIONS

A context-based ceramic analysis was carried out for the Tutu site, with the aim of describing ceramic assemblages that represent artifacts used during a limited span of time. Assemblages were defined by stratigraphy rather than artifact characteristics. Four assemblages were identified, their approximate dating being based on this author's interpretation of associated radiocarbon samples; see Figure 5.1. These assemblages represent four temporal components of the site, with the possible exception of the first assemblage, which may overlap the second. Pottery of these assemblages was analyzed, together with supplemental material from stratigraphically and temporally

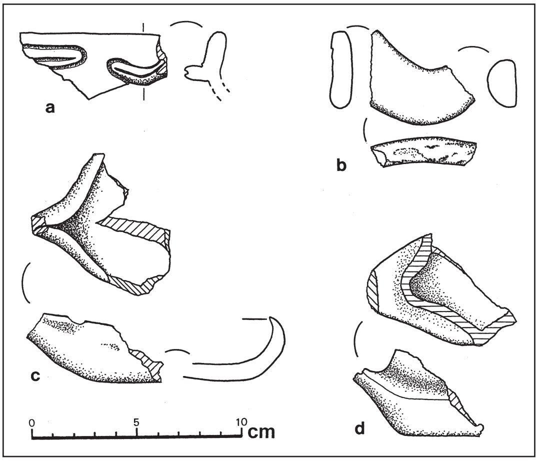

Figure 5.24 Unusual sherds recovered from mixed contexts of the Tutu site: (a) is well finished and polished but not slipped or painted; (b) is red slipped except on the flat, unfinished side; (c) has a rim pinched to a corner, poor finish, and smudge; (d) has a solid up-tilted projection, well finished but not slipped or painted.

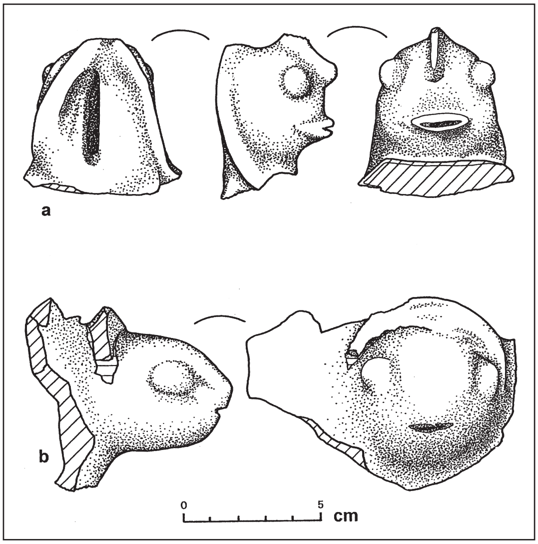

Figure 5.25 Saladoid hollow modeled heads from poor contexts of the Tutu site: (a) has white-on-red paint and a narrow slit opening to hollow interior; (b) has grainy, unpainted surfaces and a completely hollow back.

associated contexts. The results serve to incorporate a greater level of detail into the local ceramic sequence. Other ceramic samples from the site were then examined and compared to the selected assemblages in order to provide information about contexts without associated dates or without reliable stratigraphy, thus contributing to information about the site's utilization.

Assemblage 1 comprises the largest sample of pottery, but it also has the longest time span for associated radiocarbon results. In addition, it may overlap the temporal period of Assemblage 2. There is much similarity between the modes of Assemblages 1 and 2, which could be due to either long-term stylistic stability or to temporal overlap in the assemblages. That question will have to be resolved with future data. At this time, Assemblage 1 appears to be a representative of Prosperity style, perhaps the later range of the style and also transitional or extending into the succeeding Coral Bay style.

Because it is not temporally segregated and stylistically distinctive, Assemblage 1 is not an optimal assemblage for a type description of a ceramic style. On the other hand, there are modal distinctions between Assemblage 1 and Assemblage 2, and modes that are exclusive to Assemblage 1 are some of those that have been previously identified with the early Saladoid styles such as Hacienda Grande in Puerto Rico. These include zoned, incised crosshatching, thick-walled cylinders, low-relief painted modeling, and abundant outward-angled rims and flanges. At the same time, the assemblage lacks some diagnostic decorations, such as narrow-zoned crosshatching and zoned punctation, which have been ascribed to very early components on other islands. Zone-incised crosshatching is not suitable as a comparative marker simply as a technique because decorative fields and zoning may vary greatly even though the same technique is employed. The differences between this Tutu assemblage and other early site components could be due to either sociocultural difference or temporal difference, a question that will require evidence from other sites for resolution.

Assemblage 2 is considered a good example of the local style for the period between approximately cal. AD 400 and cal. AD 600, which is contemporaneous with Cuevas. Following prior

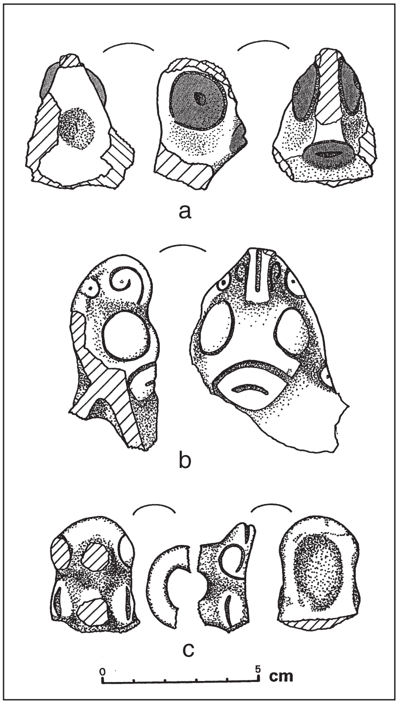

Figure 5.26 Saladoid painted modeled heads (a, b) from disturbed contexts and an unpainted modeled frog-like figure with a tiny coil attached to its back like a handle (c) from a hearth feature (F-21) from the Tutu site: (b) has an apparent handle attachment at the back and is solid, while (a) and (c) have pronounced depressions in their back surfaces.

usage (as applied by Bullen, 1962, and Vescelius, personal communications, 1978–80), this Virgin Islands style is here called "Coral Bay." In the terminology developed by Vescelius for the Virgin Islands, the representation of this style on St Thomas would appropriately be called the "Tutu aspect" because it can be well defined from the Tutu sample. Assemblage 2 includes concave-sided vessels, necked jars, "D"-shaped handles, exteriorly thickened or angled rims used to display decoration, complex white-on-red painting, white-filled incision, appliqué pellets, and a painted modeled head. Utilitarian vessels can have hastily finished surfaces, upright walls, and elliptical plan shape.

The sample for Assemblage 3 is small but much like the pottery described from Lower Camp on Culebra (Oliver, 1992, 1995). Both samples are demonstrably different from Assemblage 2 in their lack of evidence for concave-sided vessels, white-on-red painting, and modeled-incised decoration. Thickened rims are used to display red paint, which also occurs in circles on interior base surfaces of fine ware. This exemplifies material Vescelius (e.g. 1979) termed "Longfordian," and hence it is here referred to as Longford style. Radiocarbon dates associated with Assemblage 3 also validate Vescelius's estimate of between cal. AD 600 and cal. AD 800 for this late Saladoid style. Certainly with the adoption of calibrated calendrical scales the late Saladoid styles in the local region must be dated later than has previously been customary.

The Assemblage 4 sample derived from an in situ Ostionoid midden. The sample is small but distinctively Chican Ostionoid and well bracketed with radiocarbon results that date it to approximately the fourteenth century. It represents what has been termed the "Magens Bay III" style in the Virgin Islands. A characteristic vessel form has convex walls with an inward curving or sharply inward-angled rim, with decoration limited to the rim or upper wall. Decoration consists of incised bands and modeled or appliquéd zoomorphic elements, including notched strips. Exterior surfaces are commonly uneven from lack of scraping, although they may be compacted and polished, and typically are black-smudged. Ceramic forms include perforated discs and probably thin griddle-like items.

A purported contrast between thin, hard, well-made pottery and thicker, cruder pottery that corresponds generally to the division between the Saladoid and Ostionoid series is not seen in the Tutu evidence. All four assemblages include thin, polished, and sometimes decorated fine ware as well as thicker, less smoothed ware that appears strictly utilitarian. It clearly is not productive to attempt style or even series identifications of sherds based on their quality of construction and finish, as has been revealed many times under detailed analysis (e.g. Bullen, 1962: 63); rather, it seems useful to identify ware types separately. Regarding vessel wall thickness, only Assemblage 1 gives the impression that utilitarian vessels (of less compacted finish) are commonly constructed with relatively thin walls. Although technological characteristics change through time, they do not affect all wares equally. Also they do not have a simple correspondence with outward appearance, which does not necessarily equate to functional quality (Curet, 1997).

Ceramic vessels were associated with human skeletons in about a third of the burial pits at Tutu. By bone collagen dating, some of those burials could be related to Assemblages 2, 3, and 4. The early or middle Saladoid vessels in two burials are decorated with painted designs. A third early or middle Saladoid burial with probable whole vessels, and all later burials with significant portions of vessels, however, include utilitarian-appearing undecorated vessels that may be crudely shaped, crudely finished, and/or fire-smudged. These vessels were not offerings in themselves but served a function for some other aspect of burial ritual.

The Tutu site has provided a large body of ceramic data, aspects of which still remain to be investigated. The middens spared from the Tutu site's extensive pre-discovery damage, however, did not represent the entire Ceramic Age sequence. Evidence of the early Ostionoid period is lacking; no pottery samples that might exemplify the Magens Bay I or II styles were encountered in midden strata or in any of the other examined contexts. Absent, for example, are "horned" attachments (rod-shaped lugs), red and black "painted plates," and vertical incising with "vestigial handles." In the radiocarbon dating evidence for the midden strata, the unrepresented gap extends approximately between cal. AD 800 and cal. AD 1200. Whether this gap in the ceramic collections is due merely to the extensive topsoil disturbance or actually to site abandonment during all or part of it, the ceramic evidence salvaged from the Tutu site is silent on the major change taking place in pottery form and decoration during that period.

To continue building and refining a Virgin Islands ceramic chronology, additional assemblages from discrete and dated stratigraphic contexts are necessary, for the periods represented in the Tutu samples as well as those that are not. The assemblage descriptions given here must be understood as representing just one village – and even that was subjected to the

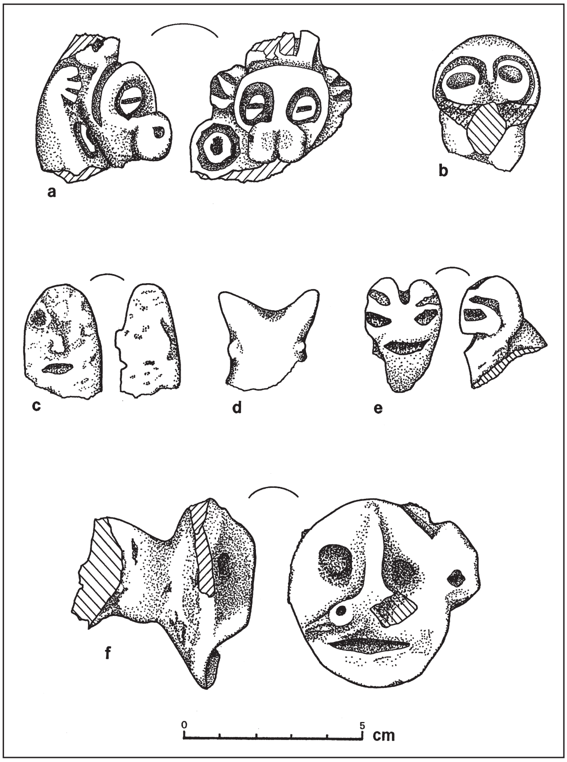

Figure 5.27 Unpainted, probably Ostionoid, modeled heads from mixed (a–d), post hole (e, from P-117), and late midden (f, from Trench 9) contexts of the Tutu site: (f) is crudely formed and poorly finished, of possible ear-spool shape. Items (a) and (f) are also shown in Figure 5.28(a) right and left respectively.

Figure 5.28a Modeled heads that may relate to the late Ostionoid occupation of the Tutu site, from a late midden context (left) and the surface. Also shown in Figure 5.27 (f) and (a), respectively (photographs by Robert Coates).

vagaries of archaeological sampling. This study, then, is only a first approximation at characterization of four Virgin Islands ceramic styles. Their type descriptions will need to be adjusted through other comparable information from several sites in order to improve increasingly their level of generality.

Figure 5.28b Various lugs and adornos from the Tutu site, mostly from surface contexts (photograph by Robert Coates).

Notes

1 Specimens illustrated in this chapter are as follows, listed in the alphabetical order shown in each figure:
Figure 5.2: 4-B-4; 5-B; 10-C-1a, 4/A, 5/A, 13; 11-B-137(a–j); 48-B-1(a–i), 102-B-1(a–l); 6-B-1/9; 6-B-1(a–f)/1a, 12, 17; 3-BI-43(a–c).
Figure 5.3: 6-B-1(a–d)/7, 50(a–e), 7, 62b; 4-B-43a, b; A1-PR4-44; 10-B2-14.
Figure 5.4: 3-BI-305a, b; 10-C-15b/A, 29; 4-B-66; SCS-Z.
Figure 5.5: 3-BI-207(a–c); 4-B-11l/11; 4-B-1a; 3-BI-234; 3-BI-244; 3-BI-53, 118, 147; 3-B(I)-17; 4-B-?; 3-BI-57; 3-BI-7; 4-B-4u/7; 4-B-2/11; 6-B-1/3a, b; 3-B-2a, b; 6-B-53a, b, 52(a–c); 4-B-1/4; 7-B-1.
Figure 5.6: 7-X-1a, b, 106-XB-8; 4-B-61(a–d); 3-BI-1a, b/2; 111-A1Z-1; 3-BI-1a, b/1, 3-BI-1/3; 3-BIII-5a; 6-B-1a, b/1, 2/1; 44-B-1a, b; 4-B-1(a–c)/W; 6-B-2/6, 1(a–g)/6.
Figure 5.7: A1-PR4-48; 4-B-3/11, 4La/11; 5-B-?; PR4-A1; SCS-Z; SCS-Z; SCS-Z; SCS-Z.
Figure 5.8: 31-BIIC-Grp. 2; 31-BIIC-Grp. 1.
Figure 5.9: 28-DF1-21(a–d), 9, 10; 31-BII-68(a–c)/3; 28-E-Be, 1, D-63; 31-BIIC-90(a–d); 31-BIIC-Grp. 2; 31-BIIC-25, 91(a–c)/13, 92a/13, BIIB-13(a–c)/5, BIIA53e, 54a, b; 28-B-46(a–c), 51b.
Figure 5.10: 28-D-54; 28-D-56, 65, 66(a–e), 74; 28-E-Ae; 28-D-37, R-5w; 31-BIIC-90(Ad); 31-BIIC-18; 28-D-21a, b; 28-D-20i, 9, 16, 215; 31-BIIC-93(a–d), 79; 28-E-Be, D-63; 31-BIIC-51; 28-B-69; 31-5mZ-6; 31-BII-21a; 31-BIIC-109, BIIA-71; 28-D-8; 31-RV-A-1a; 31-BIIB-17(a–c); 31-BII-67a/D.
Figure 5.11: 31-BIIC-97; 31-BIIB-15a, b/6; 31-RVII-D1a, b, 2, RV-S2; 31-BIIC-53, 80; Z@N2087/1950E 28-B-45(a–e).
Figure 5.12: 31-BIIC-93(a–d), 79; 28-D3a, 213, 83; 31-BII-77(a–c, f, g)/7, 28-B-73; 28-EF3-20; Z@N2090/1947E; 31-RIV-T1; 29-4-1(a–t).
Figure 5.13: 28-D-14, B-3, C-spi3124; 28-D-4; Z in N2095/1945E.
Figure 5.14a: Z bag 9003.
Figure 5.14b: 28-D-14, B-3, C-spi3124.
Figure 5.15: B-36 #3; B-36 #1; B-36 #2.
Figure 5.16: 1-D-7; 1-D-2; 1-I-35; 1-G-9, 10, 12–16, 20, 29; 1-H-1, 1-I-6a, b; 1-I-30a, b; 1-D-3, 10, 19a, b, e; 1-D-41(a–c), 1-X-4.
Figure 5.17: 1-G-25; 1-I-24; 1-H-1; I-6a, b; 1-D-36a, b; 1-I-19, 17b, 20a, b; 1-I-3; 1-D-2; 1-F-6(a–d); 1-D-1, 9a, b; 1-D-6.
Figure 5.18: B-13 #3; B-13-D, Klg, Hlf, Klc, 113(a–d)/E, A; B-13 no #.
Figure 5.19: B-4/7 no #s.
Figure 5.20: 26-B1-7(a–e); 25-C-30a, b; 26-B1-5a, b, 3a, b, 6a, b; 26-B2-1a, b; 26-B2-73(a–f), 32(a–l), 33, 34.
Figure 5.21: 26-B2-36(a–o), 20; 25-C-45; 26-B2-19; 26-B2-79; 26-B2-54; 25-C-12; 26-B1-9; 27-C-1; 26-B2-71a, b.

Figure 5.22: 26-B2-80; 25-C-43, 10; 27-B, bag 12,570.
Figure 5.23: 66-X-3; Zspi bag 46; Z scrape G in N2095/1835E; X; Tr10 bag 3302; Tr9 X.
Figure 5.24: A-1-2-15 (Z); Z bag 670; 34-B; Tr10-X.
Figure 5.25: both A4-Z (Josh).
Figure 5.26: Z bag 12,000; Z bag 673, N2094/1945E; F-21 @18-20cmbd.
Figure 5.27: Z@N2080/1880E; 105-Z-2; Z@N2085/1830E; Z spi bag 27; P-117, 0-4 cmbd; Tr9 S wall, 33cmbd, flot. 5.
Figure 5.28a: Tr9 S wall, 33cmbd, flot. 5.
Figure 5.28b: Z primarily Areas 1 and 9N.

Chapter Six

Investigation of ceramic variability at the Tutu site through acid-extraction elemental analysis

Emily R. Lundberg, James H. Burton
and Warren C. Lynn

Patterns in ceramic production have been determined through analysis of chemical element attributes of pottery samples from the Tutu site. In this study, pottery samples representing four chronological components of the settlement were analyzed, allowing rudimentary modeling of continuity and change in ceramic production processes. Sherd samples discussed here were investigated by the acid-extraction method of inductively coupled plasma emission spectroscopy (ICP). The acid-extraction ICP analyses provide measurements of the quantities of certain chemical elements extracted from the sherds.

Such compositional data primarily were sought as a means to further the investigation of variability within and between ceramic assemblages defined from the site, within a general ceramic research framework aimed at clarifying the local chronology. Chemical attributes offer a distinct data set that may have patterned interrelationships with other data sets, such as attributes of style and manufacture, that can be recorded observationally. Initial questions asked whether compositional variability might correspond to chronological or functional criteria. A secondary interest of the Tutu site research was investigation of paste mixtures and possible on-site clay resources for ceramic production.

Acid-extraction elemental analysis has been applied in numerous archaeological projects in the North American southwest, in service of local and regional research questions (e.g. Duff, 1994; Simon, Komorowski, & Burton, 1992; Stoltman, Burton, & Haas, 1992; White & Burton, 1992; Zedeño, 1995). Chemical composition studies of any sort have rarely been applied to Caribbean pottery, however, even though the few that have been undertaken have demonstrated the varied potential of such inquiry for the Caribbean (e.g. Carini, 1991; Gustave, Hubau, Belhache, Fabre, Ney & Schvoerer, 1991; Ortiz, 1993; Winter & Gilstrap, 1991). At present there is no similarly structured work to provide comparable results for the Tutu study.

This project has involved analyses performed at two different laboratories. In 1994, 24 sherds were analyzed by Warren C. Lynn at the Soil Survey Laboratory of the Soil Conservation Service (now the Natural Resources Conservation Service), US Department of Agriculture (USDA). Lynn analyzed that group of samples by acid-extraction ICP, conventional total-element ICP, and x-ray diffraction. Samples from 22 of those same sherds also were analyzed through acid-extraction ICP by James H. Burton in 1996 at the Laboratory for Archaeological Chemistry of the Department of Anthropology, University of Wisconsin-Madison (UWM), together with 49 other samples in the Tutu site study. In 1997 Burton analyzed an additional 56 samples by the same method, bringing the UWM Tutu study to a total of 127 sherd samples.

ACID-EXTRACTION METHODOLOGY

The acid-extraction method of compositional analysis measures elemental concentrations in a solution produced from the interaction of ground sherd material with dilute acid. The obtained results do not represent the total composition of the sherd, and therefore they are not comparable to results obtained from bulk compositional analysis methods such as conventional ICP, neutron-activation analysis, or x-ray fluorescence. Rather, results from the acid-extraction method reflect the acid-soluble components of the sample.

Clays and fired clays release significant quantities of the measured elements into acidic solutions, but most common minerals that would comprise the aplastic inclusions in a sherd, with the exception of carbonates, are only sparingly soluble in dilute acid. The measured elemental abundances thus are interpreted as mainly those released by the clay component of the ceramic paste, with minor contribution from the virtually insoluble mineral tempers. The acid-soluble components of sherds, however, are determined not only by the raw materials but also, to some extent, by the entire history of the sherd: from the firing methods used during the vessel's manufacture, through its contents and handling while in use, to its depositional environment and its post-excavation treatment. Therefore the elemental abundances obtained by this method do not reflect simply the raw materials of the paste. One of the strengths of this method, in fact, is this ability to investigate variability as determined by cultural factors (Burton & Simon, 1996).

In comparison to other methods of compositional analysis, the acid-extraction method uses relatively inexpensive and non-hazardous supplies in a simpler procedure that facilitates studies with larger numbers of samples. For the subject study the acid-extraction procedure described by Burton & Simon (1991, 1993) was used. Samples were prepared by abrasively removing any soil and the surface, including slip and pigment, from a small portion of each sherd and grinding the cleaned portion in an agate mortar. In the UWM procedure, 200 mg of the ground material from each sherd were combined with 20 ml of one-molar hydrochloric acid and kept at room temperature for two weeks, with intermittent agitation. The liquid portion (or "extract") was then decanted for ICP analysis. The USDA procedure incorporated minor modifications without significant effect.[1]

ICP spectroscopy identifies elements through detection of the characteristic wavelength of light emitted by each element. The UWM study used an ARL 3520 ICP spectrometer to measure the extract abundances of 12 elements: Al, Ba, Ca, Fe, K, Mg, Mn, Na, P, Sr, Ti, and Zn. Detection limits, ranging from 0.0038 parts-per-million (ppm) (Al) to 0.0001 ppm (Sr), are well below solution concentrations. Analytical precision, the critical parameter that determines how well the method can resolve different compositional groups, is excellent (< ± 4%) for all 12 elements, as determined by analyses of replicate extracts of the same material. Measured solution concentrations in ppm were multiplied by a dilution factor (extract volume/sample weight) to provide data as micrograms of extractable ion per gram of sherd (or extractable ppm). In order to obtain an inter-laboratory comparison, as a check on the method's potential for replication of results, the group of sherds analyzed in the USDA study was analyzed a second time by acid-extraction ICP in the UWM study. Abundances measured at the two laboratories were found to be highly congruent.

SAMPLE CHARACTERISTICS

The samples for the USDA analysis were selected by the Tutu site project director, Elizabeth Righter. Included were 21 Tutu site sherds, which represented a diversity of site contexts and stylistic categories. Also included, for comparison, were 3 sherds from the Main Street site on the southern shoreline of St Thomas. The materials recovered from that site represent a single component approximately contemporaneous with the earliest Tutu site component.

By the time that additional sherd samples were selected for the UWM analysis, study of the Tutu site's ceramic remains by Lundberg had identified four distinct ceramic assemblages representing four probable site components in chronological sequence, as well as various mixtures of aplastic inclusions used in sherd pastes. Accordingly, those variables were used as criteria for sample selection. Table 6.1 provides summary information about the sampled ceramic assemblages and the distribution by assemblage for sherds in the final enlarged UWM study. It may be noted that Tutu site Ceramic Assemblages 1 through 3 are linked in a continuous stylistic development in the Cedrosan Saladoid subseries. Here these are referred to as the "early" Tutu assemblages in contrast to the late period, Ostionoid series, Assemblage 4. (See Chapter 5 for detailed description and dating of Tutu site ceramic assemblages.)

Within each Tutu assemblage, samples were selected to represent sherd fabrics categorized by types of aplastic inclusions identified through Lundberg's low-power binocular microscope observations. (These inclusions are referred to here as temper, even though some portion of them may have been present in the clay when originally collected.) Pottery in all four assemblages is almost universally composed of fabrics containing abundant igneous rock grains in one of two general categories, which were each represented in the analysis by multiple examples of a number of their most common variants. Atypical fabrics were not included.

One of the two general temper categories is identified only as a heterogeneous mixture of altered rock fragments containing various minerals in light and dark colors. Grains in these mixtures usually exhibit rounding and include relatively large sizes (often larger than 2 mm). Within this broad "mixed sand" category which is based on types of primary inclusions, there are variations based on size ranges and on types of secondary inclusions present in lesser amounts.

The second general category of aplastic inclusions is more specifically identified by the dominance of felsic rock grains (light-colored, mainly quartz and feldspar). Variations are seen in the relative proportions of transparent, colorless quartz and opaque, white feldspar. They are usually associated with secondary inclusions of hornblende (observed as smaller black crystals). Frequently the grains exhibit angularity, and occur in size ranges that are relatively fine and uniform, suggestive of crushing and sieving.

In selecting representatives of each of these fabric categories for each Tutu assemblage, an attempt was made to select sherds with associated vessel information so that stylistic or functional categories could be investigated for coinciding patterns in the compositional data. The analyzed samples included sherds from fine ware and decorated vessels, utilitarian vessels, and griddles.

Table 6.1 Distribution by site assemblage for sherd samples in the UWM acid-extraction ICP analysis for the Tutu site

No.	*Assemblage*	*Approx. date range*[a]	*Ceramic style and subseries*
25	Tutu 1	cal. AD 100–400	Prosperity(?); Cedrosan Saladoid
26	Tutu 2	cal. AD 400–600	Coral Bay; Cedrosan Saladoid
30	Tutu 3	cal. AD 600–800	Longford; Cedrosan Saladoid
27	Tutu 4	cal. AD 1200–1500	Magens Bay III; Chican Ostionoid
6	Tutu, other[b]	—	—
2	Main Street site	comparable to Tutu 1	Prosperity(?); Cedrosan Saladoid
6	Magens Bay site	comparable to Tutu 4	Magens Bay III; Chican Ostionoid
5	experimental vessels from Tutu site clays	—	—

Notes

a Tutu assemblage dates are estimated from calibrated radiocarbon results and ceramic style, as discussed in Chapter 5.

b Sherds of this group are from less reliable stratigraphic contexts.

For comparison, the analysis also included 6 sherds from the Magens Bay site on the northern shoreline of St Thomas, provided by Elizabeth Righter from her excavations there on behalf of the US Virgin Islands territorial government. Although the Magens Bay site is multicomponent, the sherds selected for this analysis are stylistically roughly comparable to the latest Tutu site ceramic assemblage, Assemblage 4 (Chican Ostionoid). One sherd contained uniquely abundant calcareous sand and shell, while the other 5 contained felsic rock inclusions and hornblende, not unlike the felsic temper mixtures of the Tutu site.

In addition to the prehistoric sherds, 5 sherd samples included in this study derived from test vessels made with clays collected at the Tutu site during its excavation. Potter Betty Dalton collected clay from 18 locations at the Tutu site and, from the samples, produced wheel-thrown, small handcoiled, or pinched, bowls or saucers. Because the intention was only to test the workability of individual clays, no attempt was made to improve them with additional materials. Some of the test clays were sieved to remove aplastics, but no tempering materials were added. Of the vessels that were kiln-fired (usually at temperatures up to 1050°C) 19 did not completely fail at some point of production. Almost all of the test vessels exhibit defects such as cracks or spalls.

Of the 5 test-clay sherd samples, 3 were made from residual clays collected from in situ strata at the site, 1 was made from secondary clay accumulated on a machine-scraped surface, and 1 fired sample is not securely correlated with source information. These were selected for this study to represent a variety of types, based on source and aplastic inclusions. All contain mixed igneous rock inclusions similar to those in the majority of prehistoric sherds from the site, but the inclusions are present in much lower amounts than in most of the prehistoric sherds (they are between 5% and 25% of fabric versus between 25% and 40% of fabric). All also contain bits of shell, which are rare in the Tutu site's prehistoric sherds (and which probably filtered down into "sterile" clay strata through the soil activity of worms, insects, roots, and so forth).

RESULTS

Methods of evaluation

The quantitative results of the acid-extraction ICP analyses were explored with a variety of mathematical treatments in order to identify patterns within the data. Elemental concentrations were converted to logarithm values, and a principal-components analysis was performed on the log-transformed data. Both the raw (log-transformed) data and the factor scores for the most significant principal components were examined graphically and through clustering algorithms that measure similarity among the results for the sampled sherds.

Such mathematical operations were first applied by Burton to the acid-extraction data produced by Lynn for the samples in the USDA study, and they were found to provide strong patterns that correspond with temper data for the samples. Subsequently Burton applied similar treatments to the UWM elemental data pertaining to the enlarged sample universe. Those results will be discussed here.

The clustering treatments for the chemical element data (which included complete-linkage and Ward's method, for both principal-components results and variously treated data for all 12 measured elements) yield hierarchical linkage patterns that identify groups, or clusters, of similar sherd samples. Although the sample groupings differ somewhat by each clustering method, certain trends remain evident throughout all. By comparison of several different sets of clustering results, it is possible to identify relatively strong and stable patterns that may be evaluated against other data.

One approach to evaluating the acid-extraction results is to compare groupings of sherds already recognized on the basis of other criteria with groupings of sherds based on chemical element similarity. Three such comparisons are useful for this study.

First, in order to address one of the study's original research questions, sherds grouped according to assemblages representing different chronological periods may be compared to sherd groups based on the elemental data. Correspondence here was partial: some chemically similar sherd clusters had distinctive assemblage representation but others had none. Comparison of a second data set – that of the temper categories described above – shows a higher overall correspondence with chemically similar sherd clusters based on any method of mathematical treatment and specific correspondence with assemblage-distinct groupings. As will be explained below, the best correspondences with the elemental data concern not just one or the other of these factors but interrelationships of assemblage and temper variables.

A third comparison, prompted by the original research questions, compares sherd groupings based on vessel type to groupings based on the elemental data. The sherds in the study were categorized in 6 vessel-type groups with functional implications: griddle; jar; utilitarian bowl (thick-walled, hastily smoothed); fine-ware vessel (thin-walled, carefully smoothed, often decorated); white-on-red painted vessel; and unidentified/other. Correspondence of these groups with chemical-based sherd groups was not evident, except to the extent that some vessel-type groups (or subsets of them) are limited to certain assemblage or temper categories. The most specific vessel categories (griddle, jar, and white-on-red vessel) have no recognizable correspondence with any compositional cluster. The categories of utilitarian-ware bowl and fine-ware bowl do not wholly coincide with any compositional cluster, although some compositional clusters have a preponderance of one or the other that also corresponds to temper patterns.

Patterns of temper

Specific relationships of variability in temper and chronological affiliation to variability in extractable elemental composition are demonstrable in a dendrogram that illustrates sample-clustering results for the elemental analysis based on the principal-components mathematical treatment, which provided relatively distinct patterning in the elemental data. The principal-components mathematical treatment essentially reduces the original 12-element data to a smaller number of different variables that express most of the variance in the original data. These new variables, four principal-components scores, were used in a clustering operation that generated the dendrogram in Figure 6.1.

In Figure 6.1, each fine line at the left represents an individual sherd sample, which is identified by number in the original output but cannot be individually labeled at the reduced scale shown here. The linkages in the dendrogram express the chemical similarity among the samples, as determined by the mathematical clustering treatment. (This similarity is not based on any single element or element combination; rather, it might be described as their "proximity" in 12-dimensional space based on the 12 elements measured by the acid-extraction ICP analysis.)

Six main sherd clusters of the dendrogram have been labeled A through F for reference. When the sherd membership of those clusters is examined by assemblage and temper variables, it is apparent that there is significant correspondence. The descriptions of clusters A through F in the figure indicate the correspondence of these other data sets with the chemically-based clusters.

When the dendrogram is compared to other data sets for the sherds, its most salient pattern for major clusters reflects the contrast between the two main temper categories of sherds in this study. The clusters labeled C and D almost exclusively comprise sherds with selectively felsic, largely angular temper. (A single sherd of different temper in cluster D is one of the two from the Main Street site, which are linked together by this method.) Specific mineral composition of the temper, which varies in proportions of quartz, feldspar, and hornblende, seems not to have any effect on membership of these clusters or their subgroups.

In contrast to clusters C and D, the other four major clusters are mostly composed of sherds with coarse rounded grains, or sands, of altered mixed igneous rock. Those clusters do not completely coin-

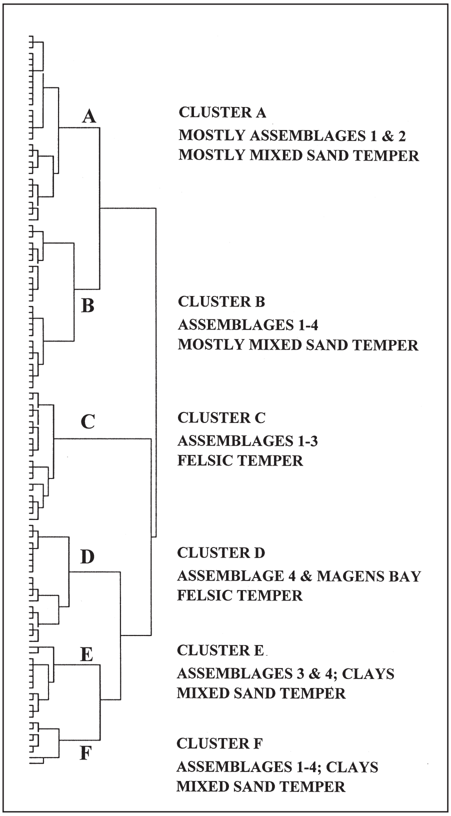

Figure 6.1 Dendrogram results of cluster analysis by the Ward method (Euclidean measure) for the first four principal-components scores of the UWM Tutu study acid-extraction elemental data, with summarized assemblage and temper characteristics for 6 clusters of chemically similar sherds (figure by J. H. Burton).

cide with that temper category; however, 13 (21%) of the members of clusters A and B are classified as having predominantly felsic rock temper. This variation from the general pattern shows, first, that temper materials, though strongly correlated with acid-extraction elemental variability, are not the primary cause of such variability but rather, in this study, are good indicators of acid-extraction elemental variability from other sources, most likely to be the clay. The correlation is persuasive evidence for ceramic paste "recipes," whereby particular temper materials were used with particular clays, or perhaps with particular production methods.

Furthermore, all the felsic-temper samples that are aberrant in clusters A and B derive from Tutu site Assemblages 1 and 2, and mostly from Assemblage 1. For Assemblages 3 and 4, therefore, these data completely support a hypothesis for the use of specific paste recipes in ceramic production. Such recipes evidently were less rigid for the earlier assemblages. Visual observations also corroborate the more mixed and variable nature of aplastics in the earliest Tutu sherds.

The mixed-temper clusters of Figure 6.1, like the felsic-temper clusters, do not evidence much patterning for the temper variants within that general category. It is interesting, in fact, that more detailed petrographic information available from Burton's review of 54 thin sections of sherds in this study, and from point-count petrographic identifications of aplastics in 14 samples by Spectrum Petrographics Inc. (DePangher, 1996, 1997), was less useful for comparisons with the acid-extraction elemental results than was the gross temper categorization. The point-count data indicate, also, general similarity of mineral composition and parent lithology for aplastics in all samples. To large degree the contrast between the two temper categories lies in the weathered nature of the coarse inclusions in the mixed igneous sand category, along with conspicuous rounding in most cases. In short, the two temper categories appear to be distinguished less by ultimate source than by collection and preparation procedures in the ceramic production process. The fact that the acid-extraction data correspond with this dichotomy in production suggests that it involved clay selection as well.

Patterns of chronological distribution

With regard to chronological distinctions between the major clusters of Figure 6.1, clusters C and D strongly contrast with one another. Cluster C is composed of sherds from only Tutu Assemblages 1, 2, and 3. Within it, a number of Assemblage 3 sherds are closely associated as a subgroup, and that association persists through other mathematical treatments as well. By contrast, cluster D comprises Tutu site Assemblage 4 sherds (with 1 aberrant member), together with 2 Main Street site sherds and 5 of the 6 Magens Bay site sherds. Those 5 Magens Bay samples are strongly linked, by all methods, as a distinct subgroup within this cluster. These results clearly indicate that among felsic-temper sherds there is a chemical distinction between sherds related to the Tutu site's early (Saladoid) components and those related to its late (Ostionoid) component: with sherds of the late Magens Bay component are similar to the latter. That same pattern is apparent by other mathematical treatments as well. In the absence of information to implicate vessel function or other factors, it may be hypothesized that the chemical separation of sherds related to early and late site components for these felsic-temper sherds is mainly related to clay selection or vessel production technique.

With regard to the 4 clusters of Figure 6.1 that are mainly composed of sherds with mixed sand temper, clusters A and E have patterned chronological associations. The sherds of cluster A derive predominantly from Assemblages 1 and 2 (out of a total of 33, there are 4 aberrant members from Assemblages 3 and 4). Cluster E is dominated by Assemblage 3 sherds characterized by minor amounts of calcareous inclusions. Its other members are 2 sherds of Assemblage 4, which lack obvious calcareous inclusions, and 3 fired clay samples from the Tutu site. This affiliation is robust throughout various mathematical treatments of the chemical data.

Clusters B and F lack chronological patterning, suggesting possible continuity in some production processes involving mixed sand temper. Cluster B is highly mixed, with multiple sherds from each of the four Tutu assemblages. Cluster F also is chronologically mixed and represents an unstable association including samples that, in different mathematical treatments, usually are only weakly linked to any cluster.

Although some chronological patterning among mixed-temper groups is detectable in results of any clustering operation, the patterns are much less stable than those for the felsic-temper groups. Most stability is within subgroups that associate particularly similar sherds. At the higher levels of linkage, various cluster results for all 12-element variables associate many of the mixed-temper sherds in ways different from the principal-components pattern in Figure 6.1. In place of a distinctive clustering of Assemblages 1 and 2, for example, there may be a clustering of Assemblages 1 through 3 and another of Assemblages 1, 2, and 4. These findings do not reveal a chronological significance for most of the acid-extraction elemental variability in wares having mixed sand temper at the Tutu site. For sherds of this temper type, there is perhaps greatest elemental similarity between Assemblages 1 and 2, and greatest distinction for a ware associated with Assemblages 3 and 4.

Fired clay test samples

The results for the fired clay samples are intriguing with respect to that same robust cluster of sherds of Assemblages 3 and 4. Although 2 of the test clays are outliers or highly unstable among sherd clusters generated from the elemental data by various methods (i.e. highly dissimilar to other samples in the study), the 3 residual clays almost invariably are closely linked to the sherds of that cluster (cluster E in Figure 1). Inasmuch as aplastic content, usage, or deposition are not the basis of this chemical similarity, a strong similarity of clay is likely.

Summary

The most informative results of this study concern the interrelationships of variability in temper, chronological affiliation, and acid-extractable elemental composition. It can be demonstrated that there are elemental differences between sampled sherds of mixed igneous sand temper and those of distinctively felsic temper, and that within the latter temper category there also are elemental differences between sampled sherds of the early Tutu site Assemblages (1, 2, and 3) and those of the late Tutu site Assemblage (4).

These general results are illustrated in Burton's discriminant function plot of Figure 6.2. The discriminant analysis used three pre-defined groups of Tutu site sherds, for which the mathematical operation on the acid-extracted elemental data identified distinguishing variables that verify the distinctiveness of the three groups. The pre-defined groups, as identified through the dendrogram patterns discussed above, were:

1 sherds with felsic temper from Assemblages 1 through 3,
2 sherds with felsic temper from Assemblage 4, and
3 sherds with mixed sand temper from all assemblages.

Essentially this analysis asks whether a systematic compositional difference can be found among the three groups (in the 12-dimensional space of the 12 element variables) and can be displayed on a 2-dimensional graph using the two best combinations of the original variables. The results in this case confirm that the temper and chronological differences indeed are reflected in measured chemical differences. The two functions graphed in Figure 6.2 identified 92.5 percent of the sherds in their correct temper/assemblage category.

In Figure 6.2, the distinction between temper groups is shown by the separation between sample groups in roughly the left and right halves of the plot. The distinction between early and late Tutu site components, within the felsic-temper group, also is shown. Within the mixed-temper category for Tutu, distinct groups are not formed on the basis of chronological affiliation.[2]

Results for the 114 Tutu site sherds may be compared to the results for other samples in the study, which were not included in the three pre-defined groups of the discriminant function analysis. The results for these other samples have been added to Figure 6.2 using the same functions. The 2 sampled sherds from the Main Street site produced inconclusive results and were insufficient in number to form any pattern. At most it can be concluded that these 2 sherds are not particularly similar to Assemblage 1 sherds representing a perhaps contemporaneous first occupation at the Tutu site. The 6 sampled sherds from the Magens Bay site divide chemically in correspondence with temper material. The felsic-temper sherds of that site form a chemically distinct group that is most similar to like-tempered sherds of Tutu's Assemblage 4, as is illustrated by the position of the 5 grouped Magens Bay sherds in Figure 6.2. Of the experimentally produced sherds from clay collected at the Tutu site, 3 are chemically similar to some of the analyzed pre-Columbian sherds.

SIGNIFICANCE AND POTENTIAL

The chemical characterization of sherds in this study has provided an attribute set that, when considered in conjunction with other data, proves useful for developing conclusions with cultural implications for the Tutu site. The analysis distinguishes chemically related sherd groups that have been compared to groups based on other variables. This comparative investigation is made possible by the availability of corresponding data sets for the samples, including attributes of aplastic inclusions in sherds, attributes of vessel morphology and style with functional implications, and chronological classification allowed by the strict control of assemblage definition for the Tutu site. For its part, the acid-extraction elemental analysis has added a dimension that improves perspective on existing hypotheses of ceramic production at the site and suggests new ones.

The elemental data for Assemblages 2 through 4 work in conjunction with the temper data to show that variability in temper, at a broad level, coincides with that of other factors that determine extractable elemental composition. These findings suggest that Tutu potters used particular "recipes" for pottery production. The evidence is strongest for Assemblages 3 and 4, in which felsic temper that appears to have been specifically selected and prepared coincides only with one major cluster of chemically similar sherds for each assemblage. The pattern is weaker for Assemblage 2, however, and is not upheld at all for sherds of Assemblage 1. This strong evidence for some sort of change in the processes of pottery production could be explained by the gradual establishment of proven pottery recipes following initial experimentation with local resources. The distinct production recipe suggested by the felsic-temper cluster of Assemblage 4 sherds could result either from such an evolution or from the introduction of new ideas before that time. The temporal hiatus in midden remains between Assemblage 3 and Assemblage 4 at the Tutu site currently prevents evaluation of such various possibilities.

Regarding vessel style and function, negative evidence from the elemental analysis supports a conclusion formulated from the visual study of sherds. Originally it was suspected that the contrast between thin, polished, and beautifully formed fine-ware vessels and thick, hastily smoothed utilitarian vessels might be reflected in paste characteristics. Aplastic inclusions in sherds, however, were found to have poor correspondence with these vessel categories, especially in the two earliest assemblages. In the chemical evidence there is no indication that other paste or production factors fully co-vary with vessel function or decorative class either.

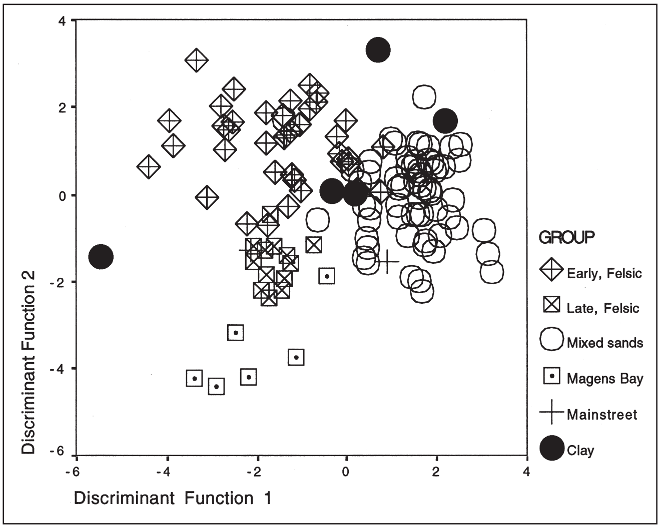

Figure 6.2 Plot of canonical discriminant functions illustrating mathematical separation among the acid-extraction data for three groups of Tutu site sherds, and the relationship with the data for Magens Bay sherds, Main Street sherds, and clay-test sherds (figure by J. H. Burton).

From the information at hand, therefore, it seems that particular pottery recipes were not reserved exclusively for particular vessel categories, at least not for the broad vessel distinctions that were possible from the fragmented Tutu site sherds. This is true of any Tutu site component, although the degree of correlation between fabric and vessel type appears to differ between site components. It is particularly noteworthy that for the early Cedrosan Saladoid material, fine wares and white-on-red vessels are not chemically distinguished. In a study that chemically analyzed early Saladoid series sherds of Puerto Rico, St Croix, and St Martin, Carini (1991) also found chemical similarity among stylistically divergent sherds. In the analyzed Tutu material, furthermore, the earliest component is not distinguished by separate clusters of chemically similar sherds such as might suggest a general practice of importation of clay or vessels from a former homeland.

Another area in which the chemical element data corroborate the temper data is in the indication of longevity for some aspects of pottery production at the Tutu site. The most common temper materials remain essentially constant throughout the site's periods of occupation, varying only in minor ways. In the chemical data, as well, it is seen that there can be much similarity among sherds of four site components. This perhaps would be explained by utilization of nearby resources throughout the site's occupation, and/or by considerable cultural continuity. Mixed igneous sands local to the site could have been used as one of the major temper categories, which is related in parent lithology to pebbles in site soils and even to the aplastic grains in clay strata sampled below excavated deposits (cf. DePangher, 1996, 1997).

Tutu project researchers were interested also in the possibility of on-site clays having been used for pottery production. This study cannot provide a clear answer to that question, but, at the same time, its results do not rule out that possibility. Only one of the five clay samples in this analysis consistently falls outside the principal clusters formed for the pre-Columbian sherds on the basis of similarity of extractable elements. Four show similarities to Tutu site sherds, and three of those are strongly linked to a distinct group of sherds from Assemblages 3 and 4. These results are encouraging for further investigation into the possibility of site-local resource procurement for at least some ceramic wares. Chemical match between Ostionoid sherds and on-site clay deposits also was reported by Ortiz (1993), for the Ojo del Buey site of Puerto Rico.

Running counter to the evidence for continuity are indications of discontinuity in manufacture of particular wares at the Tutu site, a finding that is evident only in the chemical data and not in the observed attributes of fabric. Notwithstanding a general pattern of similarity among Assemblages 1, 2, and 3, one or more production recipes for mixed-temper ware seems to have been mostly abandoned during the period associated with Assemblage 3, and another was adopted or at least became more prominent. This is consistent with stylistic evidence that distinguishes Assemblage 3 from its predecessor while manifesting continuity within the Cedrosan Saladoid development (Lundberg and Righter, 1997; also Chapter 5, this volume).

The clearest discontinuity seen in the chemical element data occurs between Assemblage 3 and Assemblage 4, which are separated by a temporal gap and which relate to different ceramic series of the regional chronology. The chemical dissimilarity between sherds of Assemblages 1 through 3 and those of Assemblage 4 concerns only the sherd groups with specifically felsic temper, however. As noted above, the mixed-temper sherds of Assemblage 4 share chemical similarities with sherds of Assemblages 1 through 3. If various pottery recipes coexisted in all site components, then it seems that they had individual trajectories, with the most specialized recipes subject to greatest change. It may also be noted that none of the fired clay samples showed chemical similarity to the groups of sherds possibly associated with such specialized recipes, and consequently those sherds might represent off-site procurement or special preparation of clay to obtain a product with specific properties. To be sure, the interrelationships of these various data sets are complex and possibly affected by unexamined factors, but at present a hypothesis of coexisting ceramic wares associated with differing resource procurement, production methods, and rate of change explains patterns of variability seen in the available information. Encompassed therein is much fertile ground for further investigation.

Finally, results for the small sample of Magens Bay site sherds included in this study provide a mere glimpse of the wider-scale potential of this type of analysis. Magens Bay sherds form a cluster that is more like Tutu's late assemblage (4) than like any of its earlier assemblages, but is still distinguishable from it. It thus is very likely that compositional research structured to compare specific cultural components at multiple sites could productively address inter-settlement and inter-island relationships in the Virgin Islands and surrounding areas.

NOTES

1 The procedure used in the USDA analysis differed by the use of minimum 100 mg ground sherd samples (variable, with weights recorded), oven-drying, and a three-week equilibration period. It also allowed for the application of three analytical methods to the same small sherd samples by a careful processing order:

  1 slurry mounts of ground sherd samples were put on slides with distilled water for the x-ray diffraction trace,
  2 these samples were quantitatively transferred to the HCl equilibration container by immersing the slide, and,
  3 after the acid-extraction clear solution was decanted for ionic ICP analysis, the sample was quantitatively transferred to the HF digestion vessel to obtain the standard-procedure (total-element) ICP sample.

2 Translated to extracted concentrations of particular elements, the discriminant function analysis indicates that the acid extracts from mixed-temper sherds as a group returned significantly higher measurements of iron, calcium, magnesium, manganese, and zinc than did those from the felsic-temper sherds. The early felsic-temper sherds differ from the later ones in returning higher measurements of aluminum, barium, and phosphorus and lower measurements of sodium, strontium, and titanium.

Chapter Seven

Biological adaptation in the prehistoric Caribbean: Osteology and bioarchaeology of the Tutu site

Mary K. Sandford, Georgieann Bogdan
and Grace E. Kissling

INTRODUCTION

From the field to the laboratory, osteological analyses of the Tutu material have involved a massive multidisciplinary effort. Results of some of the specialized studies sparked from this invaluable material are included within this volume (see Chapters 8, 9 and 10). Similar reports are expected to continue for years to come. The current chapter presents an overview of the osteological analyses of the human skeletons from the Tutu site. A discussion of theoretical and methodological approaches to paleopathology is followed by a brief review of previous osteological studies of Caribbean samples. Field and laboratory methods employed in investigating the Tutu skeletons are next described. Results of the investigation are summarized and interpreted, focusing first on the composition of the sample with respect to demographic, spatial and temporal variables. A discussion of burial practices, health and lifeways is then presented in the contexts of the Tutu site and the prehistoric Caribbean.

PALEOPATHOLOGY: HISTORY, THEORY AND METHOD

The potential of skeletal material to mirror the effects of past diseases or nutritional disorders was recognized many years ago (see reviews in Buikstra & Cook, 1980; Ubelaker, 1982; Sandford, 1993a: 15–17). Ubelaker (1982) traces the beginnings of the field of paleopathology to 1774 with the published account of a possible neoplasm in a fossilized cave bear. And, for the next century, sporadic case studies involving extinct fauna dominated paleopathology. Prior to the 1930s, and for a number of years thereafter, virtually all studies of paleopathology applied a strict clinical approach to skeletal material. Thus, paleopathology developed historically out of a clinical model which placed emphasis on the detailed, painstaking description and differential diagnosis of individual cases (see discussions in Buikstra & Cook, 1980; Ubelaker, 1982; Sandford, Bogdan & Kissling, 1997). Although some scholars were interested in tracing the history of specific diseases, such as syphilis (Whitney, 1883), few researchers attempted to interpret diseases in comparative contexts or in the light of cultural and/or environmental variables.

Since its inception, paleopathology has undergone monumental changes. Among these, several crucial turning points in the history of paleopathology help frame the broader context of the present investigation. These events include the introduction of the paleoepidemiological approach (Hooten, 1930), the call for a "new" physical anthropology (Washburn, 1953) and subsequent revitalization of paleoepidemiology (Armelagos, 1969) and, most recently, the application of newer models and standardized terminology to the study of paleopathology (Buikstra & Ubelaker, 1994).

Hooten's analysis of human skeletons from Pecos Pueblo represented a significant departure from the diagnostic–clinical approach, by interpreting diseases in the light of cultural and/or environmental factors (Hooten, 1930; also see discussion in Ubelaker, 1982). Rather than simply describing or listing pathological lesions, Hooten, in inaugurating the paleoepidemiological approach, provided data on the frequency with which certain conditions occurred in his sample. In addition, he placed specific types of pathology in temporal and cultural contexts to investigate changes in disease patterns over time. The use of paleoepidemiology as a tool for delineating cultural and environmental risk factors of past diseases paralleled methods and perspectives used by epidemiologists for studying contemporary diseases and disorders.

Paleoepidemiological approaches to disease and nutrition received a considerable boost beginning in the 1960s and 1970s (for examples, see Armelagos, 1969; Cohen & Armelagos, 1984). A number of factors influenced the growth of paleopathology during these decades (see especially Buikstra & Cook, 1980: 444). An important influence in this regard was Washburn's (1953) earlier appraisal of physical anthropology which sharply criticized studies that emphasized typology and description. Washburn envisioned a "new" physical anthropology focused on problem-oriented research and interpretation. Concurrently, proponents of the new archaeology underscored the importance of environment and subsistence patterns in understanding cultural processes, thus fostering additional investigations on the relationships between disease and diet (see discussion in Willey & Sabloff, 1974; Sandford, 1993a: 5–7).

Paleoepidemiological perspectives are quite commonly employed by paleopathologists today and certainly influenced the research reported herein. The hallmark of this approach, often referred to as the "biocultural" perspective, stresses the interaction between biology, ecology and culture in contributing to problems of disease and nutrition in the human past. In conjunction with paleoepidemiology, much greater emphasis was placed on "nonspecific indicators of stress" including linear enamel hypoplasias, periostitis and Harris lines (see discussion in Buikstra & Cook, 1980: 444–54).

While such perspectives can be quite useful in discerning trends relating to past health and disease, other scholars have focused on the needs to define the underlying processes responsible for specific lesions. In this connection, collaborative efforts between clinicians and physical anthropologists, fostered through workshops sponsored by the Paleopathology Association (Ragsdale, 1995; Ragsdale & Ortner, 1992), have resulted in a new call for rigor in describing, interpreting and diagnosing skeletal lesions (Buikstra & Ubelaker, 1994: 107–8). These perspectives have influenced our research on the Tutu skeletons in several fundamental ways. For example, as explained further below, our protocols for describing and classifying skeletal pathology were adapted from this approach. In particular, we have categorized skeletal lesions using groupings that reflect physiological and mechanical processes responsible for their formation.

OSTEOLOGICAL ANALYSES OF PREHISTORIC CARIBBEAN SAMPLES

Against this background, it is unfortunate to note that systematic studies of Caribbean skeletal samples, using contemporary techniques and perspectives, have been the exception, rather than the rule. In most instances, investigations of skeletal remains have been initiated by the accidental discovery of archaeological sites, if not the skeletons, themselves. Consequently, most of the reports on such material have a very limited scope, as they are compiled to fulfil contractual obligations. Moreover, many of these reports are of a purely descriptive nature often containing little more than lists of measurements, assessments of age and sex and other observations. Very few notations of skeletal anomaly or pathology are accompanied by contextual information on either the lesion itself, or the biocultural conditions that may have fostered its occurrence.

Despite these limitations, by reviewing these sources, we have gained valuable comparative information on topics ranging from burial customs to possible pathologies. In some instances, photographs and/or descriptions of lesions (Budinoff, 1991; Ubelaker, Murray & Watson, 1988; Lopes & Torres, 1992) have been helpful in assessing patterns of skeletal morphology and lesions in the Tutu remains. In St Thomas, prehistoric human remains have been recovered from Magens Bay (deBooy, 1919) and Botany Bay (Ubelaker, 1977), while the St Croix sites of Salt River (Rainey, 1940), Aklis (Doran, n.d.), Estate Judith's Fancy (Figueredo & Winter, 1986) and Cane Bay (Ubelaker *et al.*, 1988) also have yielded human burials. Reports on other human remains from the US Virgin Islands include those of the Calabash Boom site (Calhoun & Harper, n.d.) on St John and the historic Landing Bay site on Water Island (Buxton, Trevor & Julien, 1938). In Puerto Rico, several sites, including Maisabel (Budinoff, 1991), Hacienda Grande (Walker, 1985b) and Punta Candelero (Rodríguez, 1995), and a large museum collection (López & Torres, 1992), have provided useful information on human remains. Other comparative reports used in the present investigation are from such locations as the Bahamas (Keegan, 1982), the Lesser Antilles (Versteeg & Effert, 1987; Schinkel, 1981), Cuba (Valdes & Rivero, 1972; Tacoma, 1991), Jamaica (Flower, 1891, 1895; Haddon, 1897) and Suriname (Khudabux, Maat & Versteeg, n.d.).

Although the reports to date have been produced by different researchers under diverse field and laboratory conditions, some generalizations about burial practices and skeletal conditions in the prehistoric Caribbean can be offered and provide an interesting framework for considering the Tutu sample. For example, artificial cranial deformation, usually involving fronto-occipital flattening, has been reported for many sites in the Caribbean (e.g. Flower, 1891; Tacoma, 1991; Keegan, 1982). Examples of actual types of pathology include traumatic lesions reflecting fractures (Valdes & Rivero, 1972), and, in some instances, the possibility of interpersonal violence (Budinoff, 1991). Also, there are some indications of nutritional disorders, possibly involving relative deficiencies of iron (López & Torres, 1992). Reported dental conditions include severe occlusal wear, non-occlusal wear (Calhoun & Harper, n.d.; Budinoff, 1991), antemortem tooth loss, and periodontal disease (Doran, n.d.; Ubelaker *et al.*, 1988; Budinoff, 1991): these are discussed in greater detail by Larsen and coworkers (see Chapter 8). Finally, significant upper body strength (Figueredo & Winter, 1986) and osteoarthritic changes, particularly in the elbows and vertebrae, have been noted by some researchers of Caribbean skeletal samples (Ubelaker, 1977). In this connection some investigators have proposed specific activity patterns, including canoe paddling, to explain these skeletal patterns (Calhoun & Harper, n.d.).

Also of interest are reports of bone inflammatory lesions, probably indicative of infectious disease, from a number of Caribbean sites. As discussed further below, skeletal lesions that were likely caused by treponemal disease, a category of infection that includes the contemporary diseases of syphilis and yaws, were quite common in the Tutu collection. While the differential diagnosis of treponemal disease had not been offered previously for human remains found in the immediate vicinity of St Thomas, similar conditions have been noted in material from Puerto Rico (Budinoff, 1991; Lopes & Torres, 1992). Sappelsa (1993) found the lesions described by Flower (1895) on a tibia from a site in Jamaica to be quite similar to those seen in treponemal disease. Another site for which the provisional diagnosis of treponemal disease has been made in a pre-Columbian sample is the Kwatta Tingi Holo site in Suriname (Khudabux *et al.*, n.d.).

MATERIALS AND METHODS

Assessment of human remains from archaeological contexts involves many stages that are initiated in the field. Ideally, the actual disinterment of skeletal material does not occur until all bones and associated grave goods are exposed and documented through scale drawings, field notes and photographs.

During the excavation of the Tutu site, the use of standardized burial forms maximized the amount of information gleaned from human remains. Orientation and position of the skeleton, size and depth of the burial pit, and method of interment were all noted during excavation (Sandford, Weaver, Larsen, Russell & Righter, 1992; Righter, Sandford & Sappelsa, 1993). Wherever possible, excavators also made preliminary osteological observations, including an initial inventory, in situ measurements, and preliminary assessments of age, sex, and pathology. In situ photographs, including black and white and color slides and prints, were made of all burials. All burial soils were screened sequentially through 0.635 cm ($^1/_4$ in.) and 0.3175 cm ($^1/_8$ in.) mesh screens or sampled for other purposes including trace element, phytolithic and pollen analyses. In addition, excavators collected between 15 and 40 liters of soil either for flotation or fine screening through 0.159 cm ($^1/_{16}$ in.) mesh screen cloth.

After the burials were transferred to the Physical Anthropology Research Laboratory at the University of North Carolina at Greensboro in the fall of 1991, undergraduate laboratory assistants, supervised by Dr. Sandford and by graduate assistant Laura Sappelsa, helped to clean and label skeletal material. Skeletal remains were washed in distilled-deionized water, reconstructed and labeled. Skeletal inventory and analysis were completed using a detailed form; laboratory records were checked against field notes and burial forms. The degree of preservation for each bone and tooth was noted along with the presence of any possible pathology or anomaly. The age and/or sex of each individual was assessed using criteria described below. Other information entered on the inventory forms included any specialized studies that were performed on the burials, such as radiographic, isotopic, and/or elemental analyses.

Skeletal material from the Tutu site was extensively documented through both traditional photography and computerized imaging in the Scientific Visualization Laboratory in the Physical Anthropology Research Laboratory at the University of North Carolina at Greensboro. Laboratory photographs were made of all age and sex indicators, pathological conditions, and dentitions. Both black and white and color slides were made using a Nikon EM 35 mm camera. A photography log, containing a description of all photographs and copies of all negatives and proof sheets was maintained. Color slides were archived in a separate notebook, where they were cataloged by burial number and consisted of both field and laboratory photographs. All slides and negatives were digitally scanned, using a Nikon 35 mm Film Scanner (Model LS–1000) and a Hewlett-Packard ScanJet IIcx and stored on CD-ROM using a Hewlett Packard Sure Store (Model 4020i). In this manner, images can be easily shared with other researchers, uploaded and studied using such programs as Adobe Photoshop. All of the photographs in this report were produced using Adobe Photoshop Deluxe, Version 3.0.

AGING TECHNIQUES

In the present study, multiple age indicators were used, whenever possible, to arrive at the best possible estimate for age at death. Such methods are derived from normal physiological processes which are reflected in distinctive ways by different regions of the skeleton. Hence, the techniques used in assessing the age of infants, children and adolescents are based on events related to growth and development including tooth formation, dental eruption, longitudinal growth, endochondral ossification and epiphyseal union. The eruption and calcification sequences used in assessing the ages of individuals from the Tutu site can be found in Bass (1987) and Ubelaker (1989) and are based on Native American samples (Sappelsa, 1993; Sandford *et al.*, 1997; Chapter 8 this volume). On the other hand, endochondral ossification provided the basis for estimating subadult age using diaphyseal length (Ubelaker, 1989: 65–69; Krogman & Iscan, 1986: 55–58) and epiphyseal union (Webb & Suchey, 1985; Krogman & Iscan, 1986; Ubelaker, 1989). While epiphyseal union is most useful in aging children and adolescents, some epiphyses, including the medial clavicle and iliac crest, can be quite useful in estimating the age of young adults (Webb & Suchey, 1985).

Patterns of dental formation and eruption were often considered in conjunction with estimates generated by epiphyseal union sequences. In some cases, estimates derived from dental ages differed from those based on epiphyseal union (see Sappelsa, 1993). In these instances, we used the age estimate based on dental development, since dental formation and eruption are generally felt to have higher heritability than processes regulating longitudinal growth (White, 1991: 108).

As with subadult aging, when possible multiple age indicators were assessed for adult skeleton. Such indicators, including metamorphoses of the pubic symphyses and auricular surfaces, dental attrition, and osteoarthritic changes, reflect the cumulative effects of physiological and mechanical processes on specific regions of the skeleton. In response to such wear, bone is remodeled by osteoblasts and osteoclasts in ways that leave distinctive changes on different areas of the skeleton (see Canalis, 1990 for a review of bone remodeling mechanisms).

The most widely used methods for aging adult individuals are based on changes to the symphyseal face of the os pubis. Although such changes were first formally described by Todd (1920; see also Krogman & Iscan 1986: 148–53; Ubelaker, 1989: 75–76), we employed the Suchey-Brooks technique (Brooks & Suchey, 1990) for deriving age estimates from this structure. Age estimates using preserved auricular surfaces of the os coxae followed the techniques of Lovejoy and coworkers (1985). In contrast, cranial suture closure (Meindl & Lovejoy, 1985) was much less useful, because many of the Tutu skulls had been damaged by heavy earth-moving equipment prior to the beginning of archaeological excavations. In some instances, however, we were able to use individual sutures, such as the basilar and maxillary/palatine sutures (Mann, Symes & Bass, 1987), for age estimation. Finally, due to the small sample size and extreme enamel wear, we employed dental attrition solely to help define general age ranges for adult individuals (Sappelsa, 1993; see also discussion in Chapter 8).

ESTIMATION OF SEX

As with age estimation, sex assessment using skeletal material is most reliable when multiple criteria are employed. Evolutionary modifications of the female pelvis for childbearing have rendered this structure the best area of the skeleton to use for sex estimation. Among the specific characteristics that we evaluated in this connection were the ventral arc, subpubic concavity, medial aspect of the pubis, subpubic angle, preauricular sulcus, relative length of the pubis and the sciatic notch (Phenice, 1969; Bass, 1987; Ubelaker, 1989; White, 1991; Buikstra & Ubelaker, 1994). Other criteria of the pelvis include features that are related to differences in body size and muscularity. Such characteristics include the size of the acetabulum and femur head, the shape of the obturator foramen, and the degree of development of the iliac crest and ischial tuberosity.

The skull is often regarded as the second-best area of the skeleton to use for the estimation of sex, as male and female skulls typically differ in both size and shape. Such differences are reflected in such areas of muscle attachment as the mastoid processes, supramastoid crests and nuchal lines (Krogman & Iscan, 1986; Bass, 1987; Ubelaker, 1989; Buikstra & Ubelaker, 1994). Differences relating to cranial shape include such features as the inclination of the forehead, the presence and development of supraorbital ridges and parietal "bossing." Sexing criteria of the mandible and the dentition include the shape of the mental eminence, orientation of the ascending ramus and the relative sizes of the jaws and teeth.

Specific criteria for assessing sex have been developed for most other bones of the skeleton. Often, such criteria involve specific measurements and reflect typical body size differences between males and females. The morphometric indicators most often used in the present study for estimating sex include the diameter of the femur head, femoral shaft circumference, diameter of the humerus head, and height of the glenoid fossa. As with age determination, we evaluated *all* available criteria in the assessment of sex.

ASSESSMENT OF GENETIC AFFINITY

The genetic affinity of the Tutu skeletons was evaluated during the course of our investigation (Sappelsa, 1993: 88–89; Sandford *et al.*, 1997: 21) using standard criteria (Bass, 1987; Krogman & Iscan, 1986; Ubelaker, 1989: 119–20). In general, characteristics of the Tutu remains were consistent with individuals of Asiatic genetic affinity. Such traits are located in the craniofacial skeleton, the dentition and the postcranial skeleton. This position is further supported by the results of radiocarbon dating. Accelerated Mass Spectrometry (AMS) was performed on 27 skeletons from the site. And, in all but one instance (Burial 39), the 2-sigma (95%) calibrated C^{14} dates overlap with the pre-Columbian era.

STATURE ESTIMATION

Adult statures were estimated using a technique, based on long bone lengths, devised by Genoves (1967; Sappelsa, 1993; Sandford *et al.*, 1997). In instances where entire long bones were not preserved, methods described by Steele and Bramblett (1988) for estimating the original length of long bones were employed.

ASSESSMENT OF PATHOLOGY

Initial observations concerning skeletal pathology were made during the course of excavation, while exposing and documenting each burial in situ. Field photographs were used to make an early record of any anomalies noted on the skeletal remains. In the laboratory, each skeleton was systematically reviewed for any signs of skeletal pathology following procedures and categories outlined in Buikstra & Cook (1980), Ortner & Putschar (1981), Steinbock (1976), Ragsdale & Ortner (1992), and Buikstra & Ubelaker (1994), as described further below. Pathological lesions were visualized using several techniques. All examples of pathology were photographed and 35 mm color slides of pathology are digitally archived on CD-ROM, using the techniques described above. In many instances, macroscopic assessment of pathology was aided by capturing video input from a Canon L1 High 8 video camera on a high resolution color monitor. In other cases, digital scanning of slides and photographs at high resolution enhanced our ability to evaluate surface lesions.

A number of radiographs were taken to further evaluate pathological lesions. As part of her thesis research, Sappelsa (1993: 85) took radiographs at the Department of Comparative Medicine, Clinical Research Center, Bowman Gray School of Medicine, Wake Forest University, using a Dynard Hf–110-CM-X-Ray System with a SXR–100GE/M source x-ray tube. Settings were 50 KVP and 5, 6, or 6.5 milliamperes per second, according to the cortical bone thickness.

Tube to plate distance was 89.53 cm (35.25 in.) with a 1:1 ratio of radiographic image to natural size. Radiographs were made using Kodak diagnostic mammography film MIN-R MRM–1.

Evaluation of pathology began with documentation of lesions by describing their characteristics, their location on bone(s) and their distribution in the skeleton (see especially Ortner & Putschar, 1981: 36–45; Ragsdale & Ortner, 1992; Buikstra & Ubelaker, 1994: 108–20). Variations in the size, shape, quantity or quality of osseous tissue are important clues in the recognition and diagnosis of pathological conditions. Often, lesions involve the deposition or loss of abnormal quantities of bone due to imbalances in the mechanisms governing bone proliferation or resorption. Hence, pathologies may entail abnormalities in the texture and/or amount of bone.

Once pathological lesions were recognized, their presence was recorded according to their specific location on each affected bone and their distribution throughout each skeleton. Information on location and distribution is especially crucial because different diseases tend to favor certain areas of the skeleton over others. For example, tuberculosis most commonly affects the ribs, vertebrae and os coxae, whereas various forms of treponemal disease are more likely to be found on the tibiae, fibulae and cranial bones (see discussions in Steinbock, 1976; Ortner & Putschar, 1981).

After carefully describing areas of abnormal bone, we attempted to identify the underlying processes responsible for their formation. Ultimately, bone responds to metabolic, circulatory, mechanical processes through the actions of osteoblasts and osteoclasts (Ragsdale, 1995). Because bone can respond to such factors only in a finite number of ways, skeletal lesions can be categorized according to the major processes responsible for their formation. Based on these assumptions, the system of classification used in the present investigation employs the following categories for skeletal pathology: vascular, inflammatory/immune, trauma, anomaly, metabolic, neuromechanical, and neoplasm (Ragsdale & Ortner, 1992).

Most skeletal lesions observed in the Tutu material were assigned to the following categories: inflammatory/immune, trauma, metabolic, and neoplasm. Lesions belonging to the first category, often described simply as "bone inflammatory lesions," may be indicative of infectious disease. Therefore, all inflammatory skeletal signs were subjected to differential diagnosis following procedures delineated further below.

While less common in the Tutu skeletal series, other types of skeletal pathology were placed in the categories of trauma, metabolic, neuromechanical, and neoplasm. Lesions suspected of being traumatic in origin, a category which most often refers to fractured bones, were evaluated radiographically and categorized following Buikstra & Ubelaker (1994: 119–20). Metabolic disorders, on the other hand, commonly result from imbalances in essential nutrients or hormones. Lesions of this nature include porotic hyperostosis and cribra orbitalia which may reflect iron losses and/or dietary iron deficiencies. Such lesions were classified using criteria described in Steinbock (1976). Neuromechanical lesions include osteoarthritic changes that may be exacerbated by habitual activities. Criteria for scoring neuromechanical changes are outlined in the recently published *Standard for Data Collection from Human Skeletal Remains* by Buikstra & Ubelaker (1994) and were used in compiling the present report. Finally, neoplasms, a category reserved for abnormal bone growths, were evaluated using discussions in Steinbock (1976) and Ortner & Putschar (1981).

TREPONEMAL DISEASE: DIFFERENTIAL DIAGNOSIS AND PALEOEPIDEMIOLOGY

The methods employed in the assessment of pathology were tailored to the specific objectives of this phase of the research. For, as noted recently by Buikstra & Ubelaker (1994: 107), techniques in evaluating paleopathology differ somewhat depending on whether one is assessing overall patterns in community health or studying a particular disease, such as tuberculosis. The former approach, strongly linked to paleoepidemiology, often interprets general categories of lesions in the light of environmental and cultural variables. A different strategy is required in pursuing the latter objective, however, where more emphasis is placed, by necessity, on differential diagnosis.

Initially, the primary objective was to achieve an overall sense of the degree of health and nutritional status at the Tutu site. However, early in the investigation, as the pathology was reviewed burial by burial, several important patterns were readily recognized. Most importantly, it was found that lesions, highly consistent with those seen in treponemal infections, are quite widespread in the Tutu material. Such infections are bacterial in origin, produced by the genus *Treponema* (see discussions in Steinbock, 1976; Ortner & Putschar, 1981; Powell, 1988). Modern treponemal diseases or syndromes include venereal syphilis, yaws, pinta, and bejel; all but pinta can produce skeletal lesions. In all treponemal conditions, the infecting pathogen enters the body through abraded areas of skin and sometimes mucous membranes. Yaws, pinta, and bejel, the endemic treponematoses, are acquired through cutaneous casual contact. In contrast, venereal syphilis is acquired by a sexual mode of transmission and is identified in a skeletal sample by a suite of skeletal and dental characteristics that are not seen in the Tutu material.

The evolution of treponemal disease has been the subject of much study and controversy for many years. Traditionally, theories regarding the origins of treponemal disease have been grouped into the following three categories: the Columbian, pre-Columbian and unitarian (Steinbock, 1976: 87–90; Baker & Armelagos, 1988; Powell, 1994). Proponents of the Columbian theory propose that syphilis originated in the New World and was brought to the Old World by Columbus and crew. Alternatively, advocates of the pre-Columbian theory favor the Old World origins of syphilis, an affliction that they believe was present many years prior to 1492. Third, and finally, the unitarian theory, championed by Hudson (1965), suggests that all treponemal diseases are highly related syndromes caused by the same organism. According to his theory, the treponemal organism originated among paleolithic African hunters and gatherers and spread throughout the world by human migrations. Hudson argued that the expression of a specific syndrome in a particular geographic area, both in contemporary and past populations, reflects interactions among environmental, biological and cultural factors (see discussion in Powell, 1994).

Against this background, there is now persuasive evidence for the presence of treponemal infection in the New World prior to Columbus in skeletal samples from such regions as coastal North Carolina (Reichs, 1989; Bogdan, 1989; Bogdan & Weaver, 1992), the Florida Gulf Coast (Hutchinson, 1993), the southeastern United States (Powell, 1991) and the midwest (Cook, 1976). While the Old World origins of treponemal disease are more hotly contested, recent studies from such regions as Italy (Henneberg & Henneberg, 1994) and England (Stirland, 1994) raise the possibility for treponemal infection in the Old World prior to Columbus. Recently, the origins of treponemal infections, in general, and syphilis, in particular, were debated at an international congress (Dutour, Palfi, Berato & Brun, 1994).

The Tutu site, because of its geographic and temporal contexts, thus afforded an invaluable opportunity to learn more about the origins and evolution of treponemal disease. Because the skeletal manifestations of such diseases may resemble changes due to trauma, osteomyelitis, mycotic and mycobacterial infections, we conducted a rigorous differential diagnosis of bone inflammatory lesions (Bogdan & Weaver, 1992; Sandford, Bogdan, Weaver & Sappelsa, 1994). Documentation of the characteristics and distributions of the skeletal lesions, using criteria described by Steinbock (1976), Ortner & Putschar (1981), Hackett (1963, 1983), and Bogdan (1989), provided the basis for differential diagnosis. Also, Hackett's criteria for treponemal disease were especially important in the present investigation. According to his criteria, postcranial skeletal signs associated with treponemal conditions include periostitis, radial subperiosteal spiculation, linear striations, periosteal plaques, and diffuse pitting. Indicators of cranial lesions in treponematoses include clustered pits, confluent clustered pits and radial scars.

Table 7.1 The Tutu burials: demographic and contextual data

Burial no.	*Age*	*Sex*	*Area (A) Trench (Tr)*	*Orientation of head*	*Direction of face*	*Artifacts*	*Pathology*
1	45–55	Female	A-9N	East			Present
2	40–50	Female	A-9N	North	East		Present
3	40–50	Female	A-9S	East		Present	Present
4	18–25	Female	A-13	East	Northwest	Present	Present
5	40–50	Female	A-1	North	South		Present
6	5.50–7	Subadult	A-1	East	South		Present
7	<1	Subadult	Tr-1			Present	
8A	15	Subadult	A-1	Northeast	Northwest		
8B	15	Subadult	A-1	Northeast	Northwest		Present
9	45–55	Male	A-4	North	South		Present
10	45–55	Female	A-2	South	West	Present	Present
11	1–2	Subadult	A-1	Northeast	West		Present
12	45–55	Male	A-4	East/southeast	North		Present
13	40–55	Female	A-1	South	North	Present	Present
13A	45–55	Female	A-1			Present	Present
15	0–0.50	Subadult	A-1			Present	
16	35–45	Female	A-6	Northeast	West		Present
18	0–0.50	Subadult	A-8			Present	Present
19	40–50	Female	A-9N	East/southeast			Present
20	9	Subadult	A-4	Southeast	North		
21	40+	Male	A-5	North		Present	
22A	1.50–3	Subadult	A-3	Northeast	Southeast		Present
22B	4–5	Subadult	A-3	North	South		Present
23A	0–0.50	Subadult	A-6	East	West		Present
23B	35+	Female	A-6	?		Present	Present
24	0–0.50	Subadult	A-1			Present	
25		Subadult	Tr-1, A-13				
26	17–21	Female	Tr-6, A-6	North			
27	<2	Subadult	A-1			Present	
28A	<10	Subadult	A-7				
28B	5–7	Subadult	A-7	North/northeast			
29	45–55	Female	A-1	West	South		Present
30	35–45	Male	A-9N	East			
31	35–45	Female	A-1	North	West		Present
32A	5	Subadult	Tr-1	North/northeast	East		Present
33	35–45	Male	A-8	Southeast	North		Present
34	0.50	Subadult	A-8	North/northeast	West?		
36	40–50		A-5			Present	
38	45–50	Male	A-1	North	West		Present
39	8	Subadult	A-1	North	West	Present	Present
40	Adult		A-4			Present	
41	1.50	Subadult	A-6				

Table 7.2 Temporal and spatial contexts

Period	*Burial no.*	*AMS date Cal. 2-sigma*	*Area (A) Trench (Tr)*	*Age*	*Sex*	*Artifacts*
Early	36	450–615	A-5	40–50	Indeterm.	Present
	10	450–640	A-2	45–50	Female	Present
	21	450–640	A-5	40+	Male	Present
	13A	560–665	A-1	45–55	Female	Present
	13	605–65	A-1	40–50	Female	Present
	4	620–75	A-13	18–25	Female	Present
	16	640–870	A-6	35–45	Female	
	23B	655–770	A-6	35+	Female	Present
	3	785–960	A-9S	40–50	Female	Present
Late	1	1170–1310	A-9N	45–55	Female	
	38	1170–1400	A-1	45–50	Male	
	29	1200–1320 1350–90	A-1	45–55	Female	
	19	1200–1400	A-9N	40–50	Female	
	9	1210–1320 1340–90	A-4	45–55	Male	
	22B	1275–1310 1365–75	A-3	4–5	Subadult	
	26	1280–1400	Tr-6, A-6	17–21	Female	
	12	1295–1410	A-4	45–55	Male	
	30	1300–1425	A-9N	35–45	Male	
	6	1300–1435	A-1	5.5–7	Subadult	
	33	1300–1425	A-8	35–45	Male	
	2	1305–1445	A-9N	40–50	Female	
	31	1395–1435	A-1, Upper	35–45	Female	
	11	1395–1450	A-1, Upper	1–2	Subadult	
	20	1400–85	A-4	9	Subadult	
	8B	1420–60	A-1, Lower	15	Subadult	
	5	1435–1535	A-1, Lower	40–50	Female	
	39	1660–1700 1720–1820 1855–60 1920–50	A-1, Lower	8	Subadult	Present

RESULTS AND DISCUSSION

Table 7.1 provides basic demographic and contextual information on each burial including the estimated age and sex, as well as the burial location, orientation and position. The presence or absence of pottery and skeletal pathology also is indicated.

The Tutu skeletal sample consists of a total of 22 adults and 20 subadults. For purposes of this study, adults were defined as individuals estimated to have been 16 years or older at the time of death. Of the adults, the sample is comprised of 14 females and 6 males. Sex was indeterminant for 2 of the adults (Burials 36 and 40). For purposes of this report, sex was not estimated for subadult individuals who were 15 years or younger at the time of death.

Individuals were placed in age categories to assess further the demographic distribution of the skeletal sample. Of the subadults, 6 were aged 0–1 years, 4 were aged 1–4 years and 7 were aged 5–10 years, and 2 were >11 years (both individuals were approximately 15 years). Burial 25 could be categorized only as a "subadult" due to the extremely poor condition of the skeletal material.

Of the adults in the sample, 2 skeletons were aged 25 or less (Burials 4 and 26), while 19 skeletons were estimated to be 35 years or older. Due to the extremely fragmentary nature of its remains, the skeleton in Burial 40 is designated only as an "adult." Attempts to arrive at narrower age groupings for adults, in general, were thwarted by a number of factors. For example, specific age indicators, such as the symphyseal face and auricular surface, were differentially preserved. In addition, dental attrition occurred quite rapidly and was excessive in many adults in our sample. Similarly, degenerative joint changes and vertebral osteophytosis were quite common, and attempts to seriate such changes for aging purposes were not productive. Finally, the relatively small adult sample size precluded further efforts to arrive at narrower age groupings.

TEMPORAL CONTEXT

Table 7.2 documents information on the skeletal remains that were subjected to radiocarbon dating using Accelerated Mass Spectrometry (AMS). AMS dates listed on the table represent the calibrated results (2-sigma, 95% probability) for 21 adults and 6 subadults (Burials 6, 8B, 11, 20, 22B, 39). The adult interment that was not radiocarbon dated consisted of one adult of indeterminant sex (Burial 40).

Of the 21 adults who were dated, all fall within an early (*c.* cal. AD 450 to cal. AD 960) and a late (cal. AD 1170 to cal. AD 1535, 2-sigma) period. Based on AMS dating, adult skeletons from the early period consisted of 7 females (Burials 3, 4, 10, 13, 13A, 16, 23B), 1 male (Burial 21) and 1 adult of indeterminant sex (Burial 36). The early period burials overlap the time period previously assigned to the Cedrosan Saladoid tradition of the prehistoric Caribbean (Rouse, 1992; Sappelsa, 1993; Pearsall, 1995). This designation is further suggested by the presence of Saladoid pottery in all but one of these burials. No pottery was found in association with Burial 16, which had an estimated date of between AD 640 and AD 870 (2-sigma, calibrated), or with undated subadult Burial 23A, buried in a pit that touched that of Burial 23B.

Adult burials dating from the late period include 7 females (Burials 1, 2, 5,19, 26, 29, 31) and 5 males (Burials 9, 12, 30, 33, 38). All of these individuals overlap the time period previously assigned to the Chican Ostionoid in the Virgin Islands (*c.* AD 1200–1500). In fact, the evidence from radiocarbon dating of the human remains suggests that the Tutu site was occupied throughout the Chican Ostionoid. For example, the earliest of the 12 dated adult Ostionoid burials, Burials 1 and 38, lived near the beginning of the Chican Ostionoid period while one of the latest of the Tutu adult burials (Burial 5) appears to have lived around the termination of that phase. Finally, a subadult burial (Burial 39) interred with a late Ostionoid vessel may represent a post-Columbian burial at the site. Alternatively, bacterial contamination of the bone collagen may account for the unusual dates obtained for this burial.

SPATIAL CONTEXT

The spatial locations for the 27 AMS dated burials are listed in Table 7.3. Interestingly, the pattern of recovered burials indicates disposal in certain areas of the site at specific times. The southern portion of Area 1 contained dated human remains of *both* Saladoid and Ostionoid affinity, while

Table 7.3 Tutu burials by temporal period and spatial unit

Period	*Area*	*Burials*
Early	Area 1, Lower	13, 13A
	Area 2	10
	Area 5	21, 36
	Area 6	16, 23B
	Area 13	4
Late	Area 9S	3
	Area 1, Lower	5, 8B, 38, 39
	Area 1, Upper	6, 11, 29, 31
	Area 3	22B
	Area 4	9, 12, 20
	Area 8	33
	Area 9N	1, 2, 19, 30
	Trench 6, Area 6	26

others associated with the former period were situated in Areas 2, 5, 6, 9S and 13. Probable Ostionoid burials were found in the northern section of Area 1 and in Areas 4, 6, 8 and 9N.

BURIAL PRACTICES

A photograph of Burial 31 (Figure 7.1) illustrates characteristics typical of adult interments at the Tutu site. Individuals were usually placed in shallow, oval burial pits in flexed or tightly flexed positions. Especially during the late occupation, an individual's head was directed toward the north or east, with the face turned to the west. In only one instance (Burial 29) was an adult individual interred with the head pointed to the west. Individuals were typically placed on their backs, with their arms flexed at their elbows. In a few instances, individuals were interred in a "seated" position. Burial 9, for example, appears to have been lowered in such a position into a narrow burial pit between several large rocks.

Figure 7.1 In situ photograph of Burial 31 from the Tutu site.

As is typical for the Caribbean, burial customs varied somewhat with the age of the individual. For example, young infants were sometimes interred in pottery vessels or in a modified extended position. Examples of the former practice include Burials 15 and 24 from the early occupation. Burials 7, 18 and 27 were buried in association with bowls, but the relationship between the skeleton and the vessel(s) could not be established. Some young individuals were buried in a modified extended or "spread eagle" position. Two such examples include Burial 34, an interment of a young infant, and Burial 11, an interment of a young child of between 1 and 2 years of age.

The vast majority of burials at the Tutu site represent single interments. There were several exceptions to this practice, however. For example, 2 primary double burials, both involving subadult remains, were encountered at the site. Burial 8A, 8B contained 2 adolescents, aged approximately 15 years. Burial 22A, 22B consisted of the remains of 2 children, aged between 1.50 and 3 years, and between 2.50 and

5.50 years respectively. Burial 22A appears to have been placed on top of Burial 22B. In addition, the fragmentary remains of Burial 7, an infant, were interred with an adult female (Burial 4), in association with ceramic vessels.

For the Tutu burial group as a whole, grave goods or offerings were not commonly encountered. As shown in Table 7.4, grave goods were found principally in subadult and adult burials of the earliest Saladoid occupation and in 2 late occupation subadult burials. Subadults buried in or with pottery included Burials 7, 15, 18, 24, 27, and 39. All but 2 of these individuals (Burials 27 and 39) were less than 1 year of age at the time of death. Temporal and spatial contexts among these individuals were somewhat variable. Burial 18 was located at the northern extremity of the site, in an area that contained evidence of late period occupation; 4 subadults were located in Area 1, and 1 in Area 13. Burials 27 and 39 were located in the southern portion of Area 1, a region of the site that was apparently used in both the early and late periods, while Burials 15 and 24, from the early occupation, were recovered in the central portion of Area 1.

On the other hand, the interment of adults with pottery appears to be clearly associated with the early period. Of the 9 adults (Burials 3, 4, 10, 13, 13A, 16, 21, 23b, 36) dating from the early period (AD 450–960), all but 1 (Burial 16) were associated with artifacts in the form of pottery vessels. In contrast, none of the 11 adults dating from the later period was associated with pottery.

MORPHOLOGICAL CHARACTERISTICS

Sexual dimorphism was marked in the Tutu series, both in stature and robusticity. Males were significantly taller than females, averaging 158.20 ± 3.00 cm in height (approximately 5 ft 2 in.). Females, on the other hand, averaged 149.30 ± 4.70 cm in height (approximately 4 ft 11 in.). Stature did not differ

Table 7.4 Tutu burials with grave goods: contextual information

Burial no.	*Age group*	*Sex*	*Area*	*Ceramic series*	*AMS date 2-sigma calibrated*
3	Adult	F	Area 9S		AD 785–960
4	Adult	F	Area 13	late Saladoid	AD 620–75
7	<1 year	?	Area 13		(associated with B-4)
10	Adult	F	Area 2	Saladoid	AD 450–640
13	Adult	F	Area 1, Lower	late Saladoid	AD 605–65
13A	Adult	F	Area 1, Lower		AD 550–665
15	0–0.5		Area 1		nd
18	0–0.5		Area 8		nd
21	Adult	M	Area 5	Saladoid	AD 450–640
23B	Adult	F	Area 6		AD 655–770
24	0–0.5	?	Area 1	Saladoid	nd
27	<2 years	?	Area 1, Lower		nd
36	Adult	?	Area 5		AD 450–615
39	Child	?	Area 1, Lower	post-Saladoid	AD 1660–1700 AD 1720–1820 AD 1855–60 AD 1920–50
40	Adult	?	Area 4		nd

significantly between females from the early and late periods at Tutu. Such comparisons could not, of course, be made for males, since only one identified male (Burial 21) from a Saladoid context was recovered.

Sexual dimorphism also was quite marked with respect to muscle attachments and cranial morphology. Although both males and females evidenced very active lifestyles, males usually had extremely pronounced deltoid tuberosities and ulnar tuberosities, indicative of muscles that are involved in upper arm abduction and rotation and forearm flexion respectively. In addition, the site of insertion for the pronator teres on the lateral midshaft of the radius was also pronounced in many adult males. Such anatomical characteristics reflect a high degree of upper body strength and habitual use of the shoulders and arms. Asymmetry in the bones and muscle attachments of the upper body also was quite common although no consistent pattern was noted with respect to the more affected side. For example, contrasting patterns were noted in Burials 9 and 12, 2 of the most robust males from this sample. In the former individual, the right ulna was markedly larger than the left, while the opposite was true of Burial 12.

These observations are quite consistent with those reported for other Caribbean sites (see Figueredo & Winter, 1986; Calhoun & Harper, n.d.) and probably reflect the habitual stresses of daily life. As described below, upper body robusticity often occurs in association with degenerative joint changes, as is the case with some other Caribbean sites (see Ubelaker, 1977). Changes such as these may reflect long-term stress on bones and articular surfaces. Activities that may have contributed to the patterns seen in the prehistoric Caribbean include paddling canoes and fishing (Calhoun & Harper, n.d.). Possibly, other factors, including playing ball in a manner similar to that described in ethnographic accounts, may have furthered morphological changes in the upper body (see discussion in Righter *et al.*, 1993).

In contrast to the reports from many other Caribbean sites, we found no evidence for artificial cranial deformation at the Tutu site. Typically, unaltered cranial morphology does differ appreciably between males and females in several ways, including the presence in males of a more sloping forehead. These anatomical differences appear to be completely within the normal range of variation, however, with no indication of artificial modification.

PATHOLOGY

Inflammatory/immune

Bone inflammatory lesions, ranging from simple periosteal reactions to more dramatic presentations, were quite common among the inhabitants of the Tutu site. Of the 22 adults we observed, only 3 (Burials 21, 30, and 36) were lacking lesions of this nature. Moreover, 2 of these individuals, represented by Burials 21 and 36, were very poorly preserved; therefore, skeletal lesions may have been obscured by diagenetic processes.

As discussed in the “Methods” section above, cranial and postcranial bones were evaluated for specific lesions which are often seen in treponemal infections. Bone inflammatory lesions evident in the Tutu material strongly resemble those described in modern clinical cases of endemic treponematoses as well as in a number of other archaeological samples from the New World (Sandford *et al.*, 1994). In particular, lesions seen in the Caribbean material recall those seen in skeletal series from coastal North Carolina (Bogdan & Weaver, 1992), Florida (Hutchinson, 1993), and sites in the southeastern and midwestern United States (see Powell, 1991).

Because skeletal preservation at the Tutu site varied significantly among burials, we are reporting frequencies of bone inflammatory lesions both by number of individuals and number of observed bones. Of the 22 adult skeletons in the Tutu sample, we observed 172 cranial bones and 340 postcranial bones. Bone inflammatory lesions were documented on 26 cranial bones from 9

Table 7.5 Cranial and postcranial inflammatory lesions by temporal period

	Inflammatory lesions					
	Cranial		*Postcranial*		*Any location*	
Period	*Number of individuals*[1]	*Number of bones*[2]	*Number of individuals*[3]	*Number of bones*[4]	*Number of individuals*[5]	*Number of bones*[6]
Early	2/7 (28.6%)	4/47 (8.5%)	6/8 (75.0%)	19/112 (17.0%)	6/8 (75.0%)	23/159 (14.5%)
Late	7/11 (63.6%)	20/98 (20.4%)	9/13 (69.2%)	49/228 (21.5%)	9/13 (69.2%)	69/326 (21.2%)

Notes

1 Number of individuals with cranial lesions/total number of individuals with cranial remains.
2 Number of cranial bones with lesions/total number of cranial bones observed.
3 Number of individuals with postcranial lesions/total number of individuals with postcranial remains.
4 Number of postcranial bones with lesions/total number of postcranial bones observed.
5 Number of individuals with lesions/total number of individuals observed.
6 Number of bones with lesions/total number of bones observed.

of the 17 observed adult crania (53%). Using Hackett's criteria, the following cranial signs were present in this sample: clustered pits, confluent clustered pits, circumvallate cavitation and radial scars. In addition, a number of individuals showed a more disseminated pattern of porosity that we have termed "diffuse pitting." Regarding the postcranial remains, we identified inflammatory

Table 7.6 Cranial and postcranial criteria by temporal period

Description of lesions	*Early n (%)*	*Late n (%)*
Cranial		
Clustered pits	1 (11.1)	4 (36.4)
Confluent	0 (0.0)	2 (18.2)
Diffuse	1 (11.1)	7 (63.6)
Serpiginous	0 (0.0)	0 (0.0)
Circumvalate	0 (0.0)	1 (0.0)
Focal	0 (0.0)	0 (0.0)
Radial scar	0 (0.0)	2 (18.2)
Cribra orbitalia	3 (33.3)	3 (27.3)
Porotic hyperostosis	0 (0.0) (1?)	1 (9.1)
Postcranial		
Pitting	2 (22.2)	7 (63.6)
Destruction	0 (0.0)	2 (18.2)
Thickening	3 (33.3)	6 (54.6)
Irregularity	3 (33.3)	2 (18.2)
Plaque	2 (22.2)	7 (63.6)
Spiculation	4 (44.4)	5 (45.4)
Striation	3 (33.3)	5 (45.4)
Periostitis	3 (33.3)	4 (36.4)

lesions on 68 bones from 14 of the 19 observed skeletons (74%). Postcranial inflammatory lesions included the following skeletal signs: diffuse pitting, cortical destruction, cortical thickening/ swelling, cortical irregularity, periosteal plaques, radial subperiosteal spiculation, linear striations, and periostosis. Lesions were found most often on the patella, parietals, tibiae, and fibulae, affecting 66.7 percent, 57.1 percent, 54.8 percent, and 46.7 percent respectively of the observed bones of each type.

As illustrated in Tables 7.5 and 7.6, there are some interesting differences between the early and late period skeletons with respect to bone inflammatory lesions. Of the observed adult individuals that were AMS dated, 6 from the early period and 9 from the late period had some inflammatory lesions. Moreover, only 2 individuals from the early period demonstrated cranial lesions, while cranial lesions were found in 7 of 11 skeletons from the late period. Frequencies based on numbers of observed bones also are intriguing. For example, while postcranial involvement was present in similar percentages from the two time periods ($z = -1.01$, $p = 0.156$), cranial lesions were much more common among bones observed from the late period ($z = -2.07$, $p = 0.019$).

Reference to Table 7.6 demonstrates that remains from the early and late periods also differ in the number of different skeletal signs. Also included in the table for comparative purposes are observations on cribra orbitalia and porotic hyperostosis, cranial signs that are metabolic in etiology. For example, adult individuals from the late period were characterized by a greater variety of skeletal signs. In particular, cortical destruction, radial scars, confluent clustered pits and circumvallate cavitation were all seen exclusively in material from the late period (see Figures 7.2 and 7.3). In general, such lesions are typical of more severe infections. Also, diffuse pitting (on both cranial and postcranial bones), periosteal plaques, and cortical thickening were more commonly encountered in late period skeletons.

Figure 7.2 Burial 9 from the Tutu site. Note circular lesion with clustered pits and confluent clustered pits on the right supraorbital region of the frontal.

Figure 7.3 Burial 33 from the Tutu site. Portion of left occipital with possible radial scars.

Table 7.7 Immune/inflammatory lesions: by affected bones and by time period

	Bilateral		*One side only*	
Bone[1]	*Early*	*Late*	*Early*	*Late*
Parietal	1/4	7/10	0/4	0/10
Temporal	0/4	0/10	0/4	0/10
Zygomatic	0/4	0/6	0/4	0/6
Tibia	1/5	5/8	2/5	2/8
Fibula	3/5	3/8	0/5	0/8
Femur	1/6	2/8	1/6	0/8
Ulna	0/8	1/12	2/8	3/12
Radius	0/6	2/12	1/6	2/12
Humerus	0/7	0/11	0/7	0/11
Clavicle	0/3	0/11	0/3	0/11
Scapula	0/2	0/6	0/2	0/6
Calcaneus	0/0	1/3	0/0	1/3
Patella	0/0	3/4	0/0	0/4

Note

1 Denominators of proportions are the number of individuals for which both bilateral bones were present.

In addition, as shown on Table 7.7, individuals from the Ostionoid era also had a higher number of affected bones and were more likely to have bilateral involvement than their Saladoid counterparts. For example, during the Saladoid period, the number of affected bones averaged 2.80 per individual, as compared with an average of 5.30 bones per individual during Ostionoid times. Concerning bilateral involvement, 5 pairs of affected bones were documented from the early period, while the late period had 24 pairs of affected bones.

Most of the skeletal signs typical of chronic treponemal disease were apparent on the skeleton of Burial 31. This adult female, who dates from the Ostionoid era, was between approximately 35 and 45 years of age when she died. Diagnostic lesions were particularly evident along the diaphyses of her tibiae (Figure 7.4). Here, cortical thickening and extensive deposition of periosteal plaques evidence chronic, recurrent infection. In addition, radial subperiosteal spiculation is also apparent on several of her bones (Sandford *et al.*, 1994). Additional lesions seen on this individual occurred bilaterally throughout her appendicular skeleton.

Subadults, in contrast, had less frequent and severe inflammatory lesions on their skeletons. Two of the subadults had cranial lesions, while three had postcranial lesions. The cranial lesions observed were diffuse pitting, clustered pits, and confluent clustered pits. The postcranial lesions included diffuse pitting, radial subperiosteal spiculation and periostitis.

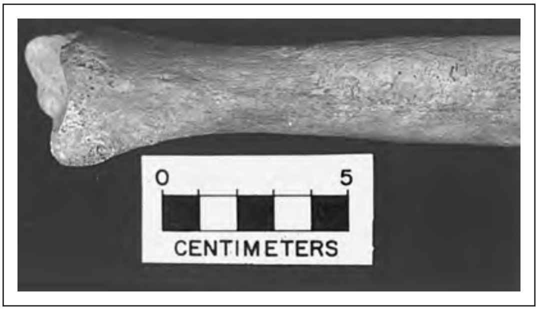

Figure 7.4 Left tibia of Burial 31 from the Tutu site. Note periosteal plaques, cortical irregularity and cortical thickening.

Figure 7.5 Burial 8A from the Tutu site. Note pattern of porosity on parietals and occipital suggestive of porotic hyperostosis.

Trauma

Examples of trauma, one of the most common pathological conditions affecting the human skeleton, were not at all common at the Tutu site. We were able to make a differential diagnosis of fracture only in the case of one adult female (Burial 23B) who had a simple, complete fracture that was actively healing at the time of death. Several suspected healed fractures were noted in Burials 1, 2, 3, 5, 10, and 19 and most often involved the radius, ulna and/or femur. In addition, Burial 19 had a mishapened clavicle, possibly indicative of a healed traumatic injury (see also Sappelsa, 1993). However, we were unable to confirm the prior occurrence of fractures radiographically, as no fracture lines were visible. Thus, at least some of the abnormalities of shape that we observed may reflect biomechanical stresses.

The low prevalence of trauma at the Tutu site is in stark contrast to that reported for some of the other prehistoric sites in the Caribbean. As discussed earlier, a high prevalence of fractures was reported by Valdes & Rivero (1972) from a site in Cuba. Moreover, unlike the reports from the Maisebel site (Budinoff, 1991) we found no evidence for interpersonal violence.

Metabolic

Cribra orbitalia and porotic hyperostosis were observed in several individuals from the Tutu site (Figure 7.5). A pattern of pitting consistent with cribra orbitalia was present in the orbits of 4 subadults (Burials 6, 8A, 8B, 23A) and 6 adults (Burials 3, 9, 12, 13, 13A, 31). Of the adults, 4 individuals with cribra orbitalia were probable females, while the lesions were present on 2 individuals who were judged to be males. In general, the presence of cribra orbitalia and/or porotic hyperostosis in subadults is believed often to be indicative of an ongoing iron deficiency, while their occurrence in adults is reflective of (a) past episode(s) of the disorder (see Stuart-Macadam, 1985).

With respect to lesions on the cranial vault, we encountered some difficulty in distinguishing between the "clustered pits" and "confluent clustered pits" stages, as described by Hackett, and the patterns of pitting described in porotic hyperostosis. However, lesions visible on the cranial vaults of Burials 5 and 39 appear to be most consistent with a diagnosis of porotic hyperostosis.

Neuromechanical

Neuromechanical lesions in the form of osteoarthritic changes were particularly common in the articular surfaces of the elbows and shoulders (Sandford *et al.*, 1994). The most severe manifestations of degenerative joint changes were seen in the distal humeri and proximal radii and ulnae of adult males (Figures 7.6 and 7.7). Most noteworthy in this regard were Burials 9 and 12. In the case of the former individual, the proximal ends of the right ulna and radius shows severe degrees of osteoarthritic lipping, consisting of extensive spiculation, over two-thirds of the margins of the articular surfaces. In addition, eburnation on the proximal end of the right ulna, indicating the loss of articular cartilage, takes the form of polish with a groove over two-thirds of the articular surface. Other degenerative joint changes include marked exostoses, representing severe lipping, over two-thirds of the borders of the condyles on the distal end of the humerus. The left distal humerus also shows coalesced and pinpoint porosity over one third of the articular surface,

Figure 7.6 Right ulna of Burial 9 from the Tutu site. Note extensive osteophytic lipping around margins of the articular surface.

Figure 7.7 Burial 9 from the Tutu site. Articulated distal humerus and proximal ulna. Note extensive osteophytic lipping.

although postmortem damage makes this condition difficult to evaluate. The left glenoid also shows eburnation, in the form of polish, coalesced porosity, and lipping, in the form of a sharp ridge. Degenerative changes of the glenoid occur over less than one-third of the surface. While a very similar degree of degenerative change was noted in Burial 12, adult females of comparable age lacked such extreme osteoarthritic deterioration. More commonly, degenerative joint changes in females consist of pinpoint and coalesced porosity, with only minor amounts of lipping. Such variation may reflect, in part, differences in the habitual activities of adult males and females. Given the large number of females in our sample it is unlikely that these differences are solely artifacts of sampling.

Neoplasm

Only a few instances of bony neoplasm were observed in the Tutu material. In all instances, definitive neoplastic lesions took the form of button osteomas. These are benign neoplasms that occur most commonly on the cranial vault (see reviews in Ortner & Putschar, 1981: 386; Sappelsa, 1993: 71–72). Single button osteomas were seen on Burials 3 and 13, while two such neoplasms were documented on Burial 31.

Finally, a few small eroded areas, possibly representing cortical destruction, occur on several fragmentary portions of ribs, left clavicle and a few vertebrae of Burial 13. These foci resemble cortical erosion and may represent lytic lesions of neoplastic or inflammatory/immune origin. However, this skeleton was extensively damaged after death by soil and ground water, rendering it very difficult to differentiate between ground damage and true pathology.

DISCUSSION

Excavations at the pre-Columbian Tutu site, St Thomas, USVI, involved the systematic excavation of 42 human burials. These remains, consisting of 22 adults and 20 subadults, have provided valuable clues about human biocultural adaptation during the Saladoid and Ostionoid eras of Caribbean prehistory. Radiocarbon dating, spatial analysis and ceramic typology help to place the human remains into distinct, clearly defined contexts. Such contextual data, often lacking in Caribbean skeletal series, greatly enhances the potential of skeletal material to yield useful insights into prehistoric health, diet and lifeways. Of the adults, at least 7 females, 1 male and 1 individual of indeterminant sex can be confidently assigned to the Saladoid period. The Ostionoid period has a higher degree of representation, consisting of at least 12 adults, of which 7 were female and 5 were male.

For the most part, the bioarchaeological data generated from this study are consistent with the findings of investigations elsewhere in the Caribbean. Like many skeletal series observed in this region, burials usually consist of single, primary interments of individuals. Adults were most often placed in flexed positions, while infants were sometimes interred in pottery vessels. For the most part, burials accompanied by grave goods in the Tutu sample were limited to peoples of the Saladoid period. The skeleton was most often in a flexed position, with the head pointed away from the west.

Regarding the osteological analyses, our investigations of this material have contributed quite significantly to our understanding of disease patterns in antiquity. In particular, the excavations at the Tutu site have resulted in additional convincing evidence for the existence of an endemic treponemal disease in the pre-Columbian New World. The patterns expressed in the skeletal signs of bone inflammatory lesions compare favorably to those described for other New World skeletal series from the southeastern United States. Interestingly, however, some apparent regional differences do occur. For example, while the pathological lesions of the Caribbean skeletal series are quite similar to those observed in coastal North Carolina ossuaries (Bogdan & Weaver, 1992; Sandford *et al.*, 1994), the skeletal signs of treponemal disease were more severely expressed in the latter material. In particular, areas of active cortical destruction and cavitation were common in the material from North Carolina. Also, complete medullary obstruction was observed in the ossuary sample while such manifestations were lacking in the Caribbean material. Moreover, cranial lesions were more diagnostic, widespread and severe in the ossuary series: in the Tutu sample only a few examples of radial scars, clustered pits and other cranial criteria were observed.

While the Tutu sample demonstrated less severe skeletal signs of treponemal disease, it also yielded some atypical lesions that have not been noted in the North Carolina ossuaries. For example, Burial 31, an adult female from the Ostionoid period, in addition to widespread inflammatory lesions, demonstrated unusual proliferative lesions on both calcanei. Also, the articular surfaces of the calcanei demonstrated degenerative changes, including lipping, while exostoses were located on the lateral, medial and posterior sides of these bones. Such lesions, together with areas of cortical swelling and periosteal plaques on the metatarsals, may indicate peripheral neuropathic changes secondary to chronic, disseminated treponemal disease. Alternatively, these unusual skeletal lesions may reflect the presence of an opportunistic disease process (Sandford *et al.*, 1994).

While shedding light on our knowledge of treponemal infections during the pre-Columbian New World, infectious disease patterns in the Tutu skeletal series also show interesting temporal variation. Ultimately, such patterns may help us understand changes in biocultural adaptation and disease processes over time. Of particular interest in this regard are the indications that the later inhabitants of the Tutu site were more severely affected by treponemal disease. Differences between the Saladoid and Ostionoid peoples with respect to the severity and distribution of bone inflammatory lesions may be related to changes in disease-host evolution and interactions. In exploring this possibility further, changes in disease patterns should be explored in connection with the apparent dietary and ecological shifts, suggested by studies of botanical and faunal remains (see Wing, deFrance & Kozuch, 1995; Piperno, 1995b; Pearsall, 1995; Righter, 1995) that transpired during Ostionoid times.

Aside from the lessons learned and new questions generated from bone inflammatory lesions at Tutu, analysis of the remains of the inhabitants of this site have helped to confirm the impressions generated by previous studies of Caribbean skeletal series. For example, Larsen's study (1995) of the Tutu dental pathology has reinforced the existence of severe dental wear, unusual non-occlusal wear (Larsen, Teaford & Sandford, 1995), and periodontal disease (see also Sappelsa, 1993) among prehistoric residents of the Caribbean. Some such problems may have had a profound effect on the overall health status of adults (see also Budinoff, 1991). In addition, like other peoples elsewhere in the ancient Caribbean, individuals from this site also may have experienced difficulties in maintaining iron homeostasis due to a variety of factors. As considered in detail by Sappelsa (1993: 134–46), the occurrence of iron deficiency anemia at the Tutu site, as evidenced by porotic hyperostosis and cribra orbitalia, may be attributable to the synergistic interaction of environmental and dietary factors. With respect to the former, parasitic burdens may have been largely responsible for iron losses. In addition, some dietary factors may have deterred iron absorption. In particular, the presence of fiber and phytate in manioc may have hindered iron absorption by forming insoluble complexes with iron. Finally, pronounced muscle attachments, skeletal asymmetries and degenerative joint changes involving the upper appendicular skeleton may be related to long-term habitual activities.

As comprehensive as investigations of the Tutu site have been to date, they are only a beginning. For, like all successful scientific endeavors, many questions have been generated through this research which will help to stimulate future investigations. In this vein, research at the Tutu site clearly underscores the need to explore the impact of ecological changes, such as those apparently encountered during Ostionoid times, on human health and adaptation. Moreover, advances in technology, including the refinement of methods of DNA extraction, will be used by future researchers to address problems currently thought unanswerable. In fact, we have already begun our efforts to use DNA technology to assess critical issues of kinship and disease at the Tutu site. Other fields will undoubtedly make similar progress in their abilities to assist in the reconstruction of ancient lifeways. Clearly, we have only begun to benefit from the rare and vast opportunity afforded by this unique series from the human past.

Chapter Eight

The Tutu teeth: Assessing prehistoric health and lifeway from St Thomas

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INTRODUCTION

For several reasons, dental remains recovered from archaeological contexts represent an important source of information about past peoples. First, owing to their extreme hardness and density, teeth of all body tissues are the least susceptible to postdepositional decay. Thus, even in archaeological settings where bones are poorly preserved, teeth are often well represented. Second, unlike skeletal tissues, teeth do not remodel once they have formed. And, except under circumstances involving pathological processes (e.g. dental caries), excessive wear, or breakage, their form does not change. Therefore, teeth found in archaeological sites are permanent records of an individual's life history. Third, the size, number, and morphology of teeth are highly genetically canalized, thereby minimizing the effects of environment on their mature form. Finally, during the life of the individual, teeth are the only hard tissue of the body that comes into direct contact with the environment. This is especially important in interpreting the impact of food consistency, texture, and composition on occlusal and other teeth surfaces.

Following the completion of archaeological excavations at the Tutu site in 1991, recovered human remains were transported from Charlotte Amalie, St Thomas, to the University of North Carolina, Greensboro, for study by M. K. Sandford (Chapter 7). The dentitions subsequently were transferred to the Bioarchaeology Research Laboratory at the University of North Carolina, Chapel Hill, for documentation and analysis.

In total the dental remains from 35 individuals number some 634 teeth, including 432 permanent teeth from 23 adults (individuals who are 15 years or older), 79 incompletely formed permanent teeth and 123 deciduous teeth from 12 juveniles. Although the series is significant in several respects, it is unlikely that the remains are representative of the population from which they were drawn. First, adult females (n=14) outnumber adult males (n=7) by a factor of two, and adults are largely mature or older individuals. Second, the temporal span of the dated individuals is more than a millennium, from *c.* AD 450 to AD 1500, representing the Saladoid and Ostionoid periods (Chapter 7). This represents an extensive time range, thereby limiting our perspective on the biology of the prehistoric inhabitants of St Thomas. Finally, with respect to the dentitions in particular, few individuals possess all teeth; thus, prevalence of pathological conditions and other data sets in this study are somewhat skewed. Despite these limitations, however, the study of the Tutu dentitions provides a picture of health, diet, and behavior that has heretofore been unavailable from the Caribbean (see Ubelaker & Angel, 1976; Drusini, Businaro & Calderon, 1987; Budinoff, 1991 for other bioarchaeological investigations).

The purpose of this study was threefold:

1. to provide a description of dental remains in the Tutu burials;
2. to describe and interpret pathological conditions in order to assess diet and physiological stress; and
3. to describe and interpret macrowear and microwear for reconstruction and interpretation of dietary and extramasticatory behavior. For this investigation, variation is examined for the sample as a whole and with respect to temporal patterning.

The following anatomical abbreviations for permanent and deciduous tooth types are used throughout this report: I=permanent incisor; C=permanent canine; P=permanent premolar; M=permanent molar; dI=deciduous incisor; dC=deciduous canine; dM=deciduous molar. Other characteristics, pathological or otherwise, are noted when present (e.g., agenesis).

METHODS

Dental pathological conditions observed include dental caries, calculus, and enamel defects (linear enamel hypoplasias). Most observations were recorded with regard to presence/absence of these pathological conditions for all available teeth. Wear on occlusal and non-occlusal surfaces of teeth was observed and recorded. Because of the variable preservation of the Tutu remains, all data sets were not systematically analyzed. In particular, although observations were made for each individual, periodontal disease and premortem tooth loss were not assessed because of the highly variable preservation of maxillary and mandibular alveoli. On the other hand, temporal comparisons are made for dental caries and non-occlusal lingual wear of anterior teeth. As discussed in the following section, unlike the other conditions considered, caries and lingual wear are abundantly represented in the series, thereby lending themselves to statistical assessment. These temporal comparisons are made on the basis of comparisons between dentitions grouped in an early period (*c.* AD 450–960) and a late period (*c.* AD 1170–1535) (2-sigma range – see Chapters 1 and 7). There is evidence to suggest a shift in dietary animal resources, involving an increased emphasis on marine resources and decreased emphasis on terrestrial resources over the occupation of the Tutu site (see Chapter 4). Pearsall (Chapter 2) finds consistency in the types of food plants consumed for food throughout the occupation of the site, with, perhaps, an increased consumption of porous root/tuber and dense cotyledon plants during the late occupation. Consideration of temporal variation in dental health and tooth use may contribute additional insight into dietary shifts in this setting.

Sex determination and age estimation

Sex determinations and age-at-death estimates for mature adults were based on information provided by Sandford (Chapter 7). Age-at-death estimates for juveniles and young adults were determined by use of the eruption/calcification schedule developed by Ubelaker (1989) for Native Americans. Given the small size of the Tutu dental sample and the predominance of younger juveniles and older adults, it was not possible to age the series by means of a wear-based seriation method (e.g. Miles, 1963). Some of the analysis focuses exclusively on adults or juveniles. As mentioned previously, for purposes of the present discussion, adults are individuals greater than 15 years of age at death.

Dental caries

Dental caries is a disease process characterized by the focal demineralization of dental tissue by organic acids (e.g. lactic acid) resulting from bacterial fermentation of dietary carbohydrates, especially simple sugars (see discussion in Larsen, 1997). Carious lesions resulting from this disease process are manifested as small pits or opacities located virtually anywhere on the tooth crown or superior root. However, in severe cases, cariogenesis can lead to complete destruction of the tooth crown and much of the root.

Research on archaeological samples worldwide reveals that human populations dependent or partially dependent on agriculture have generally higher prevalence of dental caries than hunter–gatherer groups (Turner, 1979; Milner, 1984; Larsen, Shavit & Griffin, 1991; Larsen, 1997). For example, in eastern North America, the adoption and intensification of maize, a food containing a high sugar component, occasioned a marked increase in prevalence of dental caries in later prehistory. Overall, in populations with 7 percent or more carious teeth, some level of dependency on maize is likely (Milner, 1984; Larsen, Shavit & Griffin, 1991).

For the Tutu series, all completely formed teeth were examined. Juvenile permanent teeth were for the most part either incompletely formed or not fully erupted. Therefore, these teeth have been excluded from statistical analysis. In order to determine prevalence, each available tooth was examined for carious lesion presence, location, and size. Location refers to the area on the crown or root affected. Lesion size was denoted as small (a small pit), medium (a pit of appreciable size, but not extending to the pulp chamber), and large (ranging from a pit involving the pulp chamber to complete crown destruction).

Two broad comparisons were made, including the frequency of individuals affected (at least one tooth affected by dental caries in an individual dentition) and frequency of teeth affected for the total population (incisors, canines, premolars, and molars combined). In addition, sex differences were observed for both individuals and teeth affected. Only teeth in or near functional occlusion were included in the analysis.

Calculus

Aggregation of communities of bacteria in a matrix on tooth surfaces is called dental plaque. If not removed from these surfaces, plaque can become mineralized, resulting in hard deposits known as calculus or tartar. These deposits are especially common on teeth located near ducts of primary salivary glands, such as on the lingual surfaces of anterior teeth (Hillson, 1986). Because of its high degree of mineralization, calculus is frequently preserved in archaeological dentitions. However, it is easily flaked off of crown surfaces.

The Tutu dentitions contain numerous calculus deposits, but faint traces of mineralized plaque adhering to some teeth reflect the presence of earlier deposits. This pattern of calculus deposition and later loss in some individuals indicates that the original prevalence was greater than is currently expressed in this series. Because calculus has been removed from teeth prior to my examination of them, it is not systematically analyzed for this study.

Enamel defects

Dental enamel defects known as hypoplasias are surface growth arrests of tooth enamel that are caused by physiological disruption, such as nutritional insufficiencies or disease or a combination of both (Goodman & Rose, 1990, 1991). Although hypoplasias can be manifested in a variety of forms ranging from small pits to large areas of missing enamel, the most common type of defect is a linear depression or series of depressions on the tooth crown called linear enamel hypoplasia. Hypoplasias are most frequently encountered in incisors and canines (Goodman & Rose, 1990), the crowns of which form between birth and about 6 years. Therefore, hypoplasias represent a retrospective picture of metabolic perturbation during this window of childhood growth and development. Because enamel does not remodel once it is formed, any defect that develops during the formation of the tooth is permanent, unless lost to wear or cariogenesis. Because of this state of permanency, hypoplasias is especially useful for reconstructing prevalence and pattern of physiological perturbation in human populations.

In general, researchers have found that higher prevalence of dental defects occurs in populations experiencing elevated stress. For example, Goodman and coworkers (1984) have reported an increase in hypoplasias when populations shifted to maize agriculture and lived in more densely settled communities in the prehistoric American Midwest. These factors led to an overall deterioration in quality of health, which is manifested as an increased hypoplasia prevalence.

In addition to gross visual inspection, Tutu incisors and canines were examined under low power magnification (10×) with a stereoscopic light microscope. The general location of each hypoplasia was recorded (e.g. cervical third of tooth crown), thus indicating when a physiological insult occurred. In addition, the general size of the hypoplasia was noted (e.g. narrow vs wide). Hypoplasia size is important information because it provides evidence regarding the duration and/or severity of the stress episode. That is, a relatively wide hypoplasia probably represents a long and/or severe episode of physiological perturbation (e.g. Larsen & Hutchinson, 1992).

Tooth macrowear

Following eruption into the occlusal plane, chewing surfaces of teeth begin to wear. The wear on these surfaces is caused by contact with food or abrasive material incorporated into food, such as grit from insufficiently cleaned food. Tooth wear can also be caused by movement of tooth crowns against each other, upper against lower. The rate of wear is highly variable in humans, ranging from barely discernible in contemporary American populations to severe in prehistoric native populations, from a variety of settings such as the American Great Basin and Southwest (Larsen, 1997). With regard to the former, low rates of wear occur because of the generally soft and abrasive-free nature of foods consumed. Native groups from the American Great Basin and Southwest, on the other hand, use grinding stones to prepare plants for consumption. Minuscule stone particles from the grinding stones become incorporated into the food resulting in the introduction of abrasives to diet. These abrasives contribute to relatively rapid wear of teeth once they have come into occlusion (e.g. Larsen & Kelly, 1995).

As the occlusal surface of the tooth wears, enamel is progressively removed resulting in exposure of underlying dentine. In populations with high wear rates – as in the American Southwest – significant loss of crown height and marked exposure of dentine oftentimes result.

For the Tutu series, macrowear was recorded following the method provided by Smith (1984). This method involves observation of eight potential stages of occlusal wear, ranging from polish (stage 1) in slightly worn teeth to severe loss of crown height with no enamel (stage 8) in highly worn teeth.

Dahlberg remarked in his classic paper on the role of teeth in culture that "[t]eeth have always been handy tools … " (1963:240). And reflecting this, some of the most severe mechanical demands on the human dentition occur when teeth are used in extramasticatory activities. In this regard, extramasticatory behaviors are commonplace in contemporary traditional, non-industrial societies worldwide, especially among Arctic and other foraging populations (e.g. Leigh, 1925; Pedersen, 1952; Dahlberg, 1963; Molnar, 1972; Cybulski, 1974; Merbs, 1983; Larsen, 1985; Milner & Larsen, 1991). For example, Eskimo women pull sinews across their anterior teeth, creating grooves on the occlusal surfaces (Pedersen, 1947; Pedersen & Jakobsen, 1989; Hansen, Meldgaard & Nordqvist, 1991). These grooves have been identified in living populations and in prehistoric archaeological remains in this and in several other regions of the world (e.g. Pedersen, 1947; Cybulski, 1974; Schulz, 1977; Larsen, 1985; Pedersen & Jakobsen, 1989; Hansen *et al.*, 1991; Bement, 1994; Molleson, 1994).

A second distinctive anterior tooth modification that is related to the use of teeth as a tool is a pattern involving lingual surface wear predominantly on permanent maxillary incisors and canines. From the prehistoric sites of Corondó, Brazil, and Venado Beach and Cerro Mangote, Panama, Turner and Machado (1983) and Irish and Turner (1987) first reported pronounced upper incisors lingual wear that they called “lingual surface attrition of the maxillary anterior teeth,” or LSAMAT. The lack of corresponding wear on the lower incisors suggests that this type of wear is not caused by an occlusal abnormality. Rather, the pattern and unique orientation of wear reflects extramasticatory use of the anterior dentition, perhaps in processing of an abrasive or fibrous plant food, like manioc (Turner & Machado, 1983; Irish & Turner, 1987). Support for this interpretation has been provided by study of additional prehistoric dentitions from Texas (Hartnady & Rose, 1991) and the Maya lowlands (J. M. Saul & F. P. Saul, 1997).

A third pattern of anterior tooth wear that apparently reflects extramasticatory practices is a distinctive labial surface wear that in gross morphology is similar to changes observed on the lingual surfaces of teeth. Labial wear has been observed in populations that use ornamental labrets worn through the lower lips, such as in Alaskan Eskimos (e.g. Pedersen, 1952, 1955 and personal communication), Northwest Coast Amerindians (Cybulski, 1974), and Aleuts (Turner, 1972). The labrets are heavy objects made out of ivory, stone, or animal bone and are predominantly worn by adult males. The resulting distinctive pattern of flat wear on the labial surfaces of mandibular lateral incisors, canines, and third premolars is extreme in some instances (e.g. Pedersen, 1952; Cybulski, 1974). Specifically, the contact of the labret with the labial surface of the tooth results in loss of enamel and occasionally exposure of secondary dentine. A similar pattern of labial wear in populations not using labrets has been reported by Budinoff (1991) in prehistoric dentitions from Puerto Rico. However, the wear pattern does not have the characteristic flatness seen in populations using labrets (see Milner & Larsen, 1991, for review of other types of wear).

Tooth microwear

In order more precisely to document patterns of anterior tooth use, microscopic wear is observed on occlusal, lingual, and labial surfaces. This is accomplished via scanning electron microscopy (SEM), a powerful approach for inferring the effects of different behaviors on teeth (Teaford, 1991). A representative subsample of Tutu teeth was selected for SEM analysis best illustrating lingual wear, occlusal surface grooves, and labial wear. The teeth selected for SEM analysis included maxillary incisors from Burials 4 and 8B for lingual wear, a maxillary incisor from Burial 30 for occlusal grooves, and a mandibular canine from Burial 13 for labial wear. Other teeth also displayed lingual wear, occlusal grooves, and labial wear, but these particular selected specimens provide good examples of the three patterns of extramasticatory wear discussed in this paper.

Following specimen selection, teeth were prepared for SEM analysis by M.F.Teaford at Johns Hopkins University using cleaning and replication techniques described by Rose (1983) and Teaford & Oyen (1989). Teeth were gently swabbed with acetone and subsequently air-dried. Polysiloxane dental impression material (“President Jet Regular,” Coltene) was then used to make high resolution molds of the teeth, and each mold was poured with epoxy (“Epotek,” Epoxy Technologies). Resulting epoxy casts were sputter-coated with approximately 200 Å of gold. The epoxy casts were subsequently examined in an AMRAY 1810 scanning electron microscope at 20kV in secondary emission mode. Two representative micrographs were taken at each of two positions per tooth at a lower power of magnification (9.0×–40.0×) and a higher power of magnification (40.6×–164×).

DENTAL PATHOLOGY AND IMPLICATIONS FOR HEALTH

Dental caries

As noted above, dental caries is symptomatic of carbohydrate consumption in human populations. In this regard, the presence of carious lesions in appreciable frequencies has been used to document the relative degree of dependence on cariogenic foods, such as maize in the Eastern Woodlands of North America (Milner, 1984; Larsen *et al.*, 1991) and on agriculture generally (Turner, 1979). Examination of the Tutu series reveals the presence of a moderately high frequency of carious lesions. Of the adults, 65.2 percent have at least one carious tooth. Only 2 juveniles of 12 have carious teeth (16.6%). The total carious lesion frequency for permanent teeth is 9.3 percent (Table 8.1). For the deciduous teeth in functional occlusion (n=81), 4.9 percent are carious. Analysis of individuals affected and total teeth affected (incisors + canines + premolars + molars) reveals that females have more carious lesions than males. In females, 64.3 percent of individuals and 9.9 percent of teeth are affected, whereas 57.1 percent of individuals and 7.9 percent of teeth are affected in males. Statistical (chi^2) treatment of female vs male frequency of teeth affected indicates that the difference is not statistically significant ($p > 0.05$).

Temporal comparisons of dental caries reveals a decline in prevalence of carious lesions in the permanent teeth (all teeth combined) of dated individuals, decreasing from 10.5 percent (15/143) in the early period to 8.0 percent (22/276) in the late period. However, the decrease is not statistically significant (chi^2; $p > 0.05$).

The total frequency of carious lesions in the Tutu series (8.6% of deciduous and permanent teeth in functional occlusion) is relatively high in comparison with other archaeological series from eastern North America or other populations worldwide (cf. Turner, 1979; Milner, 1984; Larsen *et al.*, 1991; Larsen, 1997). This assessment suggests that the Tutu populations utilized domesticated plants in their diets. The primary Caribbean root crop used by native populations prior to contact was manioc (Wing & Reitz, 1982). Unfortunately, corroboration of the use of this plant on St Thomas is not adequately documented by archaeological or paleobotanical evidence. However, Righter (1991a, 1997) has inferred that, like other Caribbean groups, these populations probably cultivated manioc. The recovery of a probable ceramic cassava (manioc bread) griddle at the site is consistent with this dietary reconstruction (Righter, 1991a). Manioc is a carbohydrate resulting in elevated levels of cariogenesis (e.g. Walker & Hewlett, 1990; Walker, Sugiyama & Chacon, 1995). The high prevalence of caries in the Tutu series strongly suggests that manioc was habitually consumed. Although maize also may have contributed to caries in this series, analysis of plant remains reveals little evidence for its dependence (Chapter 3).

Why the greater frequency of female teeth affected by dental caries than male teeth? A review of the clinical and anthropological literature reveals little consensus on cause of sex differences in caries prevalence. Two areas are frequently cited: physiological factors and behavioral factors. The former has very little support in the literature. For example, female teeth erupt slightly before male teeth (Dunbar, 1969; DePaola, Soparkar, Tavares, Allukian & Peterson, 1982), but the age differences are slight and are not sufficient to result in a disparity in caries prevalence. Nor does the impact of pregnancy affect dental caries prevalence in women (see Walker, 1986; Larsen *et al.*, 1991).

Many archaeological populations studied worldwide show a higher prevalence of dental caries in females than males (see review in Larsen *et al.*, 1991; and discussion by Walker and Hewlett, 1990). However, the exceptions to this pattern (e.g. Burns, 1979, 1982; Wells, 1980) indicate that this is not universal. In sum, although it is common for females to have more carious lesions than males in archaeological skeletal series, there is little evidence to support an inherent disposition to dental caries in females.

A more plausible explanation for greater caries in females than males is related to differences between sexes in dietary behavior. In the southeastern United States, Larsen, Shavit and Griffin

Table 8.1 Caries prevalence per tooth type in the Tutu adult dental series

	Total		*Female*		*Male*		*Indeterminate sex*	
Tooth	*n*[1]	%[2]	*n*	%	*n*	%	*n*	%
Maxilla								
LI1	15	6.7	10	10.0	5	0.0	0	0.0
LI2	15	0.0	9	0.0	5	0.0	1	0.0
LC	17	0.0	10	0.0	7	0.0	0	0.0
LP3	15	13.3	8	12.5	7	14.3	0	0.0
LP4	15	6.7	8	12.5	6	0.0	1	0.0
LM1	14	35.7	9	33.3	5	40.0	0	0.0
LM2	10	0.0	5	0.0	5	0.0	0	0.0
LM3	7	57.1	4	75.0	3	33.3	0	0.0
RI1	14	7.1	8	12.5	6	0.0	0	0.0
RI2	15	6.7	8	0.0	6	16.7	1	0.0
RC	17	5.9	9	0.0	6	16.7	2	0.0
RP3	18	16.7	9	11.1	7	14.3	2	50.0
RP4	16	12.5	9	22.2	7	0.0	0	0.0
RM1	13	23.1	6	16.7	6	33.3	1	0.0
RM2	9	11.1	5	20.0	4	0.0	0	0.0
RM3	5	0.0	2	0.0	3	0.0	0	0.0
Mandible								
LI1	14	0.0	8	0.0	5	0.0	1	0.0
LI2	15	0.0	9	0.0	5	0.0	1	0.0
LC	18	11.1	11	18.2	6	0.0	1	0.0
LP3	22	4.6	13	0.0	7	14.3	2	0.0
LP4	16	0.0	8	0.0	7	0.0	1	0.0
LM1	12	41.7	6	50.0	2	33.3	0	0.0
LM2	12	8.3	6	0.0	5	20.0	1	0.0
LM3	5	40.0	4	50.0	1	0.0	0	0.0
RI1	12	0.0	7	0.0	4	0.0	1	0.0
RI2	17	0.0	10	0.0	5	0.0	2	0.0
RC	18	5.6	11	9.1	6	0.0	1	0.0
RP3	15	0.0	9	0.0	5	0.0	1	0.0
RP4	14	0.0	8	0.0	5	0.0	1	0.0
RM1	11	0.0	6	0.0	4	0.0	1	0.0
RM2	11	9.1	6	0.0	4	0.0	1	100.0
RM3	5	40.0	2	50.0	2	0.0	1	100.0
Total	432	9.3	243	9.9	161	7.9	24	12.5

Notes

1 Total number of teeth observed; all teeth are in functional or near-functional occlusion.

2 Percentage of teeth affected by dental caries.

(1991) have documented increases in frequency of dental caries in populations incorporating maize into the subsistence economy during late prehistory. They found that temporal increase in caries was greater in females than males and suggested that females may have ingested a relatively greater amount of maize than did males. This finding is consistent with documented differences in sexual division of labor reported for southeastern US native populations. That is, Hudson (1976) and others (e.g. Van Doren, 1928; Swanton, 1946) observe that women were responsible for plant gathering, planting, care of crops, and various activities more directly associated with food preparation in particular, and life in the vicinity of the village in general. Males, on the other hand, were responsible for hunting and other activities away from the village. Thus, Larsen and coworkers argue that a case can be made for greater access to and consumption of cariogenic foods – maize especially – in women.

Walker and Hewlett (1990) have analyzed prevalence of dental caries in Aka, Mbuti, and Efe pygmy hunter–gatherers and Bantu horticulturalists in central Africa. Ethnographic evidence indicates that women in these populations consumed more manioc than men. Moreover, unlike pygmy men, pygmy women frequently eat between meals. Men, on the other hand, tend to concentrate eating activities in several large meals. Walker and Hewlett (1990) conclude that a greater and more frequent consumption of plant carbohydrates among women resulted in higher a caries prevalence.

Overall, then, the greater frequency of carious teeth in females than in males in the Tutu series suggests behavioral differences in food consumption between sexes. Based on previous studies for archaeological and ethnographic populations, it is fully conceivable that Tutu women had greater access to plant carbohydrates – especially manioc – than did Tutu men. The trend requires additional study before making a definitive statement.

Walker and Erlandson (1986) have examined the link between dental caries and increase in use of marine resources in the Santa Barbara Channel Islands regions of southern California. On Santa Rosa Island, diet shifted from heavy utilization of predominantly terrestrial foods, comprised largely of starchy roots and tubers, to reliance on marine foods, fish especially. Over the period between *c.* 2000 BC and the fifteenth century AD, they reported reduction in dental caries from 13.3 percent to 6.3 percent. It is important to note that the increased use of marine foods in the California setting is similar to the St Thomas situation, in that there may also have been an increase in consumption of marine foods at Tutu. However, unlike the California setting, the populations inhabiting the Tutu site consumed domesticated plants, especially manioc. Therefore, the relatively high frequency of dental caries in the Tutu series for both early and late periods likely reflects the consumption of this cariogenic plant. On the other hand, the reduction in caries prevalence is suggestive and should be explored along other biocultural lines of evidence (e.g. stable isotopes).

Enamel defects

Enamel defects are common pathological conditions in archaeological human remains and in living populations, especially in Third World nations (various papers in Goodman & Capasso, 1992). A growing body of evidence indicates that populations experiencing elevated stress (from undernutrition, disease, and so forth) have a higher prevalence of various types of defects – most commonly, linear enamel hypoplasias – than populations experiencing relatively low stress levels (e.g. Goodman, Armelagos & Rose, 1984; Goodman & Rose, 1991; Larsen, 1997).

Inspection of the Tutu incisors and canines from the maxillary and mandibular dentitions reveals that all defects are limited to the mandibular canines and maxillary first incisors and canines (Table 8.2). All defects are narrow linear grooves located in the cervical portion of the tooth. For the total sample (adults and juveniles combined), the prevalence of teeth affected ranges from 6.7 percent for the maxillary right I2 to 22.2 percent for the mandibular right C. For adult females, the prevalence

Table 8.2 Dental defect (linear enamel hypoplasia) prevalence per tooth type in the Tutu dental series

	Total		*Female*		*Male*		*Indeterminate sex*[3]	
Tooth	*n*[1]	%[2]	*n*	%	*n*	%	*n*	%
Maxilla								
LI1	19	10.5	10	0.0	5	20.0	4	25.0
LI2	17	0.0	9	0.0	5	0.0	3	0.0
LC	17	11.8	10	10.0	7	14.3	0	0.0
RI1	17	11.8	8	0.0	6	16.7	3	33.3
RI2	15	6.7	8	0.0	6	16.7	1	0.0
RC	17	17.7	9	11.1	6	33.3	2	0.0
Mandible								
LI1	17	0.0	8	0.0	5	0.0	4	0.0
LI2	18	0.0	9	0.0	5	0.0	4	0.0
LC	18	16.7	11	9.1	6	33.3	1	0.0
RI1	15	0.0	7	0.0	4	0.0	4	0.0
RI2	21	0.0	10	0.0	5	0.0	6	0.0
RC	18	22.2	11	9.1	6	50.0	1	0.0
Total	209	8.1	110	3.6	66	16.7	33	6.1

Notes

1 Total number of teeth observed.

2 Frequency of teeth affected by hypoplasia.

3 Includes adults (n = 2) and juveniles with anterior tooth crowns that are developmentally complete (n = 2).

ranges from 9.1 percent (mandibular left and right C) to 11.1 percent (maxillary right C), and for adult males, from 14.3 percent (maxillary left C) to 50.0 percent (mandibular right C). One juvenile has enamel defects on the maxillary left and right canines.

Assessment of individuals affected (at least one hypoplastic tooth in an individual dentition) showed that 14.3 percent of adult females and 42.9 percent of adult males had hypoplasias. Five individuals (21.7%) in the total adult sample (females, males, and indeterminate sex combined) had at least one tooth affected by hypoplasia.

Comparison with other archaeological samples reveals the relatively low prevalence of enamel defects in the Tutu series (Table 8.3). These dental defect data indicate, therefore, that, although physiological stress was present in the population, it may have been minor. We should caution that these other samples are not strictly comparable because different researchers employ a variety of methods for hypoplasia documentation. However, this caveat aside, a general pattern emerges in comparison of these data. That is, populations experiencing reduced levels of health due to poor nutrition, greater population crowding, and higher levels of infectious disease tend to have a relatively high frequency of enamel defects.

Assessment of the Tutu series suggests that the population from which the sample is drawn experienced comparatively low stress levels, at least as it is expressed in frequency of enamel defects. Based on the evidence of low prevalence of enamel defects, it would appear that the Tutu population enjoyed relatively good health. Preliminary reconstructions of Tutu diet reveal that a variety of marine and terrestrial foods were consumed by the Tutu population (Lundberg, Righter & Caesar, 1992; and Chapter 4, this volume), which may reflect adequate diets, although a variety of pathological conditions are present in the Tutu series, including treponematosis, non-

Table 8.3 Frequency of individuals affected by enamel defects (hypoplasia) in selected archaeological samples

Source	*Period/diet*	*%*
This study	Prehistoric	24
Cassidy, 1984	Archaic	86–94
	Mississippian	73–91
Goodman, 1989	Late Woodland	45
	Late Woodland/Mississippian	60
	Mississippian	80
Hutchinson & Larsen, 1995	Hunter–gatherer	66
Milner, 1982	Mississippian	90
Murray, 1989	Historic (Amerindian)	96
Patterson, 1984	Initial agricultural	67
	Agricultural	79
Perzigian *et al*., 1984	Late Archaic	20
	Mississippian	60
Powell, 1988	Mississippian	54
Powell, 1989	Mississippian	90
Schulz & McHenry, 1975	Hunter–gatherer	16
Sciulli, 1978	Mixed economy	30
	Agricultural	52
Hall & Browman, 1992	Historic (England)	42
Lanphear, 1990	Historic (Euroamerican)	70–3
Mack & Coppa, 1992	Hunter–gatherer (Oman)	99

Note
Unless otherwise indicated, all data are from sites in North America.

specific skeletal infections, and iron deficiency anemia (Chapter 7). On the other hand, infectious disease rates for this population appear to be relatively high – only 3 adult skeletons lack periosteal reactions, and evidence suggests that treponemal disease was present and more severe and more prevalent during the late period than the early period. Perhaps, then, infectious disease was not affecting the Tutu individuals during the critical years of growth and development of the tooth crowns (0–6 years) but, rather, later in life when it is manifested on skeletal elements.

Therefore, the low prevalence of enamel defects represents a population – in reality, a series of populations since this is an archaeological series of skeletons that accumulated over a period of many generations – that experienced low levels of physiological perturbation affecting the development of tooth crowns. This assessment is supported by the morphology of enamel defects present in the five individuals so affected. That is, without exception, the hypoplasias are singular and narrow linear grooves. This suggests that the individuals experienced episodes of physiological perturbation that were not so severe as to produce deep, wide grooves that would characterize severe or long-lasting periods of stress, perhaps associated with weaning. Later life appears to be more problematic, at least with respect to the burden of infectious diseases.

One other individual in the Tutu series presents evidence of physiological stress. Burial 8B has a number of tooth crowns that are discolored. This enamel discoloration may be hypocalcification, a

Table 8.4 Occlusal wear on adult maxillary left incisor 1 and left molar 1 in the Tutu dental series, by individual burial

	Wear stage			
Burial	*Age*	*Sex*	*LI1*	*LM1*
1	45–55	F	8	4
2	40–50	F	0	0
3	40–50	F	(4)[a]	5
5	45–50	F	4	4
8A	15	M?[b]	2	3
8B	15–18	F?[b]	3	3
9	45–55	M	4	6
10	45–55	F	0	0
12	45–55	M	7	0
13	40–55	F	8	0
13A	45–55	I	0	(5)
16	35–45	F	5	6
19	40–50	F	4	7
21	adult	M	—	(7)
23B	>35	F	0	0
26	17–21	F	4	(3)
29	45–55	F	0	0
30	35–45	M	8	3
31	35–45	F	4	0
33	35–45	M	6	6
36	40–50	I	—	—
38	45–55	M	(8)	8

Notes

a Parentheses indicate substitution of right tooth when left missing.

b With regard to individuals 8A and 8B the sex of subadults was not estimated as part of this study (see Chapter 7); however, Larsen regards them as representing a possible male and female respectively. Therefore, for purposes of analysis, they are considered so.

Data for all tooth types were recorded, but only the maxillary left I1 and M1 are reported here. The wear stage code is adapted from Smith (1984).

Incisor wear

1 unworn to polish or small facets (no dentine exposure);
2 hairline of dentine exposure;
3 dentine line of distinct thickness;
4 moderate dentine exposure, still predominantly in mesiodistal direction;
5 large dentine area with enamel rim complete;
6 large dentine area with enamel rim lost on one side;
7 enamel rim lost completely;
8 severe loss of crown height;
0 data not recordable due to loss or pathology (e.g. dental caries).

Molar wear

1 unworn to polish or small facets (no dentine exposure);
2 moderate cusp removal (blunting of cusps);
3 full cusp removal and/or some dentine exposure (pinpoint to moderate);
4 several large dentine exposures, still discrete;
5 two dentinal areas coalesced;
6 three dentinal areas coalesced or four coalesced with enamel island;
7 dentine exposed on entire surface;
8 severe loss of crown height;
0 data not recordable due to loss or pathology (e.g. dental caries).

condition whereby the enamel matrix formed during dental development but was improperly mineralized (Goodman & Rose, 1991). This, along with other features related to physiological disruption, suggests the occurrence of a severe episode of physiological stress during childhood.

TOOTH MACROWEAR AND MICROWEAR: IMPLICATIONS FOR MASTICATORY AND NON-MASTICATORY FUNCTIONS

Occlusal surface wear

Assessment of occlusal surface wear in the Tutu series suggests that the dentitions of these individuals were exposed to a high wear environment. That is, all mature adults show generally advanced occlusal wear (Table 8.4). On the other hand, the sample contains relatively few younger adults and deciduous teeth do not show excessive wear, which would be expected in a high wear environment. One individual, Burial 38, an older adult male, has a mandibular molar that is tilted lingually to a point at which the superior, buccal aspect of the roots was incorporated into the occlusal wear plane of the tooth. This characteristic has been found in populations with excessive wear (see Larsen, 1997).

These observations are consistent with coastal or island settings whereby sand and grit are incorporated into the food during its preparation. Additionally, it also reflects the fact that grit and sand have not been completely removed from food prior to its consumption. In the Tutu setting, hard particles likely adhered to commonly eaten foods, such as fish, shellfish, and other marine foods. Moreover, Caribbean populations used grinding stones in food preparation. Consumption of these foods and use of grinding stones would result in the kinds of marked wear documented in the Tutu series.

Non-occlusal lingual wear

In addition to occlusal surface wear, a significant number of adults display wear on the lingual surfaces of maxillary anterior teeth (Table 8.5). In this type of wear, the wear plane is parallel to the lingual contour of the tooth. Nearly half (43.5%) of Tutu adults – 50.0 percent (7/14) of females, 42.9 percent (3/7) of males, and 0.0 percent (0/2) of indeterminate sex – were affected in this manner. Comparison of frequency of teeth with lingual wear reveals that 12.7 percent and 12.1 percent of female and male incisors/canines are affected respectively. All adults combined (females, males, indeterminate sex) show 11.8 percent of teeth affected. None of the juveniles displays lingual wear on an anterior tooth. In addition, one maxillary left P3 also displays lingual wear. In comparing frequency of female vs male lingual tooth wear, neither individuals nor teeth affected reaches statistical significance (chi^2; $p > 0.05$). Comparisons of early and late period adults reveals that about the same proportion of individuals in each period displays non-occlusal lingual wear – 44.4 percent (4/9) in the early period; 50.0 percent (6/12) in the late period.

The Tutu teeth show this kind of wear on both maxillary and mandibular teeth, although far more maxillary teeth are affected than mandibular teeth (Tables 8.5 and 8.6). For the total series, 20.4 percent of maxillary teeth and 3.2 percent of mandibular teeth have lingual wear. This difference between upper and lower dentitions is statistically significant (chi^2; $p < 0.05$).

Scanning electron microscopy of the incisal edge of the lingual surface of the left maxillary I1 from Burial 4 shows small pits and numerous shallow, very narrow scratches lying parallel to each other in predominantly labiolingual orientation (Figure 8.1a). Moving down the lingual surface from the incisal edge, the orientation of microwear features is somewhat more varied, but with a clear labiolingual emphasis (Figure 8.1b). The direction of the microwear features indicates that the individual habitually dragged some object or material in a recurrent front-to-back motion across the incisor.

Table 8.5 Tutu individuals and teeth with lingual wear, occlusal surface grooves, and/or labial wear

Burial	*Sex*	*Age*	*Teeth affected*
1	F	45–55	lingual wear maxillary right I1, left C
2	F	40–50	—
3	F	40–50	lingual wear maxillary left C, left P3
4	F	25–35	lingual wear maxillary left and right I1, I2
5	F	40–50	lingual wear maxillary left I1, I2, C, right C
8A	M?[1]	15	—
8B	F?[1]	15–18	lingual wear maxillary left and right I1, I2
9	M	45–55	lingual wear maxillary left and right I1
10	F	45–55	lingual wear maxillary left I2
12	M	45–55	—
13	F	40–55	occlusal groove maxillary left I1; labial wear mandibular left C
13A	?	45–55	—
16	F	35–45	—
19	F	40–50	—
21	M	adult	lingual wear mandibular left I1
23B	F?	>35	—
26	F	17–21	—
29	F	45–55	—
30	M	35–45	occlusal grooves maxillary left and right I1, left I2
31	F	35–45	lingual wear maxillary left C
33	M	35–45	lingual wear mandibular right I1, I2, maxillary left and right I1, C; labial wear mandibular right I, maxillary left and right I1
36	?	40–50	—
38	M	45–55	—

Note

With regard to individuals 8A and 8B, the sex of subadults was not estimated as part of this study (see Chapter 7); however, Larsen regards them as representing a possible male and female respectively. Therefore, for purposes of analysis, they are considered so.

Burial 8B shows a more varied pattern of microwear than Burial 4 (Figure 8.2, a and b). However, the incisal edge of the mandibular right I1 displays narrow parallel scratches, mostly in the labiolingual direction. As with Burial 4, microwear on this tooth gives the impression that some material or object was passed over the tooth in a predominantly front-to-back motion.

Non-occlusal labial wear

Two individuals, Burials 13 and 33, exhibit wear on the labial surfaces of anterior teeth (incisors and canines; Table 8.5). One of these individuals (Burial 33) also has lingual wear. The specific task relating to this wear is unclear since it is unlikely that it results from stripping or shredding of manioc or other plants.

The labial surface of the mandibular left canine from Burial 13 has a large amount of microscopically visible pitting, which is mostly due to postdepositional weathering and spalling of enamel. The middle pillar of enamel, however, was heavily scratched in life, with orientations

Table 8.6 Summary statistics of lingual wear in the Tutu adult dental series

	Total		*Female*		*Male*		*Indeterminate sex*	
Tooth	*n*[1]	%[2]	*n*	%	*n*	%	*n*	%
Maxilla								
LI1	15	26.7	10	20.0	5	40.0	0	0.0
LI2	15	20.0	9	33.3	5	0.0	1	0.0
LC	17	29.4	10	40.0	7	14.3	0	0.0
RI1	14	21.4	8	25.0	6	16.7	0	0.0
RI2	14	6.7	8	12.5	6	0.0	1	0.0
RC	17	17.7	9	22.2	6	16.7	2	0.0
Subtotal	92	20.4	54	25.9	35	14.3	4	0.0
Mandible								
LI1	14	7.1	8	0.0	5	20.0	1	0.0
LI2	15	0.0	9	0.0	5	0.0	1	0.0
LC	18	0.0	11	0.0	6	0.0	1	0.0
RI1	12	8.3	7	0.0	4	25.0	1	0.0
RI2	17	5.9	10	0.0	5	20.0	2	0.0
RC	18	0.0	11	0.0	6	0.0	1	0.0
Subtotal	94	3.2	56	0.0	31	9.7	7	0.0
Total	186	11.8	110	12.7	66	12.1	11	0.0

Notes

1 Total number of teeth observed.

2 Frequency of teeth with lingual wear.

varying according to the position on the tooth. Near the incisal or occlusal aspect of the tooth, the orientation of scratches is highly variable. However, scratches are primarily in mesiodistal direction with left- and right-handed deviations (Figure 8.3a). As the cervical aspect of the crown is approached, especially between two large grooves on the labial surface, the scratches have a marked vertical (labiolingual) orientation when the tooth is observed in anatomical position (Figure 8.3b).

Extramasticatory occlusal wear

The occlusal surfaces of anterior teeth of two individuals have been unintentionally modified from non-masticatory activity (Table 8.5). Burial 13 (individual also has labial wear) has a deep, wide, and highly polished groove on the occlusal surface of the maxillary left I1. The groove is oriented in a mesiodistal direction. The maxillary incisors of Burial 30, an adult male, possess narrow shallow grooves on their occlusal surfaces, also oriented mesiodistally. These grooves are located on highly worn teeth (stage 8) and are similar to occlusal grooves documented in prehistoric series from the American Great Basin (Larsen, 1985) and elsewhere (e.g. Molleson, 1994; and see review and discussion in Milner & Larsen, 1991). The lower incisors of Burial 30 show only stage 4 wear (moderate dentine exposure). Thus, both presence of occlusal grooves and advanced wear on maxillary but not mandibular incisors indicates that the individual habitually used the anterior upper dentition in an extramasticatory capacity.

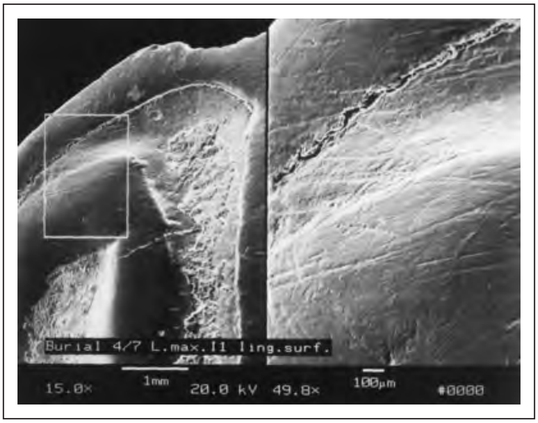


Figure 8.1a Micrograph of occlusal surface of maxillary left incisor 1 near mesial edge (Burial 4).

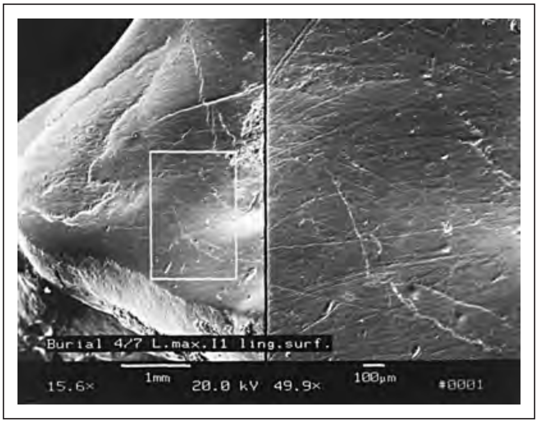


Figure 8.1b Micrograph of same tooth with field located more distally. Note the predominance of fine striations or scratches primarily in labiolingual orientation. The incisal edge of the crown is on the right in both views (mesial at the top of micrograph).

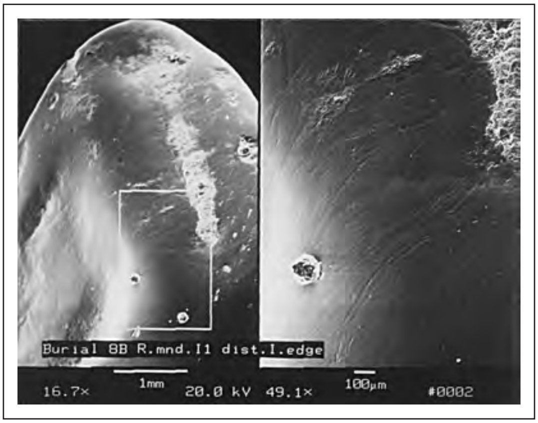


Figure 8.2a Micrograph of distal-lingual edge of mandibular right incisor 1 (Burial 8B). Incisal edge is at the right of the micrograph. Note the striations oriented in primarily labiolingual direction.

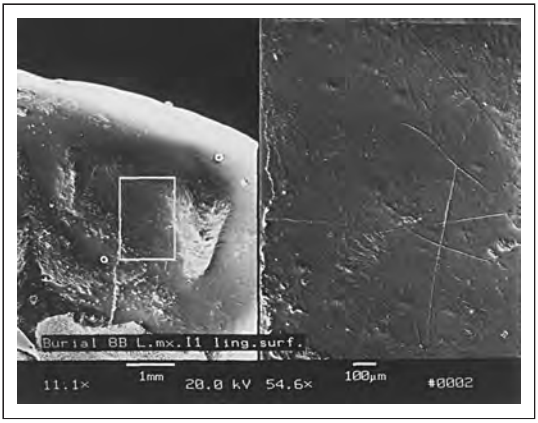


Figure 8.2b Micrograph of lingual surface of maxillary left incisor 1 (Burial 8B). Incisal edge is at the top of the micrograph.

The right maxillary I1 from Burial 30 shows a composite pattern of microwear (Figure 8.4, a and b). Along the incisal edge near the rim of the groove are several large pits combined with a series of labiolingual scratches, the latter of which indicate front-to-back motion of material dragged across the occlusal surface (Figure 8.4a). Moving into the floor of the groove, however, there are numerous pits and a few scratches in highly variable orientations. At the mesial perimeter of the floor of the groove, the features are exclusively pits (Figure 8.4b). Although there is some evidence of mesiodistal direction of scratches, the predominance of pitting associated with the groove indicates that most wear arose from the application of compressive forces on a frequent basis.

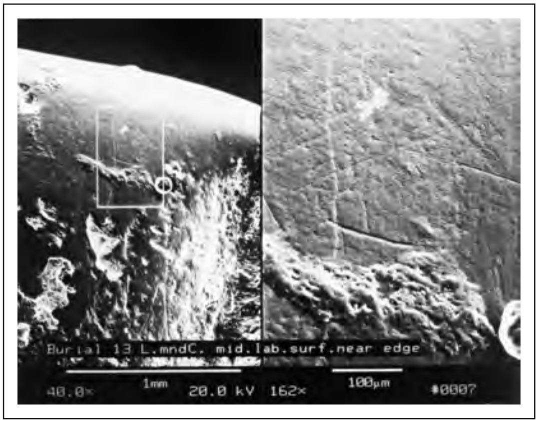


Figure 8.3a Micrograph of incisal edge of labial surface of mandibular left canine (Burial 13). Note mesiodistal orientation of scratches, with marked right- and left-handed deviations.

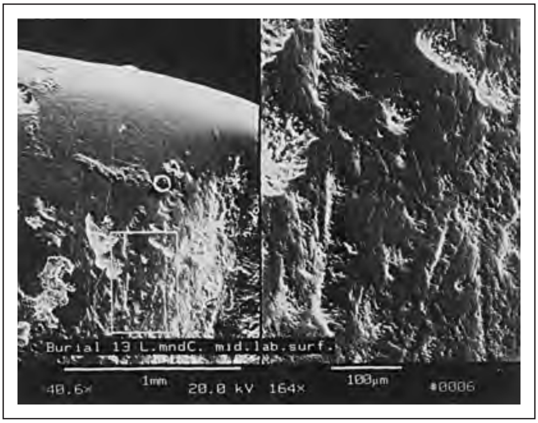


Figure 8.3b Micrograph of cervical region of labial surface of same tooth. In this view, scratches are oriented vertically (labiolingually), especially between the margins of the two main grooves shown in the right panel of the figure.

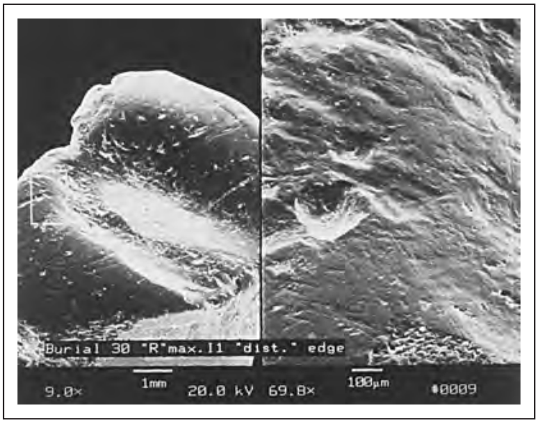


Figure 8.4a Micrograph of occlusal surface of maxillary right incisor 1, distal edge (Burial 30).

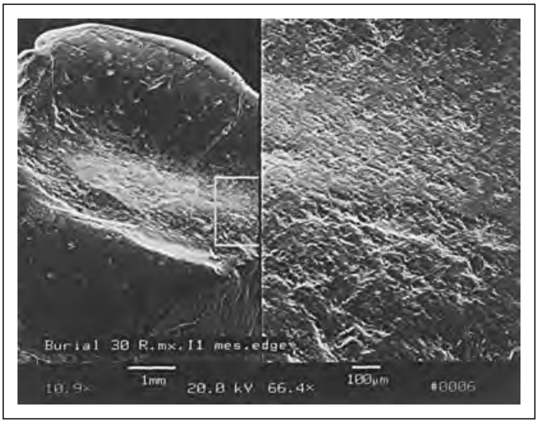


Figure 8.4b Micrograph of occlusal surface of same tooth, mesial edge. Note presence of some striations on the occlusal surface generally and predominance of pits resulting from compressive forces (and possibly adhesion) near and in the floor of the groove.

ALTERATIONS OF TOOTH SURFACES: EXTRAMASTICATORY BEHAVIORS

Modifications of human teeth reflecting different lifestyles and behaviors have captured the attention of dental anthropologists for much of the present century, especially in dentitions representing non-industrialized, traditional societies (Milner & Larsen, 1991). A great deal of information has been assembled on unintentional modifications arising from activities of various types. Most of the studies have emphasized description without the broader consideration of the meaning of these modifications in a biocultural perspective, and only recently have researchers begun to explore spatial and temporal variability.

The reliance on the anterior teeth for various tasks has been indicated by the presence of well-defined grooves on occlusal surfaces of teeth in the American Great Basin (Larsen, 1985; Brooks, Haldeman & Brooks, 1988), Northwest coast (Cybulski, 1974), California (Schulz, 1977), Texas (Bement, 1994), Greenland (Pedersen, 1947, 1952; Pedersen & Jakobsen, 1989), and Syria (Molleson, 1994). For these diverse populations, the pattern and direction of the grooves indicate that the front teeth had been used in processing of some type of flexible material. In Greenland, anthropologists have observed native individuals engaged in processing animal sinew for bow strings, a likely explanation for the grooves in the prehistoric remains (and in living populations) in this setting (Pedersen, 1947, 1952; Pedersen & Jakobsen, 1989; Hansen *et al.*, 1991). In the American West, native populations utilized plant fibers for production of a wide range of objects, including cordage, clothing, houses, and boats (Schulz, 1977; Larsen, 1985; Bement, 1994). Ethnographic documentation of twentieth-century native populations living in the western Great Basin (Nevada) includes photographs of individuals engaged in the preparation of willow shoots for basket-making by using their front teeth (see Larsen, 1985). Sinew was also prepared, which may alternatively explain this pattern of wear especially since basketry production was a primarily female activity in historic times and grooves are mostly associated with males in Great Basin dental samples (Larsen, 1985).

Very little information is available on potential causes of occlusal surface grooves in Caribbean native populations, in part because these groups became extinct within a short time following Columbus's original landfall on St Thomas in 1493. Thus, unlike the American West and Arctic regions where detailed ethnographic observations of native groups were made well into the twentieth century, activities that might result in anterior tooth modifications in the Virgin Islands are unknown. However, many other indigenous tropical populations in the New World have been observed to use a variety of leaves and other parts of tuberous and palm plants for production of matts and fibers for various utilitarian purposes (e.g. Chagnon, 1992). Analysis of phytoliths recovered from the Tutu site indicates the abundance of the plant family Marantaceae, a herbacious family that includes the minor tubers arrowroot (*Maranta arundinacea*) and Calathea (Piperno, 1994). We speculate that the presence of occlusal surface grooves on two individuals indicates the use of the front teeth in preparing tubers or some other type of fibrous plant for use in material culture. Perhaps this involved stripping the plant fibers from the tubers and then habitually passing the fibers across the occlusal surfaces from side to side in order to produce cordage in a manner similar to other populations that have been observed ethnographically elsewhere (e.g. Great Basin Amerindians).

The Tutu microwear analysis indicates, however, that use of the front teeth differed from the other populations with tooth grooves. In the dental remains from California (Schulz, 1977), the American Great Basin (Larsen, 1985; Brooks *et al.*, 1988), Greenland (Pedersen and Jakobsen, 1989; Hansen *et al.*, 1991), and Syria (Molleson, 1994), the enamel and secondary dentine in the floors of occlusal surface grooves are highly polished, thus indicating the transfer of some type of flexible material across the tooth. Scanning electron microscope analysis of teeth from the western Great Basin by Larsen (1985) shows a series of fine striations paralleling the grooves (and see Pedersen and Jakobsen, 1989; Hansen *et al.*, 1991). In contrast, the groove that we have microscopically documented from Tutu displays numerous pits probably resulting from compression. There are fine striations that are reminiscent of the Great Basin teeth, but the compression activity appears to have been an important, if not dominant, aspect of tooth use at Tutu. Additionally, adhesive "plucking" of enamel and dentine caused by forceful dragging of tough, fibrous material across the teeth could account for some of the pitting. That is, as forces are applied to the plant material by the anterior teeth, small pieces of enamel and dentine are lifted from the tooth due to adhesion. Some of the pitting extends into the dentine. Therefore, pitting may represent opening of dentinal tubules. However, the large volume and sizes of pits strongly indicates that this is not the only explanation for this pattern of wear. Regardless of cause of this pitting, SEM analysis suggests that the pattern of wear resulting in tooth grooves is due to unusual circumstances perhaps unique to this Caribbean setting.

The lingual wear on anterior teeth in the Tutu population is strikingly similar to precontact Latin American populations reported by Turner & Machado (1983) from Brazil; Irish and Turner (1987) from Panama; and Saul & Saul (1997) from the Maya lowlands. Additionally, at the Maisabel site, on the north coast of Puerto Rico, Budinoff (1991) has described lingual wear on the left, but not right, maxillary incisors, canine, and third premolar in one of 34 individuals. Lukacs & Pastor (1988) have also documented a pattern of marked lingual wear in both maxillary and mandibular anterior teeth from 1 individual, of 52 from the neolithic component of Mehrgarh, Pakistan, that is similar to these New World examples. Clearly, some individuals from all of these settings engaged in repetitive activities involving the use of the front teeth. However, there are some important differences between the single Old World and various New World examples. In the Mehrgarh individual, the pattern of tooth wear was unique to one individual and it involved both upper and lower dentitions. The relative infrequency of lingual wear and its presence in both maxillary and mandibular teeth is unlike the pattern observed in remains from Tutu. One Tutu individual displayed lingual wear on both maxillary and mandibular anterior teeth (Burial 33); all other individuals with lingual wear possessed it on either maxillary or mandibular teeth but not on both. The Mehrgarh example is also unlike the samples from Brazil or Panama where the individual prevalences of lingual wear were 84.8 percent and 57.1 percent respectively.

Similar patterns of lingual wear have also been documented in maxillary incisors and canines from prehistoric foragers from the lower Pecos region of southwest Texas (Hartnady & Rose, 1991). In this desert setting, lingual wear appears to be linked with activities involving pulling and shredding of grit-laden and tough non-domesticated plants (e.g. sotal, prickly pear, lecheguilla). In sum, then, lingual wear associated with plant processing appears to be a primarily New World phenomenon.

As with the study of all extinct populations, determination of cause of particular tooth wear patterns in the Tutu series is an intractable problem. However, as Turner and associates have suggested for other samples, because the wear occurs predominantly in the upper teeth with no corresponding wear on the lower teeth, some type of abrasive material must have been introduced between the upper (or lower in some instances) teeth and tongue on a regular basis. They suggest that either a significant amount of grit adhered to the material, or the material was a coarse, fibrous type of plant matter. The most likely scenario for explaining lingual wear has been offered by Turner and Machado in which the upper teeth were used to shred or peel tuberous plants "comparable to the modern way we eat artichokes – by pulling and planing the edible petals across the occlusal surfaces of our anterior teeth" (1983:128; and see Irish & Turner, 1987). Our microwear assessment of lingual surface wear in the Tutu series certainly confirms the unidirectional hypothesis offered by Turner and associates. However, the Tutu microwear pattern indicates a front-to-back motion of material dragged across the anterior upper dentition, which is the opposite of a back-to-front motion postulated by Turner and associates. Perhaps the Tutu individuals with non-occlusal lingual wear simply used an opposite direction toward the same end in manioc processing.

The prehistoric archaeological dentitions containing a significant presence of lingual wear – from Brazil, Panama, and the Virgin Islands – share in common a dietary focus on manioc. At the time of European contact, manioc was a critical dietary resource in these settings, and its widespread use has a considerable antiquity in the New World south of Mexico (see Turner & Machado, 1983). The dietary portion of the plant – the outer carbohydrate-rich layer – has to be removed from the inner root. That is, in order to render the plant edible, it must be peeled (Onwueme, 1978; Irish & Turner, 1987). It is highly plausible that this layer was removed by use of the front teeth in these different regions. Unfortunately, remains of manioc plants have not been preserved in archaeological settings. However, the high prevalence of permanent teeth affected by dental caries in the samples studied from Brazil (10.7%), Panama (12.3%), and Tutu (9.3%) indicates consumption of cariogenic carbohydrates, most likely manioc (Turner & Machado, 1983; Irish & Turner, 1987; Saul & Saul, 1997). These caries rates are high in comparison with other prehistoric horticulturalists in this and in other areas of the New World (cf. Turner, 1979; Larsen *et al.*, 1991). Similarly, the plants processed in the lower Pecos region of Texas were highly cariogenic. Caries prevalence was 14 percent in the skeletal series studied by Hartnady and Rose (1991). On the basis of this information, we conclude that lingual wear is related to the processing and consumption of plant carbohydrates.

The pattern of labial wear documented in two individuals from the Tutu site is especially difficult to interpret. Budinoff (1991) has noted the presence of labial wear on maxillary incisors in several individuals from the Maisabel site, Puerto Rico, dating to about the same time as the Tutu remains. However, she suggests that labial wear in the Maisabel remains is caused by malocclusion and especially pronounced prognathism. This may be the case for the Maisabel population. However, with regard to the Tutu dentitions, we could find no evidence for malocclusion. Moreover, SEM analysis reveals polishing and striations that are indicative of wear due to activity and not diet. The pattern is similar to wear resulting from labrets worn in the lower lips of adult males in northwest coast and Arctic native populations (e.g. Pedersen, 1952; Cybulski, 1974). However, to our knowledge, there is no evidence of use of labrets in the Caribbean. Therefore, we reject a labret interpretation as an explanation for labial wear on anterior teeth at Tutu. Based on the dominance of labiolingual orientations of grooves and striations on these teeth, the pattern is almost certainly related to an activity or activities involving passing an object or material front-to-back (or up-and-down) across the front of the tooth. Perhaps this wear is linked with plant processing. Until additional samples are identified and studied, this interpretation must remain in the realm of vague speculation.

The similar prevalence of non-occlusal lingual wear in anterior teeth of the early and late period inhabitants of the Tutu site indicates that behaviors associated with the wear pattern did not change appreciably from the early to late period. It suggests, moreover, that manioc preparation (and, by inference, its consumption) was present in both periods of time.

COMPARISONS WITH OTHER CARIBBEAN ARCHAEOLOGICAL DENTAL SERIES

As discussed by Sandford *et al.* (Chapter 7), very few archaeological human remains have been recovered in the greater Caribbean area. Fewer still have been systematically analyzed by biological anthropologists (reviewed by Sappelsa, 1993). With regard to dental remains, only a handful of reports document specific attributes, such as dental caries prevalence or tooth wear patterns.

Budinoff (1991) has summarized biological characteristics of skeletons from 34 burials from the Maisabel site located on the north coast of Puerto Rico. Although the frequency of carious lesions in the sample was not reported, Budinoff indicated that "[m]any of the site's adult dentitions are characterized by high caries incidence" (1991:118). As the author suggests, high frequency of caries in the Maisabel population is almost certainly related to consumption of manioc.

Similarly, the Tutu sample shares with the Maisabel a distinctive wear pattern on anterior teeth indicating that both populations employed their teeth in extramasticatory activities. Budinoff describes wear on the maxillary incisors whereby these teeth are "worn at a steep angle on the labial sides" (1991:121). However, the single published photograph of anterior teeth from one Maisabel dentition shows distinctive lingual, not labial, wear similar to the pattern of Tutu wear discussed here (see Budinoff, 1991:121). Therefore, if the published photograph is representative of the individuals described by Budinoff, it is more likely that she was documenting the pattern of lingual wear characteristic of the Tutu incisors and canines.

In addition, like the Tutu series, Budinoff describes high rates of occlusal surface wear in the Maisabel teeth. She attributes the presence of excessive wear at Maisabel to consumption of sand-laden marine foods.

Budinoff (1991) indicates that older adults in the Maisabel population had a high prevalence of premortem tooth loss. Although it was not possible systematically to document premortem tooth loss in the Tutu series, our impression of dentitions for older Tutu adults is that, like the Maisabel group, antemortem loss was extensive. Similarly, Budinoff reports high prevalence calculus. The Tutu dentitions also appear to have a significant amount of calculus. These observations are consistent with a population consuming carbohydrates, especially manioc.

One other study dealing with Caribbean human remains has documented in a preliminary fashion prevalence of dental caries and enamel hypoplasias. Drusini and coworkers (1987) have analyzed 78 protohistoric skeletons from the Juan Dolio site on Hispaniola (Dominican Republic). Like the Tutu and Maisabel series, dental caries and calculus "presented a certain incidence" (Drusini *et al.*, 1987:251), implying high frequencies of these pathological conditions. Unlike the Tutu population, however, a high prevalence of enamel hypoplasia, was interpreted to reflect elevated levels of physiological stress.

SUMMARY AND CONCLUSIONS

Based on the study of the Tutu dentitions, we characterize oral health and behavior in the prehistoric populations occupying St Thomas as follows:

1 Oral health was relatively poor in the Tutu population. That is, moderate prevalence (8.6%) of dental caries indicates that these populations relied on plant carbohydrates (manioc) resulting in tooth decay. There was a slight reduction in dental caries from the early to late periods, which may be linked to a proposed increased reliance on marine foods during the later occupation of the site. Moreover, the presence of calculus, periodontal disease, and premortem tooth loss were components of poor oral health.

2 Although poor dental health was experienced by the population as a whole, dietary reliance on manioc may have had a relatively greater negative effect on adult women than men. Juveniles have relatively fewer carious lesions than adults, but this difference is probably due to their having been exposed for a shorter period of time to consumption of cariogenic foods.

3 Analysis of dental defects – primarily linear enamel hypoplasias – indicates that the population was relatively free from physiological perturbation during infancy and early childhood, the years involving the growth and development of tooth crowns.

4 Occlusal surface wear on teeth reflects exposure to abrasives in diet, such as sand and grit incorporated into foods eaten.

5 Non-occlusal surface tooth wear – lingual and labial – and presence of occlusal surface grooves reflect the importance of teeth in the technology of the Tutu population throughout the occupation of the Tutu site. The pattern of wear described herein indicates that the front teeth were used for processing materials for production of material culture (occlusal surface grooves) and for initial preparation of manioc for consumption (lingual wear) by adult men and women.

Chapter Nine

Trace element analyses of skeletal remains and associated soils from the Tutu site

Julie F. Farnum and Mary K. Sandford

INTRODUCTION

Since the 1970s, anthropologists have employed trace element analyses of skeletal materials as a means of evaluating dietary intakes and some nutritional disorders of past peoples (for reviews, see Sandford, 1992, 1993b). Historically, efforts to use elemental analyses in this manner were concentrated along three lines. The first approach involves the use of strontium (Sr) and strontium/calcium ratios (Sr/Ca) to assess the relative dietary importance of plant resources and animal protein. In the most general terms, this strategy is based on the premise that organisms take up Sr in amounts that vary inversely to their position on the food chain such that plants tend to have higher Sr concentrations than animal species. A second paleodietary application of elemental analyses, the so-called multi-element approach, uses a much larger group of elements to make inferences about the relative importance of plant and animal constituents in the diet. Following this reasoning, the concentrations of elements such as zinc (Zn) and copper (Cu) which tend to be higher in animal food sources are contrasted to levels of such elements as magnesium (Mg) that are higher in plants. Finally, a third technique employs analyses of a single element to address questions relating to both diet *and* disease. Thus, elements such as iron have been studied to shed light on the hypothesized occurrence of iron deficiency anemia in past populations (Sandford, Van Gerven & Maglen, 1983), while analyses for the element lead (Pb) have been used to investigate possible past instances of lead ingestion and/or intoxication (Aufderheide, Whitmers, Rapp & Wallgren, 1988).

While subsequent tests of diet to bone trace element correlations indicated that simple relationships are not generally present (Weydert, 1990), some trends seem to be pronounced even when they are produced by extremely complicated mechanisms. Such appears to be the case with barium (Ba) and Sr, two elements that emerged out of the initial flurry of elemental studies in anthropology as perhaps the most informative of all. Used together, the two elements can greatly augment the assessment of the degree of terrestrial/marine dietary reliance in a population since Ba has a very low level in marine plants and animals, while Sr is highly concentrated in marine foods and less concentrated in the terrestrial environment. Several researchers have found that Ba and Sr are good discriminators between terrestrial and marine dietary reliance (Burton & Price, 1990; Gilbert, Sealy & Sillen, 1994; Weydert, 1990). These researchers have shown that Ba is a strong indicator of trophic level position and may be more sensitive than Sr. Although others (Lambert, Simpson, Szpunar & Buikstra, 1984) claim that large standard deviations in femur Ba content may obscure dietary differences, Ba/Sr and Ba/Ca ratios are reduced in marine plants and animals relative to those from terrestrial environments (Gilbert *et al.*, 1994). Gilbert and coworkers (1994) successfully plotted log Ba/Ca vs log Ba/Sr to characterize and chemically to separate marine plants, terrestrial plants, marine animals, and terrestrial animals in South Africa.

Attempts to perform dietary reconstruction using trace element data are greatly confounded, however, by postmortem alterations in bone chemistry. Thus, before dietary reconstruction can be attempted, the biological validity of the trace elemental data must be determined by testing for such postmortem changes, known as diagenesis. There are many mechanisms that can cause diagenetic alteration (see Sandford, 1993b: 41–43). Buried bones can become contaminated by the inclusion of separate mineral phases in small voids or fractures, replacement of biogenic hydroxyapatite with larger crystals of geological apatite, replacement of ions in the bone lattice positions with ions from soil or ground water, and leaching of ions from the bone matrix. Traditionally, a number of methods have been used to test for diagenesis, including comparisons of trace elemental concentrations in ancient and modern bones, comparisons of bulk soil samples and bone, and multivariate modeling of the interactions of the elemental concentrations (see Edward & Benfer, 1993; Lambert, Xue & Buikstra, 1991; Pate, Hutton & Norrish, 1989; Sandford, 1992; 1993b; Sandford & Kissling, 1994). While such techniques are useful, particularly when testing for major contaminants, they can yield conflicting results and do not provide information about low-level contamination/leaching and the structural distribution of the contaminants within the bone microstructure. Other tests have the potential to provide important additional information that cannot be obtained by other methods, as well as to test predictions about correlations of contaminants that are suggested by multivariate statistical analyses of the bulk bone and soil trace elemental data. Two such tests, employed in the present study, include the determination of the solubility of ions in grave soil samples and scanning electron microscopy x-ray analyses of histological sections of bone.

In this chapter, methods used in trace element analyses of the Tutu bones and associated soil samples are described, followed by a discussion of diagenetic testing procedures and results. This chapter concludes with a section on implications for dietary reconstruction at the Tutu site using trace element data.

METHODOLOGY

Neutron activation analysis of bulk bone and soil

Preparation of the bone samples

Femoral samples from 21 individuals were selected for trace elemental analysis at the University of Missouri Research Reactor (MURR). The samples were selected from the femora that were the least intact or with the least amount of visible skeletal pathology. The bones were washed in deionized water and allowed to air dry. Samples were cut from the femoral midshafts using a Sears Craftsman 5/8 variable speed saw with tungsten sabre blades. The periosteal and endosteal surfaces were removed from the samples using a dremal tool. Removal of 1–3 mm of the surface of the bone has been shown to reduce contamination of some elements, especially aluminum (Al), Zn, Fe, and Mn (Lambert, Xue & Buikstra, 1989; Lambert, Weydert, Williams & Buikstra, 1990; Lambert *et al.*, 1991) in archaeological samples without affecting the biogenetic components of those elements. Although it has been shown to remove small amounts of diagenetic calcium, strontium, and magnesium, acid cleaning (Sillen, 1986) was not used in this case, as it may also cause the removal of biogenetic material including zinc in studies of modern bone (Lambert *et al.*, 1990). Half of each sample was ashed at 600°C for 16 hr in a Thermolyne furnace and then weighed and sent to MURR – where it was redried in a VR–1 Hetovac and weighed for neutron activation analysis (NAA). The unashed samples were then washed for 15 min in an ultrasonic cleaner and dried at 100°C for 2 hr in an oven before being crushed and shipped to MURR, where they were dried for 48 hr in a VR–1 Hetovac and then weighed for NAA analysis.

Determination of short-irradiation elements in bone

The trace elemental contents of the bulk bone and soil samples were determined by NAA using a combination of short and long irradiations. The elements determined by full-fission (INAA) irradiation of 150 mg bone samples were: Br, Ca, Cl, Mg, Mn, Na, Sr, and V. The samples were irradiated for 5 sec in a thermal neutron flux of 8 x 10^{13}n/cm^2/s, allowed to decay for 3 min, and then counted for 5 min each using HPGe detectors with 25 percent relative efficiency. Improved counting statistics, because of less interference from Al, were obtained for Br, Mn, and Na by recounting the samples after a 4 hr decay.

Concentrations of Al, P, and I were determined from a combination of boron-shielded epithermal irradiations (ENAA) and INAA irradiations of 150 mg samples. Both shielded and unshielded irradiations are necessary to determine Al and P contents in bone because the Al–1779 characteristic x-ray can be produced from both ^{31}P(n,α) and ^{27}Al(n,γ). The boron shielding blocks the ^{31}P(n,α), allowing for the isolation of Al. Iodine concentrations were also measured from the boron-shielded irradiations. Further details can be found in Farnum *et al.* (1995). The standards for the short irradiations were Bowen's Kale and Orchard Leaves (SRM–1571).

Determination of long-irradiation elements in bone

The concentrations of Ba, Co, Cr, Fe, Sc, Sr, and Zn were determined from 100 hr irradiations of 65 mg samples in a thermal neutron flux of 5 x 10^{13}n/cm^2/s. Barium was measured from the midcounts after a one-week decay. The concentrations of Co, Cr, Fe, Sc, Sr, and Zn were measured after four-week decays. The long irradiation standards included fly ash (SRM–1633a) and Sr and Zn standards prepared from standard stock solutions.

Graphite furnace atomic absorption analysis of bone for Cu

The bone samples (250 mg) were digested in 3 ml of concentrated nitric acid in a microwave and analyzed by graphite furnace atomic absorption using a Perkin–Elmer Zeeman 5100PC spectrophotometer for Cu content.

Determination of short-irradiation elements in soil

Using the same flux as for the bone measurements the following elements were determined by short irradiations of 200 mg soil samples: Al, Ba, Ca, I, K, Mg, Mn, Na, and V. The samples were irradiated for 5 sec, allowed to decay for 25 min, and then counted for 12 min. Prior to irradiation, all of the samples were vacuum dried in a VR–1 Hetovac for 48 hr. The samples lost about 2–3 wt percent during the drying procedure. Fly ash (SRM–1633a) and basalt rock (SRM–688) were used as standards for the short irradiations. Iodine concentrations were determined from boron-shielded (ENAA) irradiations of 200 mg samples with 10 min decays and 12 min counts.

Determination of long-irradiation elements in soil

The following elements were determined from long irradiations (100 hr) of 200 mg samples in a thermal neutron flux of 5 x 10^{13}n/cm^2/s: Co, Cr, Fe, Sb, Sc, Sr, and Zn. The elemental concentrations were measured after a four-week decay. The standards for the long irradiations included fly ash (SRM–1633a) and obsidian (SRM–278).

Soil solubility from NAA

Soluble ion contents of the Tutu Village soil samples were determined using methodology adopted from Rhoades (1982). Rhoades suggests that procedures must be standardized and that methods of obtaining soil extracts in the laboratory yield only relative information about soil constituents (because laboratory conditions are considerably different from what would be observed in the field). It was not possible to duplicate Rhoades' experiment exactly because the Tutu soil samples were considerably smaller (2.5 g vs 200 g) than those used in Rhoades' work.

A 1:1 ratio of water/soil (2.5 g/2.5 g) was allowed to stand for 24 hr before filtration with a Buchner filter funnel. The filtrate was placed in a bag made of dialysis polyethylene tubing (model no. PELFT 005X02, size 0183, 0.005 cm thick by 5.08 cm wide), frozen, and vacuum dried. The residue samples (in the bags) were weighed inside polyethylene vials to prevent weighing error from air current interference. Samples from Burials 6 and 19 were partially lost in the vacuum drying process and were not included in the analysis.

The samples were irradiated using the following parameters: 1 min irradiations, 25 min decays, and 12 min counts. Granite (US Geological Survey AVG–1) was used as the standard for Ca and Mg and fly ash (SRM–1633a) was the standard for the rest of the elements measured in the analysis. The parameters listed above were chosen to optimize the number of counts for the main elements of interest (Ba, K, Mn, Na, Sr, and V). Because of the long decay time, Al values were often at or below the detection limits (approx. 1% for Al). Using short irradiations, we were unable to determine the amount of long half-life elements such as Fe, Sc and others.

Energy dispersive x-ray microanalysis of femoral cross-sections

Energy dispersive (EDS) x-ray mapping can be useful in determining the spatial distribution of elements in bone cross-sections. Uneven distributions of elements across the microstructure, as well as inclusions of crystals, salts, or carbonates around voids and fractures, can indicate diagenetic contamination in the sample (Lambert, Simpson, Buikstra & Hanson, 1983: Lambert *et al*., 1991). Energy dispersal x-ray (EDS) maps of two femoral cross-sections of B1 (MURR ID MK001), B13 (MK013), and B31 (MK031) were generated to examine the distribution of elements in the bone microstructure. The bone samples were cut at the mid-shaft of the femur, embedded in castrolite, polished with Al powder (0.3 microns), carbon coated, and then aluminum coated. It was originally planned to use only carbon coating, but it was found that aluminum coating gave better EDS resolution. The back scatter images and EDS mapping were done at 50,000× using a 20 KeV beam current, 40 mm working distance, 40 percent dead time, with tilt = 0° and take off angle = 30°. The high magnification was used to minimize sampling errors or artifacts that may occur when mapping irregular surfaces and provide better counting statistics around the Haversian canal areas. It was not possible to detect Ba or Sr above the background concentration using either EDS or wave-length dispersive point scans.

RESULTS OF TRACE ELEMENTAL ANALYSES

Diagenesis

As noted above, diagenesis is one of the most pressing, unresolved issues in the use of trace elemental analyses of archaeological bone for dietary and health reconstruction. For this reason, we employed a wide variety of tests to assess the degree and type of postmortem chemical contamination, or diagenetic change that affected the Tutu samples.

Table 9.1 Composition of unfired archaeological and modern bone

Element (ppm or %)	*1994 Ancient – Tutu, (Farnum* et al., *1995)*	*1987 Ancient Paloma (Edward, 1987)*	*1989 Modern (Hancock* et al.*, 1989)*	*1982 Modern (Gawlik* et al.*, 1982)*	*1971 Modern (Goode* et al.*, 1972)*
Al	101±110			20±6	
Ba	86±43				
Br	33±12	343±16	110±55		
Ca (%)	33.3±1.2	28.4±0.02	25.4±1.4	21.3±1.1	30.9
Cl	300±150	29,400±800	1,300±300		
Co	0.35±0.48	0.68±0.11		0.05±0.04	
Cr	0.79±0.16				
Cu	5.1±3.9				
F	n/a	1,840±90			
Fe	78±99	73.2±7.5		183±78	
I	30±24				
Mg	1,270±230	6,200±180	2,000±300		7,000
Mn	5.4±4.8	55.5±6.2			1.5
Na	3,000±400	33,500±8,600	6,000±300	4,900±900	5,000
P (%)	14.4±0.7		9.7±0.5	9.8±0.6	
Sc	0.044±0.064	0.005±0.001		0.001±0.001	
Sr	370±130	341±16		79±23	
V	3.5±1.9				1.2
Zn	115±21	123±3		151±22	

Ancient vs *modern bone*

A comparison of elemental levels in ancient and modern bones (Table 9.1) indicates that Al, Cl, Co, Cr, Mg, Mn, Na, and Sc are probably showing effects of contamination from clay mineral inclusion and/or leaching from water interactions. Cobalt, Cr, Mn, and Sc are usually not measurable in modern bone, suggesting that they are likely contaminants in the Tutu material. The Cl, Mg, and Na levels are much lower than those in modern bone indicating probable leaching of these elements in the Tutu bones. The Ca, P, and Sr values are also higher than those in modern bone. The Sr and Zn levels are consistent with those observed in studies of other marine sites including Paloma, Peru (Schoeninger & Peebles, 1981; Edward & Benfer, 1993).

Bone vs *bulk soil*

Comparisons of trace elemental levels in bones and associated soil samples may indicate movement of ions between bones and soil or soil and bones. The concentrations of most of the elements were much higher in soil than bone (Table 9.2), so any physical incorporation of soil particles could drastically alter the chemical concentrations of the bone. This is especially likely for those elements (Co, Cr, Mn, and Sc) that are not usually measured in modern bone. The concentrations of Ba, Ca, Sr, and Zn were higher in bone than soil. Grave and non-grave soils also were compared. Wilcoxon difference of means tests (Table 9.2) indicated that compared to the grave soils Sr values were significantly larger in the non-grave soils (p = 0.005). Ca values were twice as high in the grave soils. This might indicate that the original compositions of grave soils

Table 9.2 Bone, grave, and non-grave soil comparisons

Element (ppm or %)	*Unashed bone*	*Grave average*	*Non-grave average*	*Wilcoxon difference of means p-value*
Al	101±110	7.57±1.26%	8.47±0.72%	0.196
Ba	86±43	113±59	146±108	0.878
Ca (%)	33.3±1.2	11.1±5.1	5.4±2.8	0.249
Co	0.35±0.48	29.3±5.8	31.6±4.9	0.753
Cr	0.79±0.16	35.1±11.9	37.6±5.6	0.807
Fe	78±99	5.8±1.2%	6.7±0.5%	0.409
I	30.1±24.5	21.2±7.5	25.6±1.8	0.345
Mg (%)	0.13±0.23	2.6±0.5	2.5±0.4	0.249
Mn	5.4±4.8	982±270	1297±147	0.422
Na	3,000±400	5,800±2,500	6,600±2,700	0.279
Sc	0.04±0.06	35±6	36±4	0.861
Sr	370±130	151±85	268±123	0.001[a]
V	3.5±1.9	210±49	254±33	0.780
Zn	115±21	88±32	87±27	0.477

Note

[a] Statistically significant at alpha = 0.05.

different from the composition of the surrounding soils. It is also possible that the grave soils were leached from water running through the more loosely packed soil compared to the non-grave soils. Low-level contamination of Ba and Sr from the transfer of ions from the soil to the bone would not be noticeable in the soil composition, because the small amount removed from the soil would be negligible (or within one standard deviation of the bulk values) and therefore possible contamination involving these elements could only be studied using microscopic techniques (at least at this site). Comparisons between bone and grave soil Ba, Sr, Zn, and Na show no statistically significant correlations.

Non-metric multidimensional scaling

Multivariate analyses, such as principle components and multidimensional scaling, have been used extensively in many archaeometry applications. These included source group determinations in ceramics and obsidian studies and also assessments of dimensions of correlations between dietary elements in hair (Neff, 1994; Sandford, 1994). Due to the non-linear relations present in the distribution of the elements, a linear model of interpretation (such as principle components) was rejected in favor of non-metric multidimensional scaling (NMDS) using Spearman correlations, which does not require a normal distribution for each element. Kruskal's stress goodness of fit test and a scree plot (Figure 9.1) were used to determine the appropriate number of dimensions to use in the NMDS analysis. The elbow of the scree plot occurs at three dimensions with a stress value (0.073) less than 0.1, which is acceptable for NMDS (Kruskal & Wish, 1978). Using additional dimensions yield redundant information and does not significantly improve the fit of the model. The NMDS three-dimensional correlation matrix is presented in Table 9.3. The NMDS results (Figure 9.2) suggested possible separation of elements into three groups, including diagenetic elements (Al, Mn, Ca, Co, Fe, P, and Sc), biogenetic or dietary elements (Ba, Sr, Mg, and V) and salts (Na and Cl). Therefore, it is possible to form a predictive model concerning

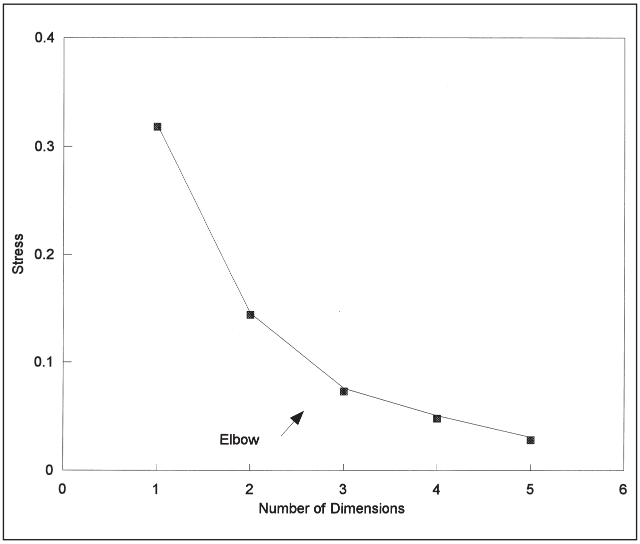


Figure 9.1 NMDS scree plot for the Tutu site. The elbow of the scree plot indicates that three dimensions are adequate to represent the spatial relations among the variables.

contamination in the Tutu material. It is hypothesized that the majority of the contamination of the Tutu material is due to precipitation of salts and/or other compounds containing the elements in the diagenetic group and that Ba and Sr are not correlated with the contaminants. This hypothesis can be tested using two additional tests: (1) measurement of the solubility of ions in soil and (2) energy-dispersive x-ray microanalysis to look at the spatial distribution of the elements, possible correlations between contaminants, mechanisms of contamination, and/or low-level contamination.

Soil solubility

The rank order results (Table 9.4) indicate that Ca and Na are by far the most soluble, while the dietary elements, Ba and Sr, are relatively insoluble in the grave soils. The least soluble elements (Sr, Mn, Ba, and V) were almost the same as those predicted in the NMDS model (Sr, Mg, Ba, and V) to be least affected by diagenesis. With the exception of Mn, the elements that were possible contaminants in the NMDS model (Al, Ca, Na, and Mn) were highly soluble in the soil samples. Wilcoxon difference of means tests indicate that Mg, Mn, and Sr are more soluble in the non-grave soils than the grave soils. The results suggest that the compositions of the soils may have changed since the time of burial due to a number of factors, including possible leaching of the burial soil, the addition of Ca, Mg, and Na leached from the skeletons and the possible addition of Ca from decomposing shells. The calcium contamination may also be a result of calcium transport from thin vein calcite deposits in the area (personal communication, Elizabeth Righter).

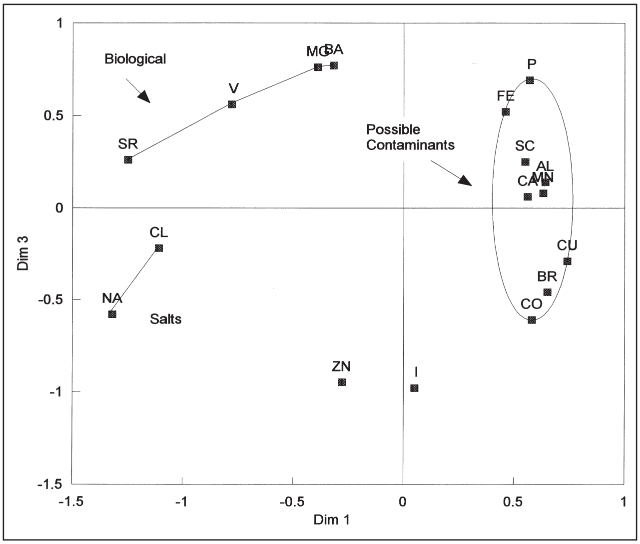


Figure 9.2 Tutu NMDS Dim 1 vs Dim 3 for the Tutu site. The NMDS results predict three (or more) possible groups of elements: biological (Ba, Sr, Mg, V), diagenetic (Al, Br, Ca, Co, Cu, Fe, Mn, Sc), and salts (Na and Cl). Zinc and iodine don't fit well into any group.

Energy dispersive x-ray microanalysis

Energy dispersive x-ray analyses were used to attempt to verify the biological nature of Sr and Ba in the Tutu bone results and to test further the predictions from the NMDS model. Due to funding limitations, only two sections from each

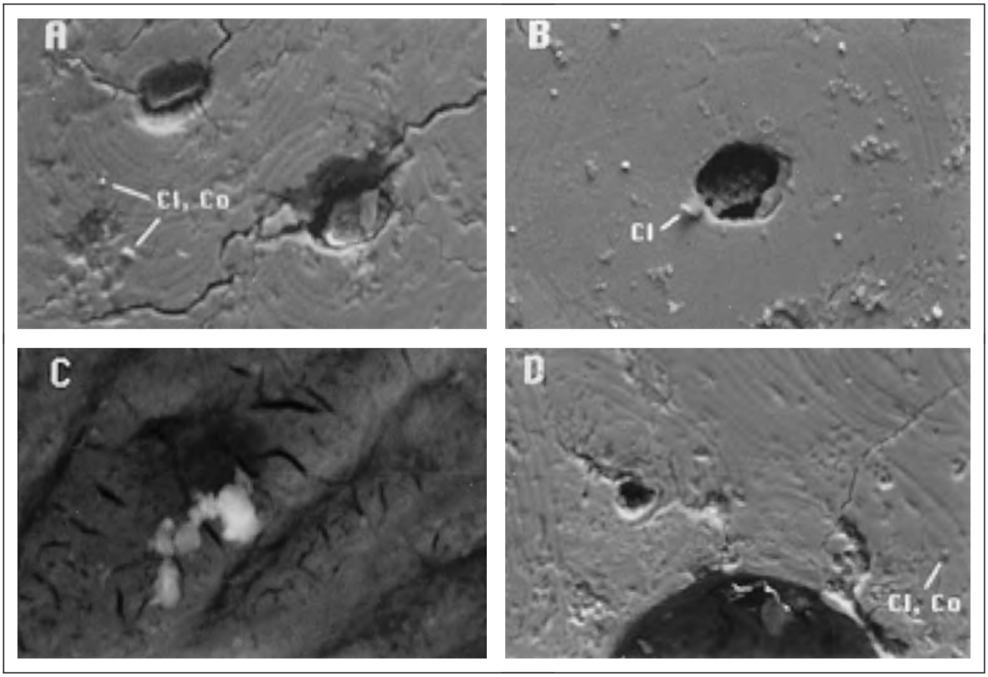


Figure 9.3a–9.3d SEM microstructural images from the Tutu Site.
a–b: 50,000× sections from B13 showing contamination from inclusion of particles containing Co, Cl, and S. c: 100,000× of a Co-S-Cl crystal embedded in B13.
d: 50,000× section of B31.

of three individuals (B1 – not shown; B13 – Figures 9.3a, 9.3b, B31 – Figure 9.3d) were analyzed. Therefore, the results presented here only indicate possible general trends in the spatial distribution of the elements in the femoral sections. Energy-dispersive x-ray analyses indicated contamination or re-precipitation of Ca in some samples (B13 – Figures 9.3e, 9.3f and B1 – not shown) (mainly around the Haversian canals) and leaching in others (B31 – Figures 9.3g, 9.3h). There is a

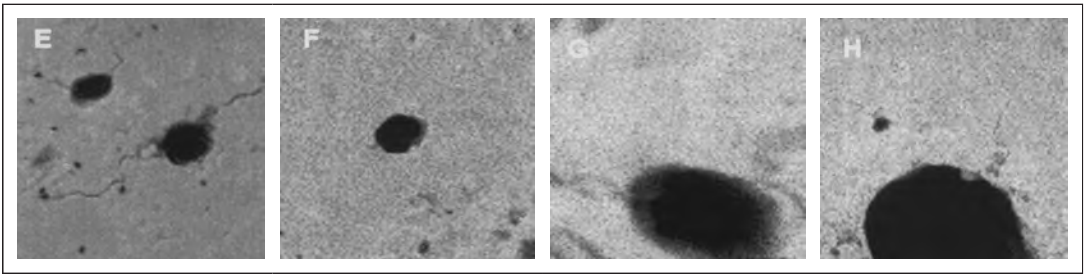


Figure 9.3e–9.3h SEM EDS composite x-ray maps from the Tutu Site, including Ca; Al; P; and both Ca and P.
e–f: are of B13 at 50,000×.
g–h: are of B31 at 50,000×.

Note
Ca contamination around the Haversian canals and overall uneven distribution of Ca indicating post-depositional chemical alteration.

Table 9.3 Tutu NMDS[a] results for three dimensions using unashed bone data

Element	*Dimension 1*	*Dimension 2*	*Dimension 3*
Al	0.64	0.14	0.32
Ba	–0.32	0.77	0.01
Br	0.65	–0.46	–0.07
Ca	0.56	0.06	–0.77
Cl	–1.11	–0.22	–0.43
Co	0.58	–0.61	0.34
Cu	0.74	–0.29	0.37
Fe	0.46	0.52	0.35
I	0.05	–0.98	0.14
Mg	–0.39	0.76	–0.59
Mn	0.63	0.08	–0.11
Na	–1.32	–0.58	0.51
P	0.57	0.69	–0.31
Sc	0.55	0.25	0.37
Sr	–1.25	0.26	0.14
V	–0.78	0.56	0.49
Zn	–0.28	–0.95	–0.74

Note

[a] NMDS = non-metric multidimensional scaling.

Table 9.4 Rank order soil solubility

Element	*Combined rank order (ppm)*	*Grave soil rank order (ppm)*	*Non-grave soil rank order (ppm)*	*Wilcoxon difference of means between grave and non-grave soil p-value*
Ca	70.2±33.3	66.9±19.8	86.4±57.4	0.152
Na	18.7±13.3	19.3±14.9	18.2±6.7	0.279
Al	5.18±2.29	4.91±1.88	5.66±3.04	0.917
Mg	4.97±2.67	4.59±1.76	6.16±4.08	0.023[a]
Sr	0.36±0.18	0.31±0.15	0.51±0.19	0.008[a]
Mn	0.11±0.12	0.08±0.05	0.21±0.20	0.013[a]
Ba	0.09±0.09	0.09±0.09	—[b]	—
V	0.05±0.02	0.05±0.02	0.06±0.02	0.552

Notes

a Statistically significant at alpha = 0.05.

b The solubility of Ba was less than the detection limits here.

large amount of variation in Ca content within an individual (Figures 9.3e, 9.3f for B13; Figures 9.3g, 9.3h for B31) as well as between individuals. Some small (approx. 1–3 micron) crystals of a mineral containing mainly Co, Cl, and S were found embedded in the microstructure (Figure 9.3c), but not always concentrated near the walls of the Haversian canals (Figures 9.3a–d). The

Table 9.5 Temporal change: early vs late: males and females combined[a]

Element (ppm or %)	*Early*	*Late*	*Wilcoxon difference of means, p-value*
Al	106±67	65±53	0.249
Ba	126±74	66±18	0.068
Br	37.9±17.7	33.9±15.2	0.463
Ca (%)	33.6±2.0	33.5±1.2	0.917
Cl	306±119	262±73	0.753
Co	0.831±0.691	0.250±0.299	0.075
Cu	9.20±4.26	4.93±3.66	0.028[b]
Fe	115.9±89.6	54.1±62.7	0.249
I	54.18±33.00	20.2±10.8	0.116
Mg	1,305±180	1,295±260	0.917
Mn	8.73±5.39	4.30±3.01	0.075
Na	2,937±349	3,002±541	0.600
P (%)	14.4±1.1	14.4±0.7	0.917
Sr	318±140	424±170	0.028[b]
V	4.2±3.38	3.30±1.18	0.753
Zn	116±20	119±30	0.917
Log(Ba/Sr)	–0.48±0.12	–0.75±0.17	0.068

Note

[a] Burial 39 excluded.

levels of Ba and Sr were not detectable above the background concentration in any of the samples, indicating that they were not being deposited with the re-precipitated Ca and that they have a more even distribution in the microstructure, as would be expected in uncontaminated samples.

Diagenesis summary

Comparisons of many methods for detecting diagenesis in the Tutu bone samples have shown that the more traditionally used methods (comparison of trace elemental levels in ancient and modern bone, comparison of bone and bulk soil, and multivariate statistical modeling) are useful in determining large-scale contamination and generating predictive models of possible contaminants and correlations between those elements.

The NMDS results (Figure 9.2) suggested possible contamination from a group of elements including Al, Mn, Ca, Co, Fe, P, and Sc. The dietary elements Ba and Sr, along with Mg and V, clustered along a line separate from the contaminants with salts (Na and Cl) forming a third group. It was predicted that the dietary elements were only minimally affected by contamination and that the majority of the contamination was from precipitated salts and metal/clay inclusions. This hypothesis was tested using data from soil solubility analysis and also energy dispersive x-ray mapping of femoral cross-sections. The soil solubility results suggested that the dietary elements (Ba and Sr) along with Mn were very insoluble in the grave soils and probably dietary in origin. This was corroborated by the x-ray microanalysis which indicated Ca leaching and/or re-precipitation and Co, S, and Cl contamination but no measurable Sr or Ba contamination. Therefore, it was concluded that Sr and Ba values were minimally affected by diagenesis, but Sr/Ca ratios should be avoided because of differential diagenesis.

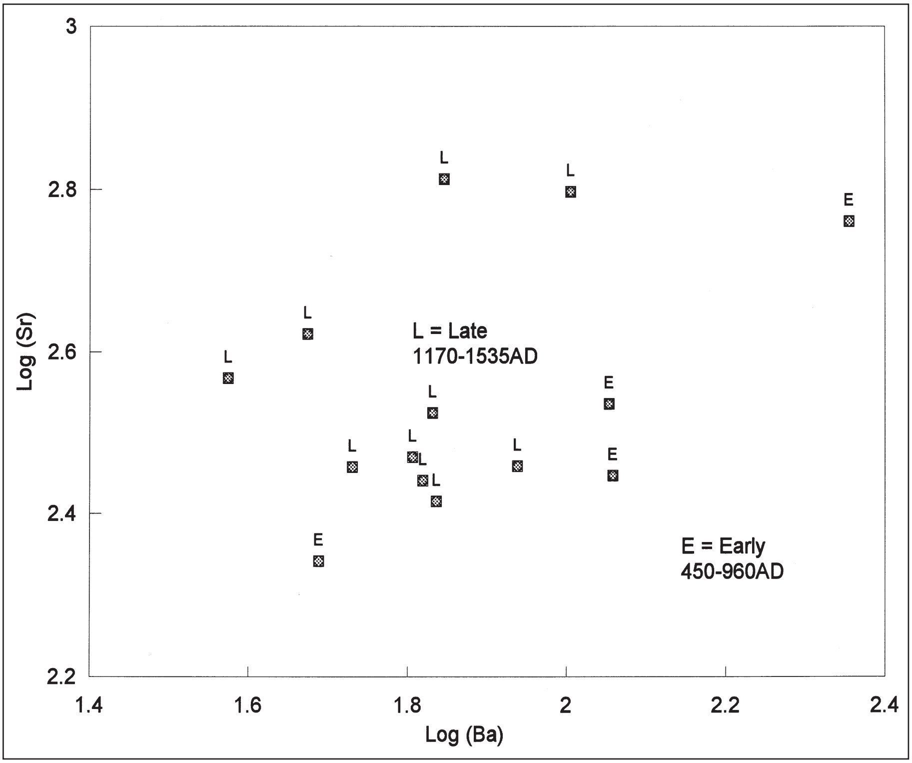


Figure 9.4 Dietary change over time for the Tutu Site. The higher Sr values relative to Ba indicate a shift towards greater marine reliance in the later time period at Tutu.

Dietary reconstruction

Degree of marine reliance

Burton and Price (1990) have developed several scales to separate marine-based subsistence from one of terrestrial reliance. They find that marine diets generally have log (Ba/Sr) ratios between –1.3 and –1.8 terrestrial diets averaged between 0 and –0.4. The Tutu samples have an average log (Ba/Sr) ratio of –0.63, which indicates a mixed diet. Plotting log (Sr) vs log (Ba) also separates marine and terrestrial diets (Burton & Price, 1990). Using Burton and Price's graph (1990; p. 793), the Tutu material (log (Sr) = 2.57 and log (Ba) = 1.93) again falls between the two groups, suggesting a fairly equal contribution from both terrestrial and marine resources.

Variation by time period

Variation in marine/terrestrial reliance was examined for two time periods (early, AD 450–960 and late, AD 1170–1535). Since B39 may be much later than the others, it was excluded from the analysis. Wilcoxon tests of the difference in means between the early and late time period individuals indicate a significant difference in Sr and Cu contents (Table 9.5). Most of the elements were more highly concentrated in the early material, so diagenesis may have been more pronounced in that time period. Since Sr values increased over time and did not follow the trend of the diagenetic variables, it seems probable that the increase reflected a dietary trend. Figure 9.4 shows the shift in log (Sr) vs log (Ba) values. Almost all of the late time period individuals have higher Sr levels than those from the

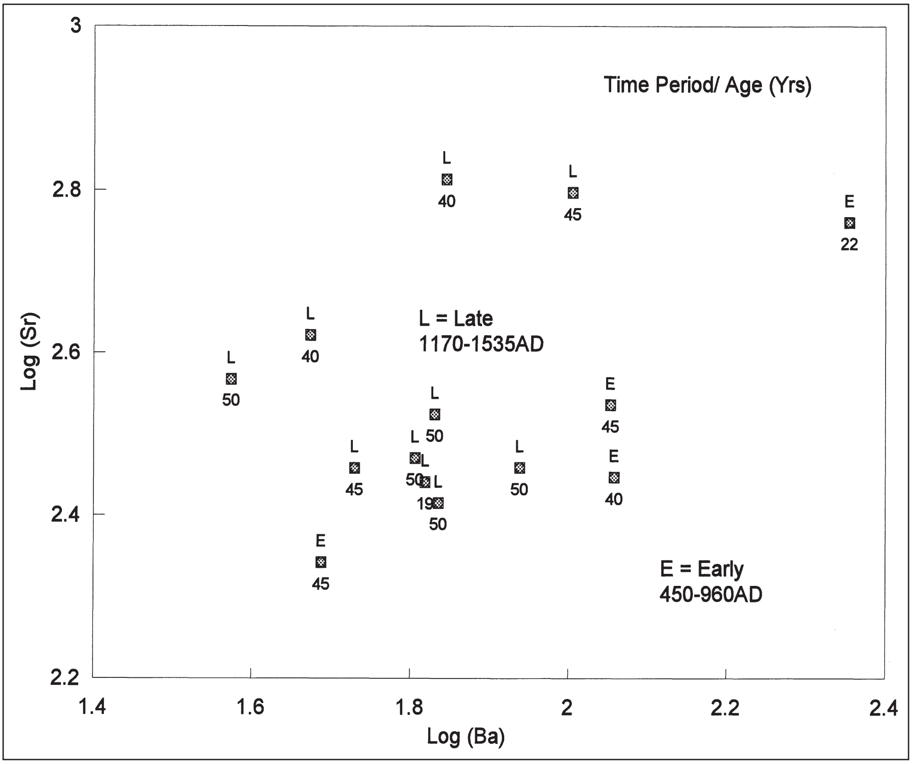


Figure 9.5 Dietary change and age for the Tutu site. There is no correlation between dietary change over time and the age of the individuals.

earlier time period. Comparing where the early and late log (Sr) vs log (Ba) points fall on Burton and Price's graph (1990; p. 793), the early material (log (Ba) = 2.1 and log (Sr) = 2.5) falls within the lower edge of the terrestrial reliance group, and the late material (log (Ba) = 1.8 and log (Sr) = 2.6) is located between the marine and terrestrial reliance groups. These results suggest a shift from lesser marine consumption to a near-equal distribution of marine and terrestrial components in the diets. If the Ba levels in the early material are slightly enhanced from diagenesis, then the early time period group may have had a lesser reliance on terrestrial resources than is suggested by the Ba/Sr ratios. The high mean Sr values for both groups are indicative of marine reliance populations.

Variation by age

Individual ages were added to Figure 9.4 (see Figure 9.5) to determine if there was any age influence in the dietary shift. Since most of the individuals fall within the same age category (40–50 yrs) it was not very useful to examine age-related trends, as the other age ranges did not contain enough individuals to be a representative sample of those age groups.

Variation by sex

Table 9.6 shows the Wilcoxon tests for differences between males and females for the later time period. There were no statistically significant differences in any of the elements related to sex in the later time period. It was not useful to look for sex-related differences in the early material because the sample only contained one male.

Table 9.6 Variation with sex: females vs males: late time period only[a]

Element (ppm or %)	*Females*	*Males*	*Wilcoxon difference of means, p-value*
Al	69±63	61±53	0.686
Ba	66±21	67±16	0.345
Br	33.9±15.2	27.1±5.6	0.500
Ca (%)	33.5±1.2	32.9±0.5	0.893
Cl	262±73	241±28	0.893
Co	0.250±0.299	0.087±0.033	0.080
Cu	4.93±3.66	2.69±0.675	0.138
Fe	54.1±62.7	37.4±28.4	0.893
I	20.2±10.8	16.5±13.5	0.893
Mg	1295±260	1307±363	0.500
Mn	4.30±3.01	4.24±6.49	0.500
Na	3,002±541	3,065±310	0.893
P (%)	14.4±0.7	14.5±0.6	0.893
Sr	424±170	313±61	0.893
V	3.3±1.18	2.62±0.37	0.225
Zn	119±30	119±15	0.893
Log(Ba/Sr)	–0.80±0.15	–0.68±0.19	0.273

Note

[a] Burial 39 excluded.

Correlations with pathologies

Possible correlations with pathologies have not been extensively investigated. Correlations between linear enamel hypoplasias, Harris lines, and Zn (Farnum, 1996), and anemia and Fe (Benfer, 1990) have been reported in other studies. It may be possible that the treponemal infection present in the all of the Tutu individuals analyzed could have influenced some elemental concentrations. Further work involving SEM x-ray analysis could be useful in examining elemental variation in affected vs non-affected bone sections.

CONCLUSIONS AND RECOMMENDATIONS

The results of the Tutu trace elemental analyses indicate that the Tutu people were consuming a mixed marine and terrestrial diet with an increased reliance on marine foods in the later (AD 1170–1535) time period. Further separation of marine components would involve analyzing possible food sources from the Caribbean area and constructing scales similar to those used by Gilbert *et al.* (1994) who plotted log Ba/Ca vs log Ba/Sr to characterize and to separate chemically marine plants, terrestrial plants, marine animals, and terrestrial animals in South Africa. There were no statistically significant differences between males and females, and age was not a factor in the dietary shift. The impact of pathology on the trace elemental concentrations has not been extensively studied, but seems to be a reasonable project to consider for future work.

Chapter Ten

Bone isotopic analysis and prehistoric diet at the Tutu site

Lynette Norr

INTRODUCTION

This chapter presents the background, methods, results, and paleodietary interpretations of bone stable isotope analyses performed on human and faunal remains from the Tutu site. As part of a larger multidisciplinary project addressing a broad array of questions related to culture history, society, ecology, and individual health, this study contributes information regarding human subsistence patterns and the exploitation and/or production of certain classes of food resources.

Bone samples from 24 pre-Columbian burials were processed for analysis of the stable nitrogen and stable carbon isotopic composition of bone collagen and bone apatite carbonate. The human samples are from two temporal periods. At 2-sigma, burials 3, 4/7, 10, 13, 13A, and 16 date prior to AD 1000, and Burials 1, 2, 5, 6, 8A, 8B, 9, 12, 19, 20, 22B, 26, 29, 30, 31, 33, and 38 date to after AD 1150. The cultural entities represented by the prehistoric burials are Saladoid and Ostionoid in Caribbean prehistory. The sampled individuals also represent males and females, as well as children and adults.

The stable isotopes of carbon and nitrogen in archaeological human remains can be used to provide information about prehistoric subsistence. This is because specific categories of food resources differ naturally and predictably in their isotopic composition, and that composition is recorded in the consumer's body tissues. The consumption of plants with different photosynthetic pathways, specifically maize and other tropical grasses vs most other plants, and the consumption of marine vs terrestrial protein, can be identified in most populations.

Potential research questions that can be addressed through this type of analysis include, among others:

1 the identification of maize agriculture as part of the subsistence base (Buikstra & Milner, 1991; Lynott, Bouton, Price & Nelson, 1986; Norr, 1990; van der Merwe & Vogel, 1978; Vogel & van der Merwe, 1977; White & Schwarcz, 1986);
2 the importance of coastal resources in the diet (see e.g. Chisholm, Nelson & Schwarcz, 1982; Johansen, Gulliksen & Nydal, 1986; Norr, 1990; Sealy, 1986, 1989; Sealy & van der Merwe, 1985; Tauber, 1981; Walker & DeNiro, 1986);
3 changes in subsistence patterns over time (Hutchinson & Norr 1994; Larsen, Schoeninger, van der Merwe, Moore & Lee-Thorp, 1992; Norr, 1990, 1995, 1996; Schwarcz, Melbye, Katzenberg & Knyf, 1985; van der Merwe, Roosevelt &Vogel, 1981);
4 regional diversity in subsistence (Ambrose & DeNiro, 1986b);

5 within-group dietary differences, for example between males and females (Lovell, Nelson & Schwarcz, 1986; Norr, 1990:270–71), individuals of different status (Murray & Schoeninger, 1988), different age groups (Lovell *et al.*, 1986), or the local population and "foreigners" (e.g. Andean highland vs coastal, Verano & DeNiro 1993); and
6 the relationship between diet and health (Buikstra, Autry, Breitburg, Eisenberg & van der Merwe, 1988; Norr, 1984, 1990, 1992).

Early in the history of the use of stable isotope geochemistry for paleodietary reconstruction, bone collagen was the bone fraction selected for analysis. This is because the protein collagen maintained its integrity well and could be isolated from other biogenic organic compounds in the bone as well as from soil organics adhering to and penetrating the bone. The carbon isotope ratios of carbonate in bone and tooth enamel apatite, however, also provide dietary information that complements that from bone collagen (Ambrose & Norr, 1993; Lee-Thorp, 1986; Lee-Thorp & van der Merwe, 1987; Sullivan & Krueger, 1981, 1983) provided integrity of the apatite carbonate can be demonstrated (Schoeninger & DeNiro, 1982; Koch, Fogel &Tuross, 1994; Wright & Schwarcz, 1996).

Interpretation of the human bone isotopic data is dependent on knowledge of local food resources and their isotopic composition. As we improve our understanding of how different kinds of foods are incorporated into body tissues, and as our knowledge of the variation of the isotopic composition of tropical foodwebs increases, more specific and more quantitative questions can be addressed through stable isotope analysis. Meanwhile, in complex ecosystems such as those found in the tropical environments of the Caribbean, it is advisable to limit dietary interpretations to relative contributions to the diet rather than attempt to calculate percent maize or marine foods in the diet (Norr, 1995). In addition, dietary conclusions based on stable isotopic data can be supported by other lines of dietary evidence, such as faunal, botanical, and microbotanical data, as well as evidence for food production and food preparation technology.

In many tropical environments, poor preservation of archaeological bone is a serious problem. Often there is no bone preserved, and when bone is found the collagen may not be preserved or the carbonate may be contaminated. Thus, assessing sample quality is also an important aspect of the analytical procedure (DeNiro, 1985; Koch *et al.*, 1994; Tuross, Fogel & Hare, 1988; Schoeninger & DeNiro, 1982, 1983; Wright & Schwarcz, 1996).

BACKGROUND

Analysis of archaeological bone for ratios of the stable isotopes of carbon and nitrogen is now a well-established technique for reconstructing paleo-diet. This is possible because specific food resources have distinct ratios of the stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$). Dietary isotopic composition is incorporated into body tissue fractions such as bone collagen and bone and tooth enamel apatite, and may be preserved for thousands of years after death (Ambrose & Norr, 1993; DeNiro, 1987; DeNiro & Epstein, 1978, 1981; Lee-Thorp, 1986; Lee-Thorp & van der Merwe, 1987; Schoeninger, DeNiro & Tauber, 1983).

The stable isotope ratios of carbon or nitrogen are expressed using the delta (δ) notation as parts per thousand (‰, per mil) difference from a standard. This is an analytical method that gives more accurate results than a determination of the absolute abundance of each isotope. For carbon, the analytical standard is the Pee Dee Belemnite (PDB) limestone fossil (Craig, 1957). $\delta^{13}C$ sample values are usually negative because the PDB limestone has more ^{13}C relative to ^{12}C than do most other substances. For nitrogen, the standard is atmospheric nitrogen, AIR (Mariotti, 1983). The sample $\delta^{15}N$ values are usually positive, because they have more ^{15}N relative to ^{14}N than does air.

Certain categories of foods differ predictably in their stable carbon isotope ($^{13}C/^{12}C$) ratios. In the tropical regions of the pre-Columbian New World, these include:

1 plants with C_3 vs C_4 or CAM (Crassulacean Acid Metabolism) photosynthetic pathways (Bender, 1968; Smith, 1972; Smith & Epstein, 1971);
2 animals feeding on those plants (DeNiro & Epstein, 1978; Land, Lundelius &Valastro, 1980; Tieszen 1991; van der Merwe, 1982); and
3 animals in terrestrial vs marine ecosystems (Chisholm, 1986; Chisholm *et al.*, 1982; Keegan & DeNiro, 1988; Norr, 1990; Schoeninger & DeNiro, 1984; Walker & DeNiro, 1986).

C_3 plants have very negative $\delta^{13}C$ values, averaging near –26‰, and include most temperate grasses, trees, fruits, nuts, and tubers. C_4 plants native to the New World include tropical grasses and other weedy plants, such as maize, setarias (foxtail), sedges, some amaranths, and some chenopods. These plants have less negative $\delta^{13}C$ values, averaging about –12‰ (Bender, 1968; Norr & Hutchinson, 1998; Smith, 1972; Smith & Epstein, 1971; Troughton, Wells & Mooney, 1974). Plants using CAM photosynthesis have carbon isotope ratios spanning the range of C_3 and C_4 plants, and are succulents, such as cacti, some euphorbias, and bromeliads (Bender, 1968; Mooney, Troughton & Berry, 1977; O'Leary, 1981; Smith, Otto, Martin & Boutton, 1979; Szarek & Ting, 1977; Troughton *et al.*, 1974). Economically important CAM plants vary from region to region, but would include edible cacti, century plants, pineapple, and vanilla.

Most terrestrial plants have $\delta^{15}N$ values in the range of 2–4‰. Hot, dry, saline environments will drive those values much higher (Ambrose, 1991). Legumes are C_3 plants with $\delta^{15}N$ values that are slightly lower than those of other terrestrial plants due to their use of nitrogen produced by symbiotic bacteria (DeNiro & Epstein, 1981; Létolle, 1980; Wada, Kadonaga & Matsuo, 1975). Among animals, there is a trophic level effect on $\delta^{15}N$ values, with herbivores having $\delta^{15}N$ values higher than their plant diets, and primary carnivores and secondary carnivores having increasingly higher $\delta^{15}N$ values (Minagawa & Wada, 1984; Schoeninger, 1985; Schoeninger & DeNiro, 1984). Marine animals usually have higher $\delta^{15}N$ values than terrestrial fauna because of higher values of their source nitrogen. Nitrogen fixation in reef and mangrove environments, however, may lower the $\delta^{15}N$ values in resident organisms (Capone & Carpenter, 1982; Keegan & DeNiro, 1988; Schoeninger & DeNiro, 1984). Local environmental conditions can affect the isotopic composition of organisms living in a given region (Ambrose, 1991; Ambrose & DeNiro, 1986a; Leavitt & Long, 1986; Sealy, van der Merwe, Lee-Thorp & Lanham, 1987 Smith, Oliver & McMillan, 1976; Tieszen, 1991). Therefore the isotopic ecology of the local foodweb should be determined in each study where paleodietary reconstruction is attempted.

A schematic representation of the isotopic composition of some relevant tropical New World food resources is illustrated in Figure 10.1.

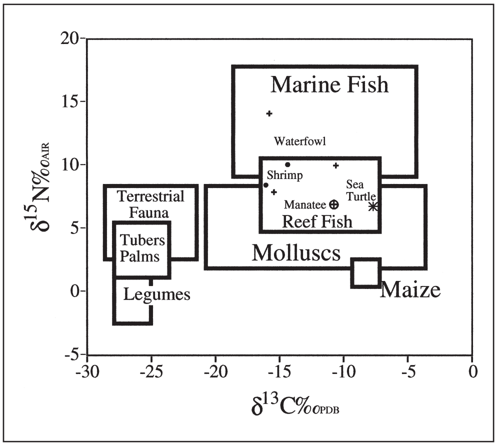


Figure 10.1 Isotopic composition of pre-industrial food resources in the circum-Caribbean region (1.50‰ was added to the $\delta^{13}C$ value of modern foods to compensate for ^{12}C enrichment of the atmosphere from the burning of fossil fuels, as per Tieszen 1991). Figure is compiled from data from this study as well as from Hutchinson & Norr, unpublished data; Keegan, 1992; Keegan & DeNiro, 1988; Norr, 1990; Norr & Cooke, unpublished data; Norr & Hutchinson, 1998; Schoeninger &

Accurate dietary interpretation of the isotopic composition of body tissues is dependent upon a clear understanding of how different types of foods (e.g. meat vs grains) and their biochemical fractions are incorporated into those body tissues. The relationship between dietary carbon atoms and those of consumer body tissues has been investigation by Ambrose and Norr (1993) through a series of controlled diet experiments designed to determine the degree to which dietary protein may be routed to bone collagen and dietary energy to bone apatite carbonate. The initial results of their study demonstrate that the $\delta^{13}C$ value of rat bone collagen largely reflects that of dietary protein rather than that of the whole diet. In contrast to collagen, bone apatite carbonate $\delta^{13}C$ values of the rats raised on experimental diets closely followed the carbon isotope values of their whole diet (Ambrose & Norr, 1993; Norr, 1995). Thus, carbon in bone collagen and in tooth apatite carbonate is related to dietary carbon in different ways, and both can be used to infer paleodiet. The interpretive model used here comes from experimental studies using animal models (Ambrose & Norr, 1993).

Just as the use of both carbon and nitrogen isotopes in bone collagen will give a clearer picture of diet, the use of $\delta^{13}C$ values from both bone collagen and bone apatite carbonate will give a more accurate indication of prehistoric diet than will collagen alone. The relationship between $\delta^{13}C$ values of carbonate and collagen ($\Delta^{13}C_{\text{carbonate-collagen}}$) varies predictably with the isotopic composition of the dietary protein and energy sources. This is because bone collagen disproportionately represents dietary protein, while bone carbonate accurately represents the whole diet (Ambrose & Norr, 1993).

The experimental relationship between the isotopic composition of the diet, and the difference between the bone carbonate and collagen $\delta^{13}C$ values ($\Delta^{13}C_{\text{ca-co}}$), varies predictably (Table 10.1). When the $\delta^{13}C$ of the dietary energy is C_3 or more negative than that of the dietary protein (e.g. a diet of marine fish and tubers, fruits, and palm nuts) the $\Delta^{13}C_{\text{ca-co}}$ is *small*. When the $\delta^{13}C$ of the dietary protein is more negative than that of the dietary energy (e.g. a diet of deer meat and a C_4 plant such as maize) the $\Delta^{13}C_{\text{ca-co}}$ is *large*. When the dietary protein and energy sources have similar isotopic values, then the $\Delta^{13}C_{\text{ca-co}}$ is *intermediate* (based on data from Ambrose & Norr, 1993:Table 4). While bone and tooth apatite carbonate provide an accurate record of the carbon isotope composition of the diet, the issue of diagenetic alteration of buried bone, such as isotopic exchange with ground water carbonates, must always be considered (Koch, Behrensmeyer, Tuross & Fogel, 1990; Koch *et al.*, 1994; Nelson, DeNiro, Schoeninger, DePaolo & Hare, 1986; Schoeninger & DeNiro, 1982, 1983; Sillen, 1989; Wright & Schwarcz, 1996).

The method of sample preparation and its resulting purity can affect the isotopic results and, ultimately, the dietary interpretation. If the sample fraction analyzed (e.g. collagen, apatite

Table 10.1 The relationship between the isotopic composition of the diet and the experimental values of bone $\Delta^{13}C_{\text{carbonate-collagen}}$

Isotopic composition of the diet	*Experimental* $\Delta^{13}C_{ca\text{-}co} \pm 1$ *s.d.*
Monoisotopic	Intermediate
(e.g. marine fish and maize)	5.7±0.4‰
(e.g. deer meat, and tubers and palms)	
C_4-like protein with C_3 energy	Small
(e.g. marine fish, and tubers and palms)	1.7±0.3‰
C_3 protein with C_4 energy	Large
(e.g. deer meat and maize)	11.0±0.8‰

Source: Ambrose & Norr, 1993; see also Norr, 1995.

carbonate) is not pure or has undergone an exchange of carbon atoms over time, then the delta value of the sample will represent, at least in part, the contaminant rather than the biogenic tissue fraction and the diet of the individual. Contaminants of collagen may be other biochemical fractions found naturally in bone (e.g. lipids) or they may be external contaminants (e.g. rootlets or soil organics). Bone carbonate contaminants can result from isotopic exchange with ground water carbonates or organic carbon.

Bone samples from tropical climates are particularly susceptible to collagen degradation due to high soil temperature and acidity and to contamination from humic acids in soil organic matter. When the sample C/N ratio is highly divergent from that of modern collagen, there is a chance that the delta value of the sample will be different from that of pure collagen. If contaminated samples are carelessly purified, the result can be a contaminated "collagen" residue that can yield highly unreliable results (Ambrose, 1990; Ambrose & Norr, 1992; Kennedy, 1988; Norr, 1990, 1995).

Collagen contamination and degradation can be identified for most samples by using simple determinations: the percent yield collagen from whole bone; the collagen C/N ratio; and the percent-by-weight of carbon (%C/wt) and nitrogen (%N/wt) of the collagen. The C/N ratio of the extracted collagen residue can be determined from manometric measurements of CO_2 and N_2, or by a CHN analyzer (%C/%N x 1.16). The C/N ratio of the sample should be similar to that of modern collagen, which is theoretically calculated to be 3.21 (Ambrose, 1990, 1993; Kennedy, 1988); the %C/wt (μm yield of CO_2 x 12 ÷ mg collagen used in combustion ÷ 10) is approximately 47 percent and the %N/wt (μm yield of N_2 x 28 ÷ mg collagen for combustion ÷ 10) is approximately 17 percent (Ambrose, 1990; Norr, 1990; Kennedy, 1988). DeNiro (1985) has shown that collagen extracted from ancient animal bones with C/N ratios between 2.9 and 3.5 most often had $\delta^{13}C$ and $\delta^{15}N$ values reflecting the known or expected diets of the animals.

The mineral phase of bone is most susceptible to isotopic exchange of apatite carbonate when most or all of the collagen has been lost and after burial for long periods of time (Koch *et al.*, 1990; Koch *et al.*, 1994; Lee-Thorp & van der Merwe, 1987, 1991; Sillen, 1989). Postmortem carbonate contamination and soluble biological carbonates must be removed from the apatite sample prior to isotopic analysis of the carbonate. This can be accomplished through a series of pretreatments of bone or tooth enamel powder with 1.5 percent sodium hypochlorite (50% Clorox) to remove organics, and dilute (1 molar) acetic acid to remove soluble carbonates (Krueger, 1991; Lee-Thorp, Sealy & van der Merwe, 1989; Nelson & Featherstone, 1982). The selection of bone with most of the original collagen preserved is recommended for dietary reconstruction from apatite carbonate. When bone is used as the source of apatite carbonate, animal bones from the same archaeological contexts can serve as controls. Herbivores and carnivores on natural diets will have a limited range of variation in the difference between their carbonate $\delta^{13}C$ and collagen $\delta^{13}C$ ($\Delta^{13}C_{ca\text{-}co}$) values. Deviations from expected values may indicate diagenesis. In samples where collagen is not preserved, the apatite is more exposed to the burial environment and more susceptible to contamination (Ambrose, 1993; Koch *et al.*, 1990; Koch *et al.*, 1994). All but one human sample examined from the Tutu site had adequate concentrations of well-preserved collagenous protein.

Laboratory precision and accuracy are determined through the periodic isotopic analysis of a variety of laboratory and international standards. Through the comparison of results obtained on the same substances in different laboratories, the inter-laboratory comparability of archaeological results can be determined. The Tutu samples were prepared and analyzed at two different laboratories, but comparisons of international and national standards as well as duplicate sample runs indicate that the data from both labs are comparable.[1] Internal and international standards used during the analyses of the Tutu materials consistently conformed to the laboratory, national, and international standard values within ±0.2‰.

STABLE ISOTOPIC ANALYSIS OF TUTU REMAINS FOR PALEODIETS

Twenty-four pre-Columbian humans buried at the Tutu site have been analyzed for their stable carbon and nitrogen isotopic composition of collagen, and the stable carbon and oxygen isotopic composition of bone apatite carbonate. Bone preservation was adequate for most of the individuals. Collagen yields from whole bone for all the human samples ranged between 3.3 percent and 12.2 percent. In general, the bone samples were very clean and the organic residues gave no visual indication during the NaOH pretreatment of being contaminated with soil organics. The %N/wt and %C/wt, as well as the C/N ratios, were all determined for the Tutu samples, and are presented below. Apatite yield from the whole human bone ranged between 13.6 percent and 46.8 percent. Generally the higher the percentage of organics, the greater the loss of organics during the apatite preparation, and the lower the percent yield of apatite from whole bone.

The isotopic composition of the archaeological faunal bone collagen is used to calculate the isotopic composition of the edible portions of those animals. The isotopic data on the edible portions of the fauna are used to help interpret the isotopic composition of the human diet. Archaeological fauna from Tutu were analyzed for their isotopic composition to add to the growing data base of potential food resources for the circum-Caribbean region.

Analytical methods

Samples were prepared in two different laboratories, the University of Illinois (UIUC) and the University of Florida (UF) with comparable results. All collagen was prepared using 0.8 g of clean, dry bone crushed to between 0.25 mm and 0.5 mm and placed into a 50 ml fritted-disk funnel fitted with a Teflon stopcock (Ambrose, 1990; DeNiro & Epstein, 1981; Norr, 1990). Samples were demineralized in 0.2 molar HCl for 24 to 72 hours. Neutralized samples were soaked in 0.125 molar NaOH for 10 to 20 hours. Following neutralization, samples were solubilized in 10^{-3} molar HCl (pH 3) at 95°C for 10 hours, with 100 µl 1 molar HCl added after five hours. The hot solution was then filtered, evaporated, and freeze-dried. At UIUC, 6–8 mg of collagen were sealed in quartz tubes under vacuum with copper granules, copper oxide (CuO) wire, and silver foil. Sealed tube combustion occurred at 880°C, producing CO_2, N_2, and H_2O. Slow cooling to 600°C over a 12-hour period allowed the formation of N_2 and prevented the formation of any of the oxides of nitrogen, which would introduce mass error into the isotopic determinations. CO_2 and N_2 were then distilled cryogenically, measured manometrically, and collected in sealed Pyrex tubes on a glass vacuum line fitted with a Toepler pump and a quartz and copper trap at 700°C, once again to reduce nitrogen oxides to N_2 gas. Isotope ratios were determined on Nuclide and Finnegan Delta-E mass spectrometers. Collagen samples prepared at UF were introduced directly into a VG Isogas PRISM Series II stable isotope ratio mass spectrometer after combustion in a Carlo Erba CHN analyzer. The $\delta^{13}C$ analysis used 0.5 mg, and the $\delta^{15}N$ and C/N analyses each used 1 mg collagen, in this automated procedure.

Apatite prepared at UIUC used 1 g of <0.25 mm bone powder in 50 ml centrifuge tubes and chemical treatments described by Lee-Thorp (1986, 1989). Organics were removed with 50 percent Clorox bleach (active ingredient, sodium hypochlorite), and centrifuged and refreshed twice daily until effervescence ceased (36–48 hours). Neutral samples were put into 1 molar acetic acid and again centrifuged and refreshed twice daily until effervescence ceased (24–48 hours). Neutral samples were freeze-dried and 100 mg were reacted under vacuum at 25°C with 100 percent phosphoric acid until bubbling ceased and the sample was dissolved (1–3 days). CO_2 was distilled cryogenically under vacuum and analyzed by mass spectrometry. Samples prepared at UF were treated in the same way except that only 100 mg of bone powder was used for the same chemical preparation, and only 1.50 mg of apatite were reacted at 90°C in a multiprep unit directly attached to the Isogas PRISM II mass spectrometer.

Interpretive methods

The first step of this interpretive process is to determine the isotopic composition of the potential food resources. In the case of plants, modern samples from circum-Caribbean habitats similar to those on the US Virgin Islands were used. Edible portions of modern animals, when available, were analyzed to complement existing lists of analyzed food resources (Keegan, 1992; Keegan & DeNiro, 1988; Norr, 1990; Norr & Hutchinson, 1998; Schoeninger & DeNiro, 1984; Hutchinson & Norr, unpublished data; Norr & Cooke, unpublished data). All modern $\delta^{13}C$ values were adjusted by +1.50‰ to compensate for ^{12}C enrichment in the post-industrial atmosphere caused by the burning of fossil fuels (Keeling, Mook & Tans, 1979; Tieszen, 1991). Bone collagen from archaeological fauna also was used to determine the isotopic composition of potential food resources. To derive the isotopic composition of the edible portions of the animals from the collagen, the $\delta^{15}N$ collagen values were adjusted by +1.70‰ and the d13C values were adjusted by –3.70‰ (DeNiro & Epstein, 1978, 1981; Keegan & DeNiro, 1988).

The second step is to reconstruct the isotopic composition of the human diet from that of the human bone. The relationship between diet $\delta^{13}C_d$ and collagen $\delta^{13}C_{co}$ is variable, making collagen $\delta^{13}C_{co}$ an unreliable indicator of overall diet. Apatite carbonate $\delta^{13}C_{ca}$ values in laboratory animals fed controlled diets, however, are consistently spaced at a 9.50‰ interval from that of the diet (Ambrose & Norr, 1993). Following this experimental model, diet $\delta^{13}C_d$ values can be obtained by subtracting 9.50‰ from the bone apatite carbonate $\delta^{13}C_{ca}$ values. The $\Delta^{15}N$ diet-to-collagen spacing of 2.50‰ (DeNiro & Epstein, 1981) was used to determine the diet $\delta^{15}N$ from human bone collagen $\delta^{15}N$ (collagen $\delta^{15}N$ less 2.50‰). The error bars in Figure 10.2 represent two standard deviations from the means of the Tutu human diet.

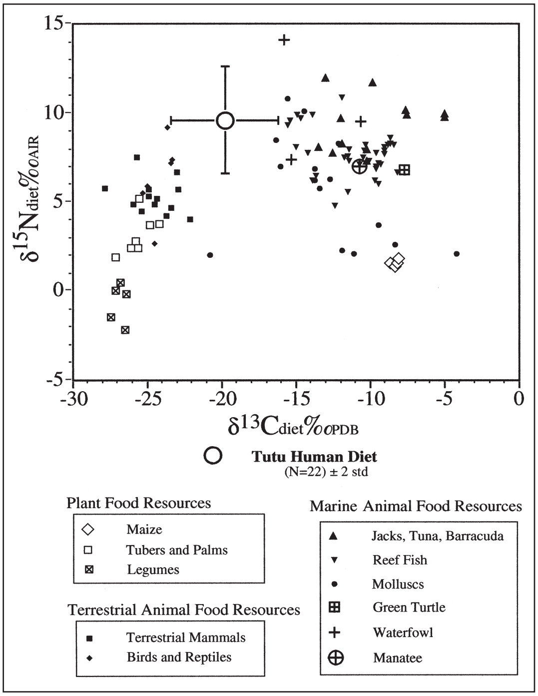


Figure 10.2 Isotopic composition of human diet at the Tutu site, based on reconstructions from human bone collagen $\delta^{15}N$ and bone carbonate $\delta^{13}C$, and compared to food resources from the circum-Caribbean region (plant and animal data are from this study as well as from Hutchinson & Norr, unpublished data; Keegan, 1992; Keegan & DeNiro, 1988; Norr, 1990; Norr & Cooke, unpublished data; Norr & Hutchinson, 1998; Schoeninger & DeNiro, 1984).

Results

The results of the Tutu human bone collagen and apatite extractions and the isotopic analyses are presented in Table 10.2; the animal results are presented in Table 10.3. Summary descriptive statistics for the Tutu site, including the calculated isotopic values of the human diet, are presented in Table 10.4.

The Tutu human skeletal remains have a mean bone collagen $\delta^{13}C$ value of –15.50 ±1.80‰ (all values are ± 2 std). It is difficult to reconstruct dietary $\delta^{13}C$ values from collagen, but these values are typical of a diet that is intermediate between C_3 and C_4, or marine. The mean $\delta^{15}N$ value of the Tutu human bone collagen is 12.10 ± 1.70‰. The dietary $\delta^{15}N$ is, on average, 2.50‰ less positive than collagen, giving the Tutu human diet an average $\delta^{15}N$ of 9.60 ± 2.80‰ (Figure

Table 10.2 Human bone collagen and bone apatite carbonate stable isotope results from the Tutu site

Burial	*Sex*	*Age*	*%co*	*%N/wt*	*%C/wt*	*C/N*	$\delta^{15}N$	$\delta^{13}C_{co}$	*%carb*	$\delta^{13}C_{ca}$	$\Delta^{13}C_{ca\text{-}co}$
Burials dating prior to AD 1000											
3	?	Adult	5.3	12.7	34.3	3.1	12.9	–14.4	15.7	–10.9	3.5
4/7	X	Adult	6.1	12.1	35.0	3.4	10.1	–16.3	—	–11.0	5.3
10	X	O Adult	4.5	10.6	28.8	3.2	12.7	–15.8	28.6	–10.6	5.2
12	Y	Adult	9.1	14.2	38.6	3.2	12.9	–14.7	24.8	–10.9	3.8
13	X	Adult	9.3	14.6	39.4	3.1	12.8	–15.7	18.0	–9.2	6.5
13A	X	Adult	6.5	1.6[b]	3.2[c]	2.0[c]	—	—	46.8	–11.2	—
16	X	Adult	4.5	10.3	28.5	3.2	12.5	–15.2	22.5	–10.5	4.7
39	—	Child	5.7	10.1	30.3	3.0	11.6	–15.3	—	–9.7	5.6
Burials dating post AD 1000											
1	X	Adult	5.4	12.8	34.4	3.1	13.4	–15.9	24.5	–8.4	7.5
2	X	Adult	6.9	14.0	37.2	3.1	12.6	–15.5	24.3	–9.6	5.9
5	X	Adult	5.7	15.8	42.3	3.1	12.2	–16.5	28.4	–11.5	5.0
6	—	Child	7.5	8.0	24.5	3.1	12.9	–15.6	13.6	–9.4	6.2
8A	—	Subadult	6.4	16.1	42.9	3.1	11.2	–16.4	18.6	–10.1	6.3
8B	—	Subadult	6.7	14.0	37.4	3.1	11.8	–15.0	23.7	–9.7	5.3
9	Y	O Adult	7.8	15.9	42.8	3.1	12.1	–15.2	30.9	–10.1	5.1
12	Y	Adult	9.1	14.2	38.6	3.2	12.9	–14.7	24.8	–10.9	3.8
19	X	Adult	7.6	13.1	35.2	3.1	12.9	–15.8	19.3	–11.0	4.8
20	—	Child	5.2	10.0	30.0	3.0	11.7	–15.6	35.4	–10.1	5.5
22B	—	Child	8.6	14.3	41.2	3.4	11.4	–15.4	—	–11.2	4.2
26	X	Y Adult	3.3[a]	7.8	22.1	3.3	12.8	–16.8	25.6	6.4[d]	10.4[d]
29	X	Adult	10.4	13.9	37.5	3.1	12.3	–14.9	26.6	–10.6	4.3
30	Y	Adult	9.5	12.4	36.2	2.9	12.7	–15.6	—	–11.4	4.2
31	X	Adult	12.2	14.3	41.5	2.9	10.3	–17.3	—	–11.0	6.3
33	Y	Adult	9.2	11.4	33.9	3.0	11.6	–14.9	—	–11.8	3.1
38	Y	Adult	10.4	12.5	37.4	3.0	11.1	–12.9	—	–10.8	2.1

Notes

The sex of children and subadults was not estimated as part of this study.

%co = percent yield collagen from whole bone.

%N/wt = percent of nitrogen, by weight, in bone collagen.

%C/wt = percent of carbon, by weight, in bone collagen.

C/N = the ratio of carbon to nitrogen in bone collagen.

$\delta^{15}N$ = delta ^{15}N value in parts per mil (‰) of the nitrogen in bone collagen.

$\delta^{13}C_{co}$ = delta ^{13}C value in parts per mil (‰) of the carbon in bone collagen.

$\delta^{13}C_{ca}$ = delta ^{13}C value in parts per mil (‰) of the carbon in bone apatite carbonate.

$\Delta^{13}C$ = difference between the delta ^{13}C of the bone apatite carbonate carbon and the bone collagen carbon.

a % yield collagen is low or insufficient.

b % yield C and N from collagen is insufficient.

c C/N ratio is outside the acceptable range.

d value is an outlier.

X female

Y male

Table 10.3 Animal bone collagen stable isotope results from the Tutu site

Fauna	*%co*	*%N/wt*	*%C/wt*	*C/N*	$\delta^{15}N$	$\delta^{13}C_{co}$	$\delta^{15}Ned$	$\delta^{13}Ced$
Columbidae	7.7	10.6	30.4	3.4	7.5	–19.9	9.2	–23.6
Unidentified bird	9.7	10.1	29.3	3.4	7.8	–6.9	9.5	–10.6
Cheloniidae	2.0[a]	2.2[b]	4.7[b]	2.5[c]	—	—	—	—
Iguana	2.0[a]	1.7[b]	2.8[b]	2.0[c]	—	—	—	—
Manatee	7.1	13.1	37.6	3.4	5.3	–7.0	7.0	–10.7
Labrid (wrasse)	1.5[a]	5.1	13.0	3.0	4.5	–10.2	6.2	–13.9
Lutjanus (snapper)	1.3[a]	4.5	11.0	2.8	6.1	–8.8	7.8	–12.5
Sparisoma (parrotfish)	2.0[a]	2.5[b]	5.1[b]	2.4[c]	3.1[c]	—	—	—
Diodon (porcupine fish)	2.5[a]	7.6	21.1	3.2	6.3	–6.5	8.0	–10.2
Caranx (jack)	2.3[a]	4.9	12.0	2.9	6.4	–9.8	8.1	–13.5
Haemulon (grunt)	1.8[a]	4.3	11.3	3.1	5.6	–6.5	7.3	–10.2
Balistidae (triggerfish)	1.7[a]	1.5[b]	2.4[b]	1.9[c]	5.3[c]	—	—	—
Manatee	5.7	11.5	32.5	3.3	4.4	–6.0	–9.7	—
Cheloniidae	0.4[a]	—	—	—	—	—	—	—
Scombridae	2.5	10.9	30.9	3.3	5.8	–10.0	7.5	–13.7
Belonidae	3.7	11.1	31.1	3.3	6.2	–7.4	7.9	–11.1
Serranidae	0.7[a]	—	—	—	—	—	—	—
Sparisoma (parrotfish)	2.2	11.6	32.1	3.2	4.5	–7.8	6.2	–11.5
Halichoeres	2.3	9.5	26.0	3.2	5.9	–8.9	7.6	–12.6
Halichoeres	1.8	8.7	23.6	3.2	5.3	–8.6	7.0	–12.3
Diodon (porcupine fish)	1.8	5.8	16.6	3.2	7.3	–4.9	9.0	–8.6
Sparidae cf. *Calamus*	0.8[a]	0.8[b]	0.9[b]	1.4[c]	—	–14.0	—	–17.7
Sparisoma (parrotfish)	2.0	10.1	27.5	3.2	4.8	–9.6	6.5	–13.3
Lutjanidae cf. *Lutjanus*	0.8[a]	3.0	7.8	3.0	7.0	–8.7	8.7	–12.4

Notes
%co = percent yield collagen from whole bone.
%N/wt = percent of nitrogen, by weight, in bone collagen.
%C/wt = percent of carbon, by weight, in bone collagen.
C/N = the ratio of carbon to nitrogen in bone collagen.
$\delta^{15}N$ = delta ^{15}N value in parts per mil (‰) of the nitrogen in bone collagen.
$\delta^{13}C_{co}$ = delta ^{13}C value in parts per mil (‰) of the carbon in bone collagen.
$\delta^{15}Ned$ = an estimate of the delta ^{15}N value in parts per mil (‰) of the nitrogen in the edible portion of the animal.
$\delta^{13}Ced$ = an estimate of the delta ^{13}C value in parts per mil (‰) of the carbon in the edible portion of the animal.
a % yield collagen is low or insufficient.
b % yield C and N is insufficient.
c C/N ratio is outside the acceptable range.

10.2). The $\delta^{15}N$ values are moderately high, at the upper end of values for reef fish and the lower end of values for more pelagic fish, indicating that most of the dietary protein was of marine origin. The mean human bone apatite carbonate $\delta^{13}C$ value is –10.30 ± 2.40‰. Adjusting the bone apatite value by –9.50‰ will give us a good estimate of the average $\delta^{13}C$ isotopic value of the diet, i.e. –19.80‰. The $\delta^{13}C$ values represent a diet intermediate between the C_3 the food chain and a marine diet. The individual bone apatite carbonate (δ^{13} C_{ca}‰) values (Table 10.2), less the average difference between diet and bone carbonate ($\Delta^{13}C_{d\text{-}ca}$), 9.50‰ (Ambrose & Norr,

Table 10.4 Minimum, maximum and mean carbon and nitrogen isotope values for bone collagen, apatite carbonate, and estimated diets, for the Tutu site

Human bone	*n*	*Min.*	*Max.*	*Mean*	*±2 s.d.*
$\delta^{15}N_{co}$ ‰	23	10.1	13.4	12.10	1.52
$\delta^{13}C_{co}$ ‰	23	–17.3	–14.7	–15.51	1.78
$\delta^{13}C_{ca}$ ‰	23	–11.5	–8.4	–10.26	2.36
$\Delta^{13}C_{ca\text{-}co}$ ‰	22	2.1	7.5	5.01	2.48
$\delta^{15}N_{co}$ diet ‰	23	7.8	10.9	9.70	3.60
$\delta^{13}C_{ca}$ diet ‰	23	–21.0	–17.9	–19.76	3.00

Note
n = number of individuals yielding isotope results.

1993), gives a diet $\delta^{13}C_d$ of –19.80 ± 3.60‰ for the humans living at the Tutu site. A reconstruction of the isotopic composition of the average Tutu prehistoric diet is compared to the isotopic composition of food resources from Tutu and the greater circum-Caribbean in Figure 10.2.

In addition, and as explained above, the mean difference between human bone carbonate and collagen $\delta^{13}C$ values ($\Delta^{13}C_{ca\text{-}co}$) is indicative of the isotopic compositions of the protein and carbohydrate sources of the diet. The mean $\Delta^{13}C_{ca\text{-}co}$ is a small to medium number, 5 ± 2.40‰ (individual 26 was an outlier, and was eliminated from calculations because of extreme bone surface erosion and the potential of diagenesis; see Chapter 7). When compared to experimental results (Ambrose & Norr, 1993:Table 4; see also Norr, 1995), this suggests a diet with a protein source that was mixed marine and C_3, and an energy source that was terrestrial C_3, analogous to a diet comprised of predominantly marine fauna plus terrestrial fauna and C_3 cultigens (Figure 10.3).

CONCLUSIONS

The results from this study can be compared to those of a study by Keegan & DeNiro (1988) of prehistoric diet in the Bahamas. In that study, humans from several islands in the Bahamas have mean bone collagen $\delta^{15}N$ values of 9.90 ± 1.30‰ and mean $\delta^{13}C$ values of –13.30 ± 1.70‰. It is more difficult to reconstruct the Bahaman diet without the human bone apatite carbonate $\delta^{13}C$ values, but the collagen values of the two studies can be compared directly. The Tutu mean bone collagen $\delta^{15}N$ value of 12.10 ± 1.70‰ (± 1 std for comparison) indicates relatively fewer reef fish and mollusks, which are low in ^{15}N, in favor of a higher consumption of deep-water fish with higher $\delta^{15}N$ values. The Tutu mean bone collagen $\delta^{13}C$ value of –15.50 ± 1.80‰ suggests a relatively higher proportion of terrestrial C_3 resources in the Tutu diet than at Bahamian sites. The isotopic analysis of a large number of human and food resource samples from Caribbean sites is currently in progress by Stokes (1998), and dietary interpre-

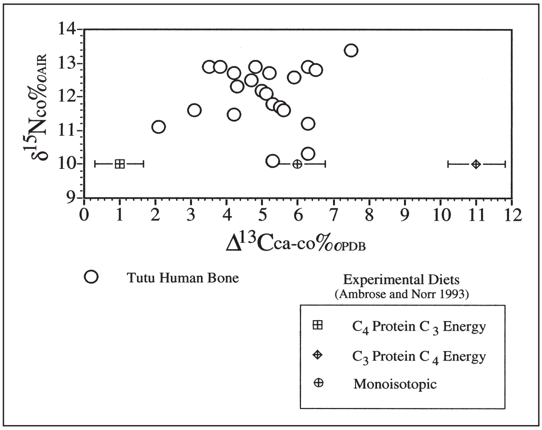


Figure 10.3 $\Delta^{13}C_{ca\text{-}co}$ of human bone from Tutu compared to that of laboratory rats fed isotopically controlled diets (experimental data from Ambrose & Norr, 1993; see also Norr, 1995).

tations for those sites, which are in a broad range of habitats, is forthcoming. Her larger sample size will allow for the identification of dietary patterns which may be specific to either temporal or geographic contexts.

Among the Tutu skeletons, there is essentially no temporal variation in bone isotope values between the pre-AD 1000, and post-AD 1000 burials (see Table 10.2). In addition, no patterns emerge that indicate different diets were consumed either by males and females or by adults and children. The overall dietary pattern is homogenous throughout the sample of 24 people analyzed. This suggests that the range of available foods on the island and offshore was available to all members of the society.

NOTE

1 The organic standard used in the stable isotope labs in the Department of Anthropology at the University of Illinois at Urbana-Champaign and the University of Florida is thiourea (Sigma Chemical Co.), which when combusted produces CO_2 and N_2 at a C/N ratio of 0.50. The inorganic standard at UIUC was Corydon calcite (supplied by the biogeochemical laboratory at Indiana University), and selected human bone apatite and mammoth tusk as a carbonate standard for reactions at the University of Florida. The laboratory's working standards are prepared with each batch of 10–15 archaeological samples, and the working standards are checked against appropriate IAEA and NBS standards with a similar frequency.

Chapter Eleven

Flaked stone artifacts from the Tutu site

Dave Davis

INTRODUCTION

In contrast to ceramics, which have been the cornerstones of most cultural chronologies in the West Indies, lithic artifacts have received relatively little attention from Caribbean archaeologists. Several investigators have attempted to characterize the technology of flaked stone artifact manufacture on different islands (e.g. Davis, 1993, in press; Febles, 1988; Kozlowski & Ginter, 1973; Pantel, 1977; Rives & Febles, 1990; Walker, 1980). However, as Pantel (1988) has noted, published discussions of flaked stone artifacts more often have focused upon the identification of *fossiles directeurs*, or marker types, for different cultural phases. On the island of St Thomas, Bullen's (1963) defining publications on the Krum Bay complex exemplify that approach. Moreover, lithic research in the Caribbean has been overwhelmingly concerned with the preceramic or Archaic period. For many parts of the West Indies (including the entire Virgin Island group) there has been virtually no systematic study of lithic industries for the Ceramic Age.

Against this backdrop, the flaked stone artifacts from the Tutu site offer an opportunity to begin sketching a picture of Ceramic Age lithic technology in the Virgin Islands. Excavations and surface collection at the site yielded a series of flaked and ground stone artifacts manufactured on a wide array of raw materials, including chert, rhyolite, and basalt, as well as quartzite, shale, and other metamorphic rocks. The vast majority of these artifacts was recovered from contexts that are assigned to the earlier of the two components at the site (i.e. the Saladoid component). For this reason, and because the small number of artifacts associated with the later (Ostionoid) component have few culturally or technologically interesting features, this paper is concerned exclusively with lithic artifacts and technology that are thought to be associated with the Saladoid occupation of the Tutu site. Because of the paucity of comparative data in the published literature and the modest size of the flaked stone artifact sample from the Tutu site, this endeavor is necessarily more descriptive and less synthetic than one would prefer. Closer attention to flaked stone industries from other sites in the Virgin Islands will be needed before regional, functional, or chronological patterns can be discerned with any clarity.

In examining these materials, the goal was to characterize raw material selection and the technology of stone artifact production at Tutu, within the constraints of the available data. Two major limitations must be noted. First, a significant number (46.4%) of the flaked stone artifacts were recovered from surface contexts, or from spoil piles associated with particular excavation units. In the discussion that follows, surface and spoil materials which occurred in areas of the site that contained exclusively Saladoid materials are included with materials excavated from Saladoid subsurface contexts.

A second limitation was the paucity of fine-fraction lithic material. I refer here to the virtual absence of very small flakes, blades, burin spalls, and manufacturing debris that should have been recovered given that midden and feature soils were screened through 0.635 cm, 0.3175 cm and 0.159 cm mesh screen. The lack of such material does not significantly affect any of the conclusions that are offered below, but it does mean that a body of potentially valuable auxiliary information is missing.

GENERAL FEATURES OF THE FLAKED STONE COLLECTION

The lithic collection from Tutu includes a variety of flaked stone artifacts, along with a smaller number of ground stone items. My study was focused upon the flaked stone artifacts, which include a number of subdiscoidal and irregular flake cores, core tools, flakes retouched into scrapers, burins on flakes, utilized unretouched flakes, other unretouched flakes and blades, and a quantity of angular debris (these categories are defined below). The collection also includes fragments of ground artifacts, some of which appear to have been broken accidentally, but others of which show signs of deliberate flaking. The flaked stone technology at Tutu was dominated overwhelmingly by direct hard hammer ("stone-on-stone") percussion, and there is no evidence of use of indirect percussion methods such as punch flaking.

Several types of raw materials were used in flaked stone tool manufacture at Tutu. In addition to fine-grained volcanics and metamorphic rocks that could not be identified to type, the dominant identifiable materials are basalt, rhyolite, chert, and a laminar light green volcanic rock that I will refer to as "greenstone." Quartzite and shale are present in small quantities.

As a rule, Ceramic Age lithic industries from the West Indies are neither highly elaborated nor technologically complex, and the materials from Tutu are no exception. However, the Tutu collection is noteworthy for the use of a prepared core technology (subdiscoidal cores of basalt and rhyolite, which were used to produce flakes); and for the presence of a series of artifacts that I have called "pecking stones," which may have been used in the manufacture of ground stone artifacts.

DEFINITIONS OF MAJOR ARTIFACT ATTRIBUTES AND CLASSES

Basic technological attributes

Most of the raw materials that were used in the manufacture of flaked stone artifacts at Tutu are sufficiently fine-grained and homogeneous to manifest or mimic conchoidal fracture properties. As a result, a piece that has been removed from a pebble or cobble and not further damaged usually exhibits the two essential signs of conchoidally fractured rock: a *striking platform* and a *bulb of percussion*. The striking platform appears as a plane that is located on but transverse to the edge of the piece. The location of the striking platform defines the *proximal end* of the piece, and the end opposite is the *distal end*.

Any piece removed in this fashion will, of course, have both a *dorsal* and a *ventral* side. The former is the side that was exposed before the piece was removed, and is covered by either *cortex* (the "skin" or covering of the original pebble), or by *flake scars* that mark the locations of previous flake removals from the pebble or cobble. The ventral or inner side of the piece, newly created when the piece was produced, is generally smooth and may exhibit visible waves that chart the flow of force that separated the piece from the parent material. The ventral surface is also the location of the bulb of percussion, a round protrusion below the striking platform.

The act of removing a piece from a pebble or cobble by controlled percussion also creates the beginning of a *core*, which is a pebble or cobble that has been modified by the removal of flakes. The patterns, sizes, and shapes of scars on the surfaces of cores preserve a record of some of the characteristics of the pieces that were removed from them.

The term *flake* actually has two different but related uses in lithic analysis. First, any piece that is removed from a core by controlled percussion may be termed a flake. In this sense, "flake" stands in contrast to "core." However, lithic analysts commonly recognize a special category of flakes that are called "blades." In its second sense, "flake" is often used more restrictively, to refer to only those flakes that are not blades. Lithic analysts also widely employ both uses simultaneously, relying upon the context of their statements to clarify which definition of "flake" is in play. In practice, this works well enough. *Blades*, which are simply flakes whose lengths are greater than twice their widths, are absent in the Tutu collection, although a single blade core is present.

Once they have been removed from the core, flakes or blades may be further *retouched* by the removal of smaller flakes to modify either the angle or shape of the cutting edge, or the thickness of the piece. Retouch may be either *unifacial* (confined to one side or face of the piece) or *bifacial* (occurring on both sides), and may occur along some or all of one or more edges. In any case, retouch may be further characterized by the extent to which it extends inward from the edge of the piece. Under one traditional usage, retouch that extends less than 20 percent of the distance across the piece from an edge is called *marginal*, while retouch that extends across more than 20 percent of the distance across the piece is called *invasive*. The (usually) small flakes that are removed during retouching leave flake scars on the piece, and those flake scars may also be characterized in terms of the terminations that are visible in the remaining scars of the retouching flakes. In lithic analysis, the term "tools" is usually reserved for target forms made on cores, and for flakes and blades that have been retouched. Flake and blade tool types are traditionally defined chiefly by the location and extent of retouch, sometimes in combination with the overall shape or edge angle of the piece. Thus, for example, a *bifacial endscraper* may be a flake or blade that has been marginally retouched along both sides of the distal end. Clearly, terms such as "scraper," "chopper," or even "knife," all defined with reference to the location, extent, and angle of retouch, imply nothing about artifact function.

A final attribute of note at this point is the *snap*. Snapping is a form of breakage that occurs to a flake or blade at some time after its removal from the core, and is usually assumed to be non-deliberate. As the name suggests, a snap is a break that is approximately transverse to the plane of the piece and that cuts entirely through it. It is the lithic equivalent of breaking a dry cookie or twig, and is generally assumed to have been produced by acute transverse stress, either during use or after the artifact was discarded.

Major classes of chipped stone

Because chipped stone can be created and damaged in many ways, apparently simple concepts can become difficult to apply when one is confronted with the variations that are presented by hundreds or thousands of archaeological specimens. Any classification of lithic material should have as one of its goals replicability, or the ability of other analysts to sort the material into the same categories that were used by the creator of the classification. It is with that goal in mind that I record the definitions of the major classes of chipped stone at the Tutu site. In addition to those listed below, I include *cores* (defined above), and *angular debris*, a term that refers to material which exhibits flake scars but which does not clearly meet the other criteria for either core or flake material.

- Whole flakes

  These flakes possess a complete striking platform. The ventral side is intact except for any retouch that may be present. There is no evidence of snaps.

- Unretouched whole flakes

  Whole flakes lacking evidence of retouch, whether or not microflaking that resulted from utilization is present.

- Broken flakes

  Artifacts with clear evidence of one or more of the following: a striking platform, ventral surface, or bulb of percussion, together with evidence that one or more of these attributes has been snapped or is otherwise damaged and incomplete.

- Retouched flakes

  Flakes, whether whole or broken, bearing patterns of continuous or quasi-continuous secondary flake scars along one or more edges and on either the ventral or distal side, or both.

- Scrapers

  A scraper is any flake or blade which is marked by one or more lines of marginal retouch along one or more edges. Retouch may be either unifacial or bifacial.

- Burins

  Flakes or blades which have been retouched by one or more burin blows to create a flattened point similar to that of a graving tool.

- Decortication flakes

  Flakes which maintain some of the cortex of the parent core on their dorsal sides. Flakes that lack dorsal flake scars, and on which the entire dorsal surface is covered with cortex, are termed "primary decortication flakes." Those exhibiting both cortex and flake scars on the dorsal surface are called "secondary decortication flakes." Decortication flakes rarely exhibit any retouch or marginal utilization damage.

- Pecking stones

  Pecking stones are essentially a class of core tool. With most of them, marginal modification is involved around much, or all, of the perimeter of a flat cobble of fine-grained massive material such as basalt. In addition to a working edge angle of about 40–60° that is created by direct percussion bifacial flaking, the perimeters exhibit heavy step flaking that appears to be due to use of the artifact edge for battering or pecking. Although it cannot be proven, pecking stones may have been used in the manufacture of ground stone artifacts.

FREQUENCIES AND TECHNOLOGY OF FLAKED STONE ARTIFACTS

Cores

Technological processes are perhaps best understood first by consideration of the cores, which are the final products of chipped stone manufacture. A total of 17 cores and core fragments was present in the Tutu collection, and all but one are flake cores. However, the flake cores may be further divided into two types: irregular flake cores and subdiscoidal flake cores.

Irregular flake cores

As their name suggests, irregular flake cores are marked over most or all of their surfaces by irregularly distributed scars that were created by the removal of flakes which themselves were highly variable in both shape and size. The depths and irregular shapes of the flake scars suggest that direct hard hammer ("stone on stone") percussion was the usual method of flaking for cores of this type. These 11 cores range in maximum dimension between 7.45 cm and 11.06 cm, with most falling between 7.5 cm and 9.5 cm.

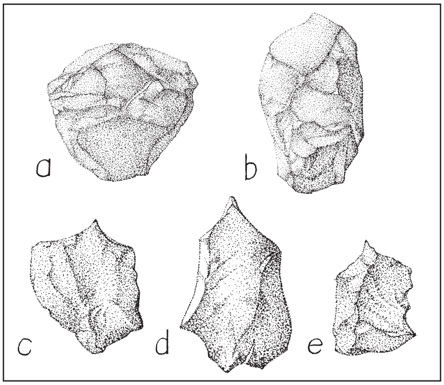


Figure 11.1a–e Cores and burins from the Tutu site. a: irregular flake core; b: subdiscoidal core. Both specimens are basalt. c–e: burins (drawings by William A. Burgess).

Subdiscoidal flake cores

Among the subdiscoidal flake cores, (Figure 11.1), four exhibit more-or-less defined equators, creating a core that is plano-convex in cross-section (one of the four is broken in such a way that its original dimensions cannot be measured). Most of the flake scars are irregular in form, although some are triangular. Subdiscoidal flake cores range in maximum diameter between 7.98 cm and 9.25 cm, and in thickness between 3.22 cm and 6.29 cm. Some cortex remains on three of the four cores.

Blade core

One roughly cylindrical core exhibits a combination of blade and flake scars. The number and arrangement of blade scars indicate that, at least in its terminal reduction stages, this core was deliberately crafted for direct-percussion blade production. The core exhibits a total of six blade scars and six flake scars. Five of the six blades were removed from one direction. The lengths of the blade scars in cm are: 4.67, 2.82, 3.62, 6.12, 5.5, and 5.44. The length of the core is 7.22 cm, and its maximum width is 4.52 cm.

Unretouched flakes

Unretouched flakes are highly variable in plan form. Although some are more or less triangular, most are irregularly shaped. A small minority exhibits lipping on the ventral surface below the bulb of percussion and other features of soft hammer percussion, but the overwhelming majority were products of direct hard hammer percussion. Of 145 unretouched flakes in the collection, 37 are whole, while 108 are snapped or otherwise broken. In total, 18 of the unretouched flakes are chert; the chert flakes represent at least six different color categories, covering a range of greens, greys, and browns. A total of 31 (83.8%) of the unretouched flakes are made of fine-grained volcanic rocks (Tables 11.1 and 11.2).

The fact that only 2 of the 145 unretouched flakes represent primary decortication is of note (see Table 11.2). This paucity of primary decortication flakes suggests that either the inhabitants of Tutu were working very large nodules of chert and volcanic materials, yielding a low ratio of primary decortication flakes to flakes of later reduction stages, or the initial stages of core preparation were conducted elsewhere, perhaps at quarries.

There is a marked contrast in evidence of utilization for whole and broken unretouched flakes (Table 11.2). Thirteen of the 37 whole unretouched flakes (35.1%) exhibit marginal edge damage indicative of utilization, while only 6 of the 108 broken unretouched flakes (5.6%) have similar damage. This difference indicates that a significant number of the whole unretouched flakes were in fact utilized; and that a larger percentage of broken flakes are by-products of manufacture, rather than flakes that broke during use.

Retouched flakes

There are 14 retouched flakes, or tools in the strict sense, in the Tutu collection. One of these is made of chert, 11 are of fine-grained volcanic rocks in the basalt and rhyolite range, and 2 are of fine-grained volcanic or metamorphic materials that could not be identified. The retouched artifacts fall into two major typological categories – burins and scrapers.

Table 11.1 Raw material utilization at the Tutu site

	Retouched tools		*Whole flakes*		*Broken flakes*		*Angular debris*		*Cores/fragments*		*Ground stone*		*Pecking stones*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Fine volcanic	11	78.57	31	83.78	93	85.98	130	78.79	7	41.18	20	47.62	6	60.00
Chert	1	7.14	4	10.81	14	13.08	7	4.24	2	11.76	0	0.00	2	20.00
Greenstone	0	0.00	0	0.00	0	0.00	12	7.27	0	0.00	0	0.00	1	10.00
Quartz	0	0.00	1	2.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Unknown	2	14.29	1	2.70	1	0.93	16	9.70	8	47.06	22	52.38	1	10.00
Totals	14	100.00	37	100.00	108	100.00	165	100.00	17	100.00	42	100.00	10	100.00

Table 11.2 Comparison of whole and broken unretouched flakes at the Tutu site

	Whole flakes		*Broken flakes*	
	No.	*%*	*No.*	*%*
Volcanic	31	83.78	93	86.11
Chert	4	10.81	14	12.96
Quartz	1	2.70	0	0.0
Unknown	1	2.70	1	0.93
Primary decortication	1	2.70	1	0.93
Secondary decortication	12	32.43	20	18.52
Tertiary stage	24	64.86	87	80.56
Utilization damage	13	35.14	6	5.56
Average weight (g)	17.03		6.48	

Burins

One of three burins (Figure 11.1c) from the site is a dihedral burin on the dorsal side of the distal end of a poor-quality light brown translucent chert flake. Its dimensions are 3.33 cm by 2.18 cm and 0.65 cm in thickness. The second burin (Figure 11.1d) is a double-ended burin on a grey fine-grained volcanic flake. The distal end of the flake is modified as a dihedral burin, while the proximal end exhibits one burin scar. The overall dimensions of the piece are 5.07 cm by 3.10 cm and 1.03 cm in thickness. The third burin (Figure 11.1e) is a dihedral burin formed on the edge of a sidestruck flake of light brown quartz. Under low-power magnification, none of the burin bits shows signs of utilization.

Scrapers

Of 11 scrapers from the site, 4 are retouched bifacially, while the remaining 7 exhibit unifacial retouch. Each of the 11 pieces is more or less distinctive, making further classification of scrapers into finer categories impossible (see examples in Figures 11.2a–f). All 11 scrapers were made on relatively thick flakes. As Table 11.3 indicates, retouching was applied to either proximal or distal ends. In all cases, retouching appears to have been conducted in order to change (lower) the cutting angle of the edge, rather than to modify the plan form of the piece. With the exception of one carinated scraper that exhibits heavy step fracturing along the retouched edge, retouching scars on the scrapers are relatively shallow, with feather terminations.

Angular debris

The 165 pieces of angular debris in the Tutu collection are distributed among raw material classes as follows: fine-grained volcanic rock, 130; chert, 7; laminar medium-grained blue-green volcanic rock, 12; and unidentifiable material, 16. While the fine-grained volcanics and chert undoubtedly are by-products associated with production of lithic artifacts of the same materials, the medium-grained blue-green volcanic rock identified as “greenstone” in Table 11.1 has no counterparts in the rest of the flaked stone industry. The greenstone angular debris may represent by-products of manufacture of pecking stones, one of which is made of the same material.

Total weight of the angular debris is 943 g, yielding an average weight for each piece of 5.72 g.

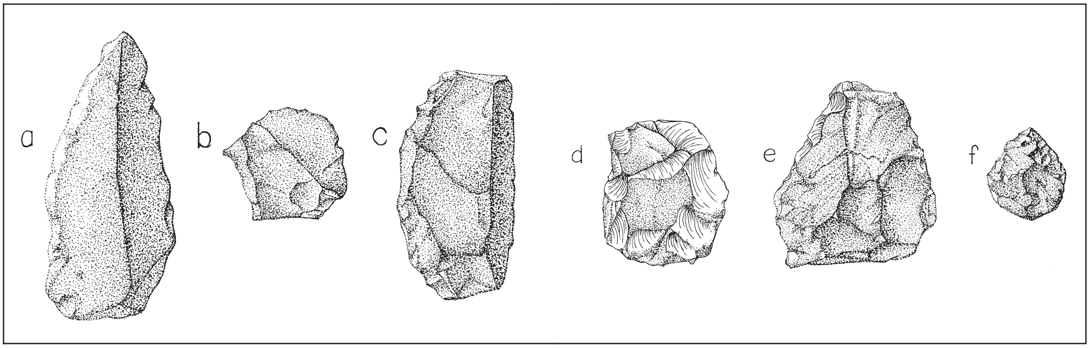


Figure 11.2a–f Scrapers from the Tutu site. a: side scraper on blade; b: ground stone fragment modified as side scraper; c–f: assorted scrapers (drawings by William A. Burgess).

Pecking stones

The 10 pecking stones in the Tutu collection are (usually elongate flattish or subspherical) cobbles whose perimeters exhibit signs of intensive crushing and battering that is indicative of use as a hammerstone or pecking implement. It seems likely that these objects were used as pecking stones in the production of ground stone artifacts. Unfortunately, 8 of these 10 artifacts were recovered from surface contexts. The pecking stones are described individually below:

- *31-BII-C-12*: Flat cobble of blue-grey volcanic material with a few phenocrysts of white feldspar. Extensive cortex on one side, no cortex on other side. Evidence of pecking on one end and one side. Length = 9.15 cm; width = 6.28 cm; thickness = 2.49 cm.
- *3-54/68-Z*: Plano-convex green stone pebble, most of cortex remaining on both sides, pecked on two sides and one end. Length = 6.56 cm; width = 5.43 cm; thickness = 3.63 cm.
- *A-R-Z-6/48*: Flaked, battered, rounded plano-convex cobble of very fine-grained dark green cryptocrystalline rock (chert?). Cortex on 15 percent of surface (one area only). Pecked fully around equator. Length = 4.1 cm; width = 3.81 cm; thickness = 2.93 cm.
- *MDL-Z-1*: Same dark green cryptocrystalline material as above. Flat elongate pebble with cortex present on about 50 percent of surface. Rather heavily flaked on each long axis edge, but not on end. Length = 11.0 cm; width = 4.77 cm; thickness = 3.35 cm.
- *A-R-Z-5*: Very fine-grained dark green volcanic rock with a few phenocrysts of feldspar. Plano-plano in form, pecked fully around perimeter. Length = 5.39 cm; width = 5.09 cm; thickness = 2.80 cm.
- *A-1-Z-13*: Dark green volcanic rock containing some phenocrysts and streaks of white feldspar. Planoconvex in form. Cortex present on 50 percent of one side. One (accidental?) blade removal. Pecked around 65 percent of equator. Length = 7.33 cm; width = 6.20 cm; thickness = 4.35 cm.
- *A-6-Z-10*: Semi-tabular, slightly battered on one side and one end, material unknown.
- *A-5-Z-1*: Double-convex dark green volcanic rock with some white feldspar phenocrysts. Some cortex present on one side. Length= 7.29 cm; width = 4.72 cm; thickness = 4.60 cm.
- *Z-3; Pile 3*: Tabular basalt cobble (see Figure 11.3a) with step fractures and evidence of battering around 70 percent of perimeter. Maximum dimension 10.00 cm; thickness = 2.88 cm.
- *Unassigned*: Tabular basalt cobble (see Figure 11.3b) with flake removals around 70 percent of perimeter and step fractures and battering/pecking along one of the modified edges. Maximum dimension 8.35 cm; thickness = 2.88 cm.

Table 11.3 Edge locations and facial retouching of the 11 scrapers examined from the Tutu site

Edge location		*Face location*	
End	*Side*	*Unifacial*	*Bifacial*
P	E	present	—
P	E	—	present
D	E	—	present
D	Do	present	—
D	V	present	—
D	Do	present	—
D	E	—	present
D	E	present	—
—	V	present	—
—	E	—	present
—	D	present	—

Note
P = proximal; D = distal; E = end; Do = dorsal; V = ventral.

GROUND STONE AND OTHER LITHIC MATERIAL

Although it was not a focus of the study, 42 fragments of ground or ground and polished stone were examined (see e.g. Figures 11.3c and d). Some appear to be adze and pestle fragments, while others are too small to associate with any particular form of implement. One of the smaller fragments exhibits apparent utilization damage in the form of microflaking along one end, suggesting the possibility of expedient use of broken ground stone for other purposes (Figure 11.3c). Raw materials represented by the ground stone fragments include basalt, rhyolite, and various grey and grey-green metamorphic and volcanic rocks.

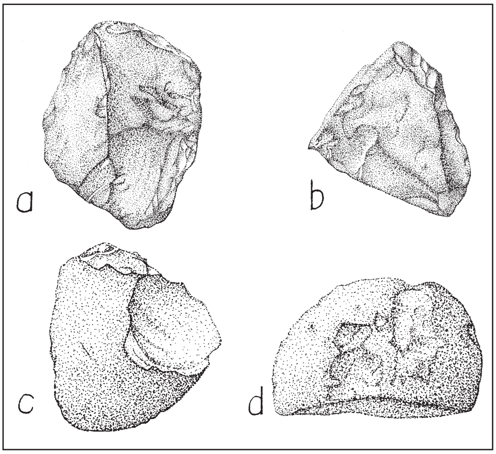


Figure 11.3a–d Pecking stones and flaked ground stone from the Tutu site. a and b: pecking stones. Both specimens are basalt; c: ground stone fragment with evidence of flaking; d: ground stone fragment utilized as a hammerstone (drawings by William A. Burgess).

COMMENTS ON FLAKED STONE ARTIFACT PRODUCTION AT TUTU

The inhabitants of the Tutu site used a variety of fine-grained volcanic rocks and (less frequently) chert in the manufacture of flaked stone artifacts. The volcanics in question include basalts, rhyolites, and similar massive fine-grained rocks, mostly in the mafic range. In at least one case, a third material, a green laminar medium-grained volcanic rock, was used to make a pecking stone.

The ratio of decortication to later reduction stage flakes suggests that, in at least some cases, the initial stages of flaked stone artifact manufacture occurred outside the site, perhaps at the sources of the raw materials.

Although direct percussion blades were made at Tutu, they are rare, and most flaked stone production was oriented around flake cores, which are of two types. The majority (64.7%) of the cores are irregular flake cores, showing no pattern in the removal of flakes. The resulting flakes themselves also are irregular in form. A smaller number of cores were prepared into subdiscoidal forms, from which flakes were then removed by bipolar direct hard hammer percussion. In this context, "bipolar" does not imply use of the "bipolar technique" that originally was defined by Bardon and Bouysonnie (1906) and first recognized in the Caribbean at Sugar Factory Pier site on St Kitts by Jeffrey Walker (1980). The classic bipolar technique involves the use of an anvil (Crabtree, 1972: 42), and yields cores that are irregular to cylindrical in shape. In contrast, the subdiscoidal cores from Tutu are generally conical in form, and the absence of signs of terminal shattering of flakes suggests that the cores were held in the hand rather than set upon an anvil.

Cores that appear to be broadly similar in morphology are illustrated for the preceramic site of Playita in Cuba by Febles (1988: Fig. 21:2–5); however, the Playita cores are microlithic, with diameters of less than 4.0 cm. Subdiscoidal cores from the early preceramic site of Seboruco in Holguín province, Cuba, also bear little similarity to those from Tutu; the Seboruco specimens are massive in size (typically greater than 12 cm in maximum dimension), and are flaked on only one face (Febles, 1991). However, the subdiscoidal cores from the "sub-Taíno" site of Aguas Gordas, Cuba (Febles, 1978) appear to be more similar to those from Tutu. Moreover, Febles (1978) noted the common occurrence at Aguas Gordas of cores which, in his view, had been previously used as hammerstones. These artifacts may be counterparts of the tools from Tutu that are termed "pecking stones" herein.

Some of the Tutu flakes produced from subdiscoidal cores are triangular in shape, while others are irregular. Although the majority of all whole flakes produced at Tutu is not further retouched, a significant number (35.1%) appear to have been utilized, as is indicated by patterns of edge damage which are clearly visible under low-power magnification.

Retouched flakes, or flake tools, include burins and a variety of both unifacial and bifacial scrapers. In the relatively small sample of scrapers (n=11), specific modes of edge modification are sufficiently variable that the artifacts do not cluster into types. The range and frequencies of raw materials used for finished tools do not differ significantly from those used for unretouched flakes.

Overall, the sample of flaked stone artifacts from the Tutu site presents several interesting technological and typological features. If the lithic collection that has been discussed here does in fact represent a single flaked stone industry, then its most distinctive characteristics probably include: the almost universal use of hard hammer direct percussion (except perhaps for retouching); the use of subdiscoidal cores; the production of a variety of (both unifacial and bifacial) marginally retouched scrapers on irregularly shaped flakes; the frequent utilization of irregularly shaped unretouched flakes, and the production and use of pecking stones. Fine-grained volcanic rocks in the basalt range were the most frequently used raw materials for flaked stone manufacture. The degree to which these and other features discussed above are characteristic of Saladoid ceramic technology in the Virgin Islands generally remains to be tested through future excavations.

Chapter Twelve

Post hole patterns: Structures, chronology and spatial distribution at the Tutu site

Elizabeth Righter

INTRODUCTION

The "curious neglect of architecture by academic anthropology" has been attributed to the fact that houses are taken for granted or treated as ethnographic "case" studies in symbolism or cosmology, rather than studied in their own right, or considered in relationship to the landscape on which they are situated (Carsten & Hugh-Jones, 1994: 3, 4). A similar neglect may be observed in Caribbean archaeology which, until recently, has focused on excavation of midden deposits, ceramic typology and development of a cultural chronology for the Caribbean (Bartone & Versteeg, 1997). As noted by Siegel almost a decade ago, the study of architectural remains is one undeveloped archaeological domain which might help to balance archaeological research perspectives (Siegel, 1996: 2).

In the past, some Caribbean archaeologists addressed the more obvious and impressive ceremonial structures, such as the ball and dance court complexes of Puerto Rico and Dominican Republic (Mason, 1941; Alegría, 1983; Oliver, 1998) but only recently have there been attempts to expose large contiguous expanses of prehistoric settlements for the purpose of documenting domestic structures and recording layouts of entire villages. Although few in number, these comprehensive investigations have inspired research into such related issues as estimated household population and village size (Curet, 1992 ; Siegel, 1992, 1996; Schinkel, 1992), cosmology, social organization and sociopolitical change reflected in settlement structure (Curet & Oliver, 1998 ; Hofman & Hoogland, 2000; Keegan & Maclachlan, 1989 ; Kingsley, 1985; Siegel, 1989, 1992, 1996; Schinkel, 1992). From these studies, it is increasingly demonstrated that households have an active role in social and cultural change (Curet, 1992; Curet & Oliver, 1998) and, in order to begin to understand these processes, much more information is needed about the diversity of house sizes and shapes, and their distribution on the land in relation to the physical and environmental setting of a site and the economy and social organization of its inhabitants.

Previously, there had been no real information about prehistoric village layout in the US Virgin Islands. For the Saladoid period, limited investigation of midden deposits and a few features, including human burials, at the Cane Bay and Judith's Fancy sites on St Croix (Payne & Thomas, 1988; Joseph, 1989), tentatively indicated an arrangement of structures in a horseshoe-shaped pattern around a central plaza. On other islands, investigations at the Maisabel, Punta Candelero and Monserrate sites in Puerto Rico, the Golden Rock site in St Eustatius, and Indian Creek in

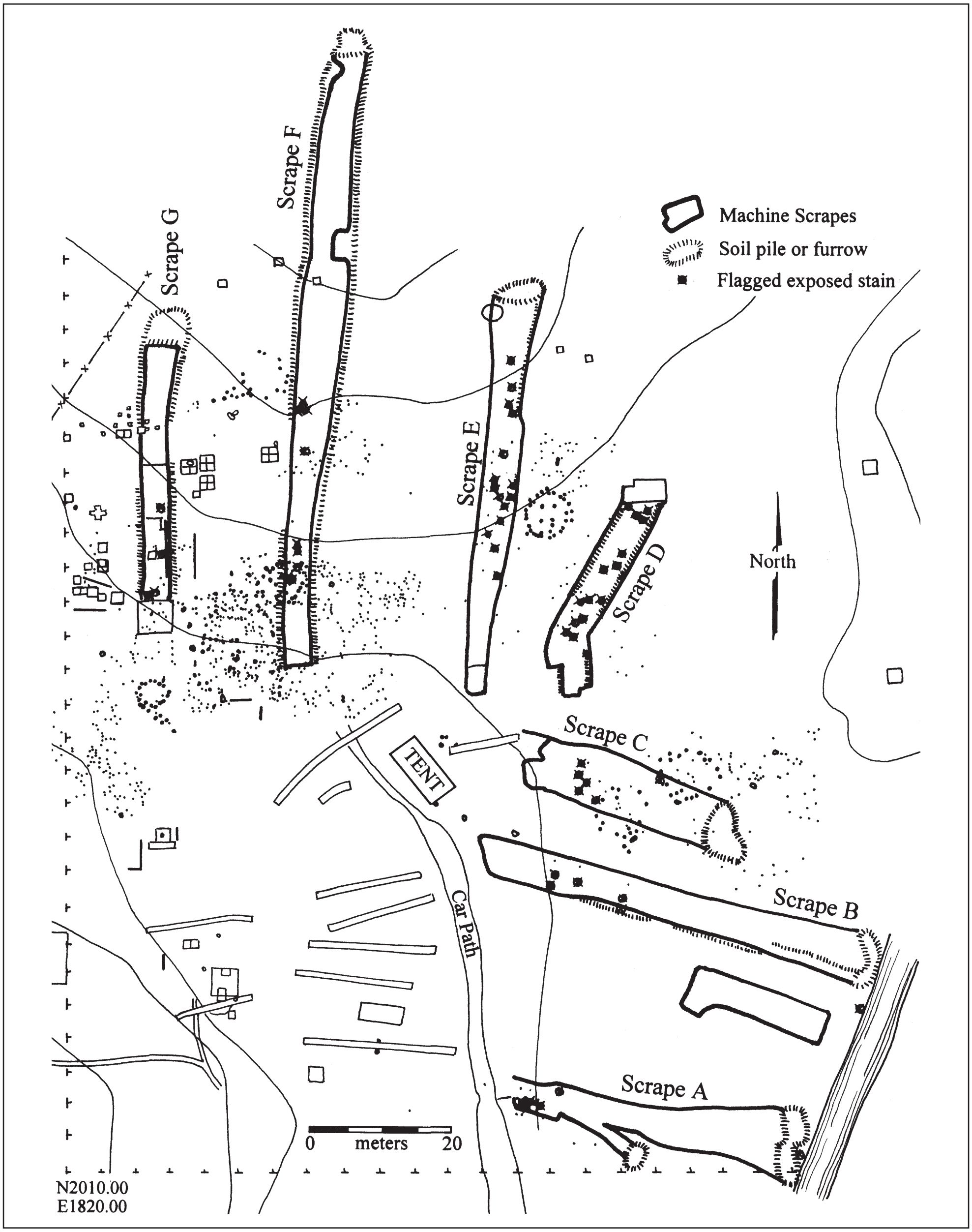


Figure 12.1 Pathways of Machine Scrapes A–G, showing structures that were by-passed or only partially exposed (recorded by Elizabeth Righter, graphic by Julie Smith).

Antigua (Curet & Oliver, 1998; Rodríguez, 1991b; Rouse & Faber Morse, 1999; Siegel, 1992, 1996; Watters, 1994) revealed circular and horseshoe-shaped settlement layouts.

Until recorded by the Tutu Archaeological Village project, Saladoid and post-Saladoid structures had not been documented in the Virgin Islands. Identification of seven late Ostionoid structures within an established framework and village plan at Tutu (see Figures 1.7 a–d for a complete site map showing the distribution of structures, post holes, other features and other stains), and documentation of burial distributions, should contribute substantially to our knowledge of Virgin Islands prehistoric settlements, and shed light on the cultural and sociopolitical changes that took place between the Saladoid and late Ostionoid periods.

CHARACTERISTICS OF THE TUTU POST HOLES

Investigative techniques

Although origins of a few post holes could be identified in unscraped portions of Areas 1, 8, 9N, 9S and 13, the origins of most features had been lost to pre-1990 scraping. Structure floors also had been lost. In some cases, exposed surfaces under topsoil had been lightly scraped, and in others they had been repeatedly scraped into the subsoil. Given the urgency of meeting the developers' deadlines for construction start up (discussed in the Preface), archaeological re-scraping of previously scraped areas seemed appropriate. Initial attempts to limit scraping to selected avenues, where a quick sampling would be conducted by auguring of exposed stains, produced misleading results (Figure 12.1). In order fully to understand relationships among stains and identify discrete structures, it was necessary to scrape and record features in large contiguous expanses. Accordingly, archaeological re-scraping was conducted using a small scraping machine designed to minimize damage to underlying features.

As the machine advanced, archaeologists and volunteers followed behind and, with shovels and trowels, manually shovel shaved, scraped and swept loose soil from the surface. This soil was taken by wheelbarrow to the water screen area where it was sieved through 0.635 cm and 0.317 cm mesh screen. Soil in furrows left by machine scraping also was water screened as time allowed. As each feature was exposed and cleaned, a labeled plastic surveyor's flag was inserted into its center. Feature locations were mapped in Autocad Release 9/10 and with a transit, rod and tapes.

Numbering and mapping exposed stains

In scraped areas, exposed stains originally were numbered, by area, in lots of 100. For example, Area 1 stains were assigned numbers 1–99; Area 2 stains were assigned numbers 100–199 and so forth. However, after manual cleaning of exposed areas, new stains continued to appear and additional numbers were assigned. In each area, therefore, numbered stains higher than the originally alloted 100 numbers were discovered after initial scraping, and reflect the sequence in which they were discovered.

In major scraped areas of the site, center points of exposed stains were recorded in Autocad (Release 9/10). Because dimensions of small stains were not recorded during Autocad mapping, the original Autocad maps produced for the site by Travis Gray are not presented in this volume. Rather, Figures 12.2–12.7 were prepared, on which spatial relationships between features are those accurately mapped in Autocad, and feature dimensions are accurately shown to scale using information transferred from field drawings. Post holes and stains, present in unscraped portions of the site, and sparse stains in the central open space (cemetery and plaza), and in Area 10, are not shown in these figures.

In Figures 12.2–12.7, and in other figures which depict post holes in this volume, true post holes are drawn to scale and numbered with a "P" designation. The suffix "A" is used to designate a post *mold* and the suffix "B" indicates a post *hole*. Investigated non-cultural stains are shown to scale with a number and a check through the stain. Uninvestigated stains with recorded diameters are drawn to scale with dashed lines. Although the dimensions of all exposed stains were recorded in the field, during field mapping, some stain diameters were overlooked and dimensions were not entered into the mapping data base. These stains are known only by their numbers and center

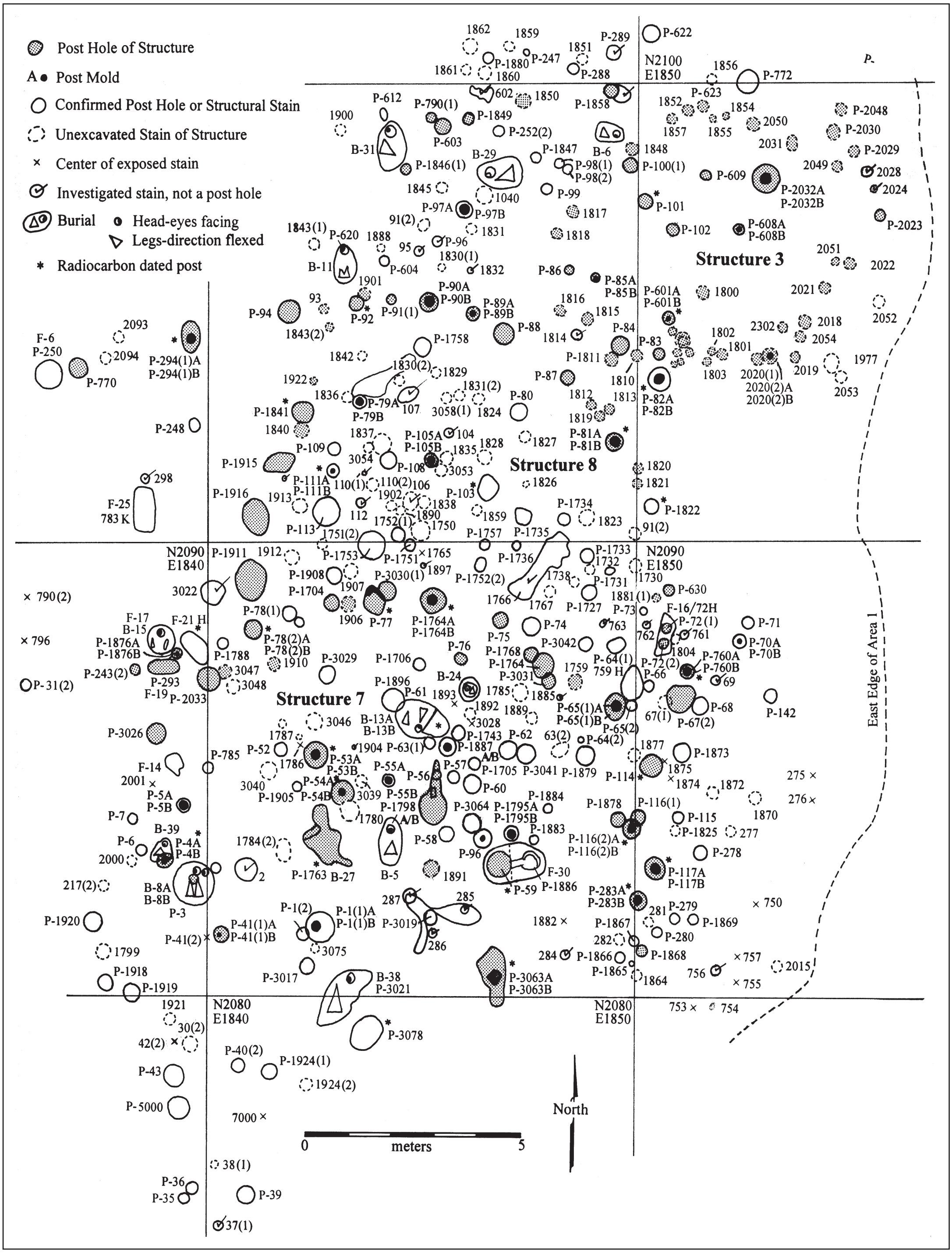


Figure 12.2 Post holes, burials and features of scraped portions of Area 1, including post holes of Structures 3, 7 and 8 among myriad stains and post holes (composite developed from mapping in Autocad Release 9/10 by Travis Gray, Humphrey Ongondo, Cameron Scobie and Alan Perry, graphic by Julie Smith).

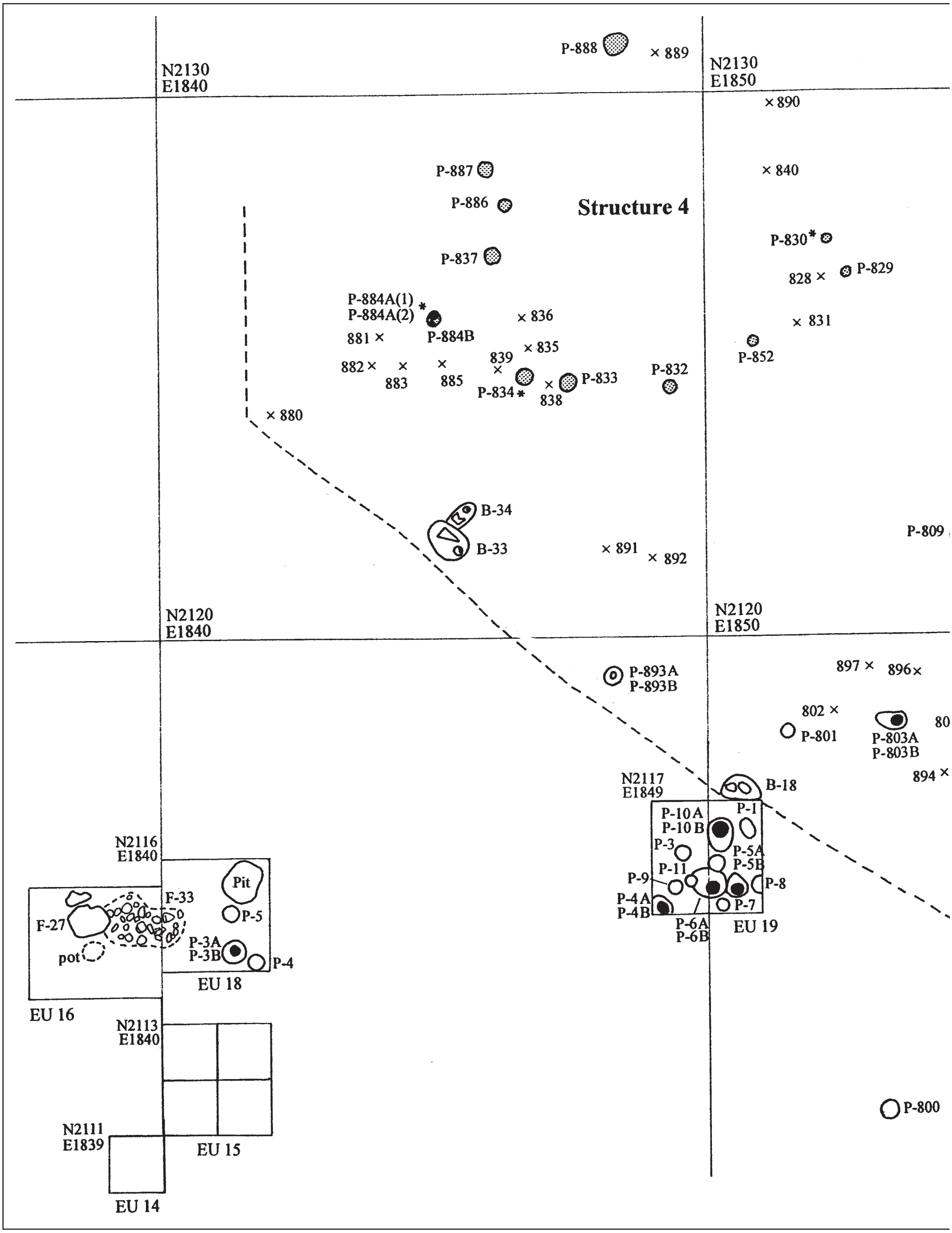
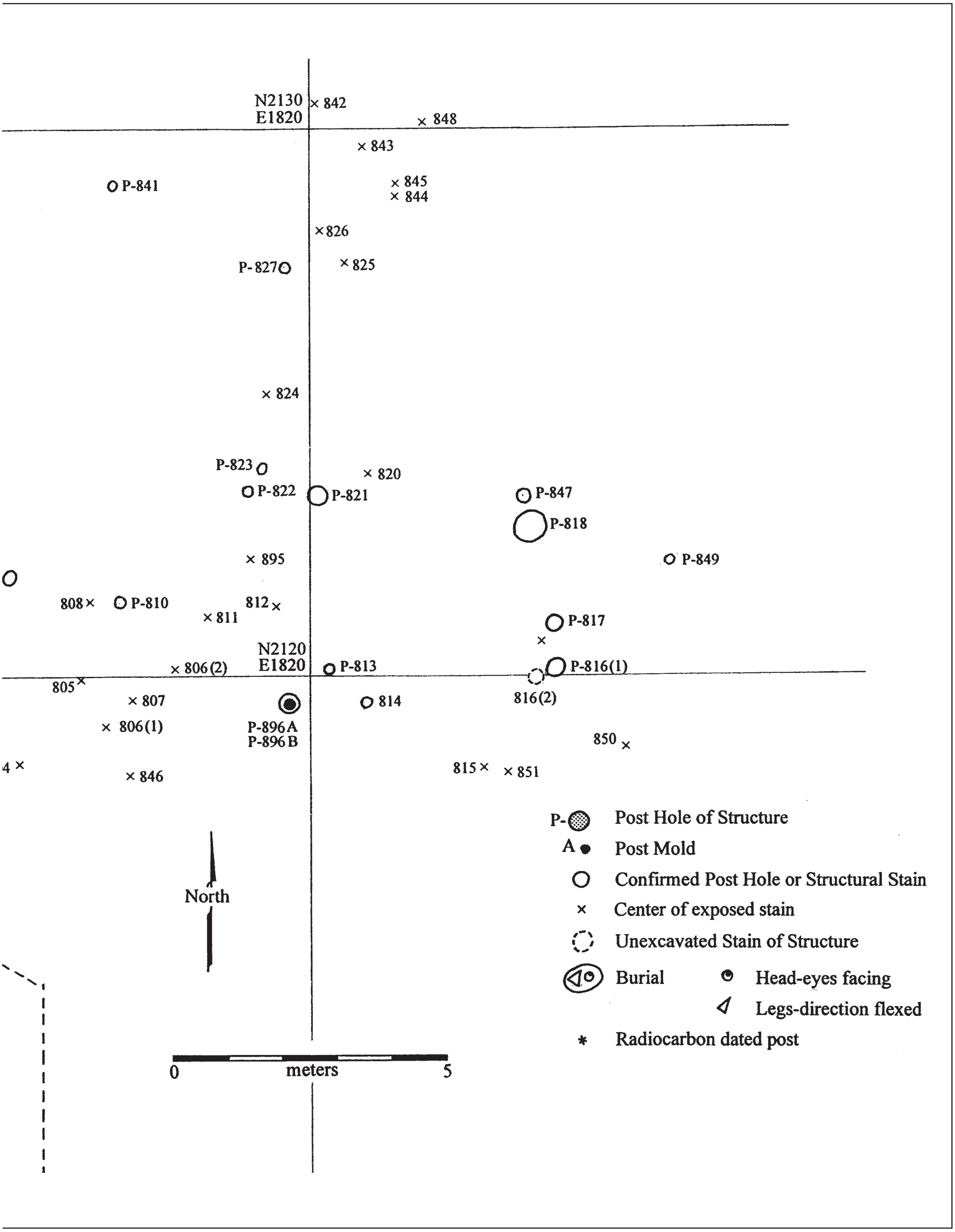


Figure 12.3 Post holes and stains of excavated and scraped portions of Area 8, including Structure 4, associated burials, and features (mapped in Autocad Release 9/10 by Travis Gray and Humphrey Ongondo, with assistance from Alan Perry, graphic by Julie Smith).


N2130
E1820
842
848
843
P-841
845
844
826
P-827
825
824
P-823
820
P-822
P-821
P-847
P-818
P-849
895
808
P-810
812
811
P-817
N2120
E1820
806(2)
P-813
P-816(1)
805
807
814
816(2)
806(1)
P-896A
P-896B
850
4
846
815
851
North
0
meters
5
P- Post Hole of Structure
A Post Mold
Confirmed Post Hole or Structural Stain
Center of exposed stain
Unexcavated Stain of Structure
Burial
Head-eyes facing
Legs-direction flexed
Radiocarbon dated post

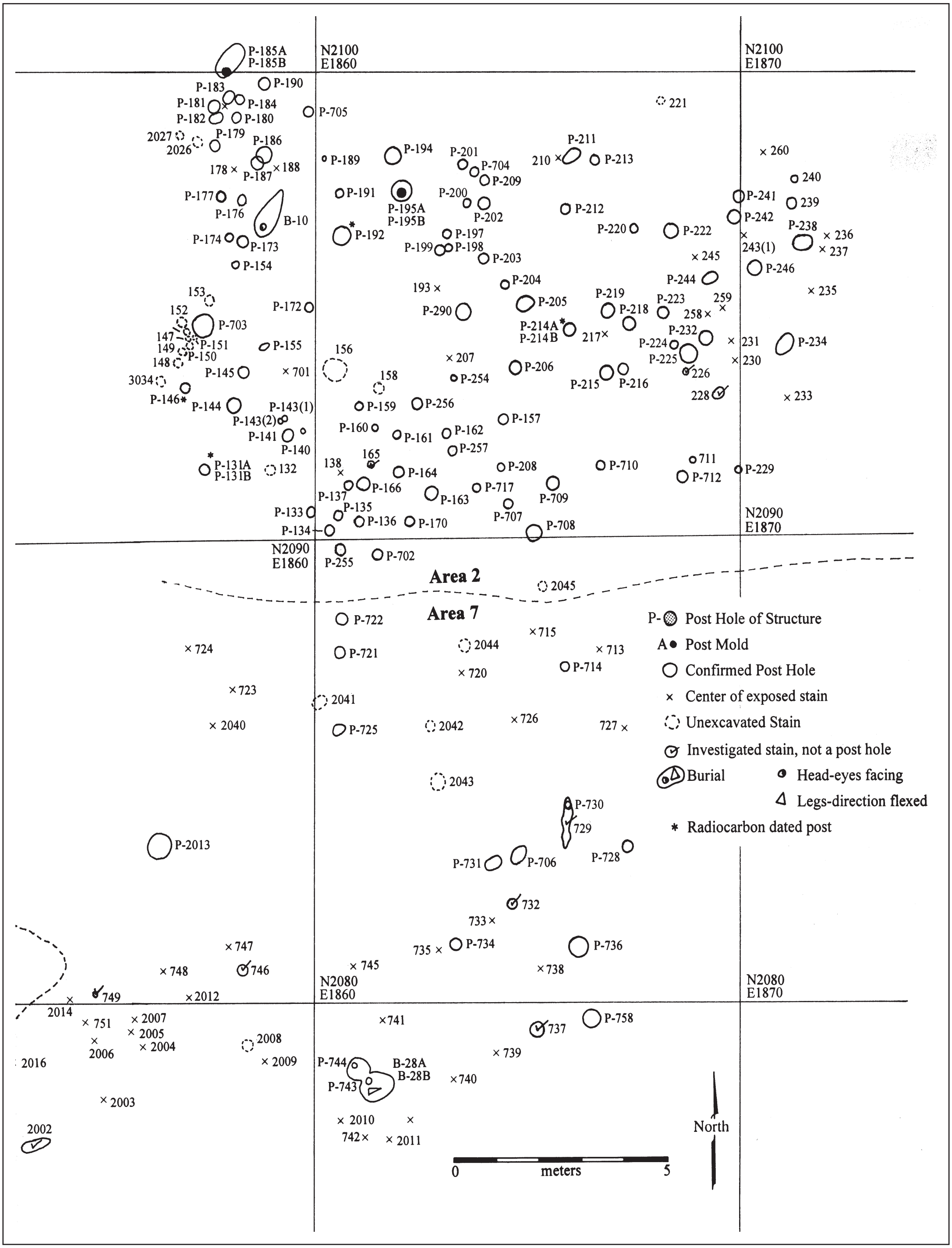


Figure 12.4 Dated posts and burials among exposed post holes and stains in scraped portions of Areas 2 and 7 (mapped in Autocad Release 9/10 by Travis Gray and Humphrey Ongondo with assistance from Alan Perry, graphic by Julie Smith).

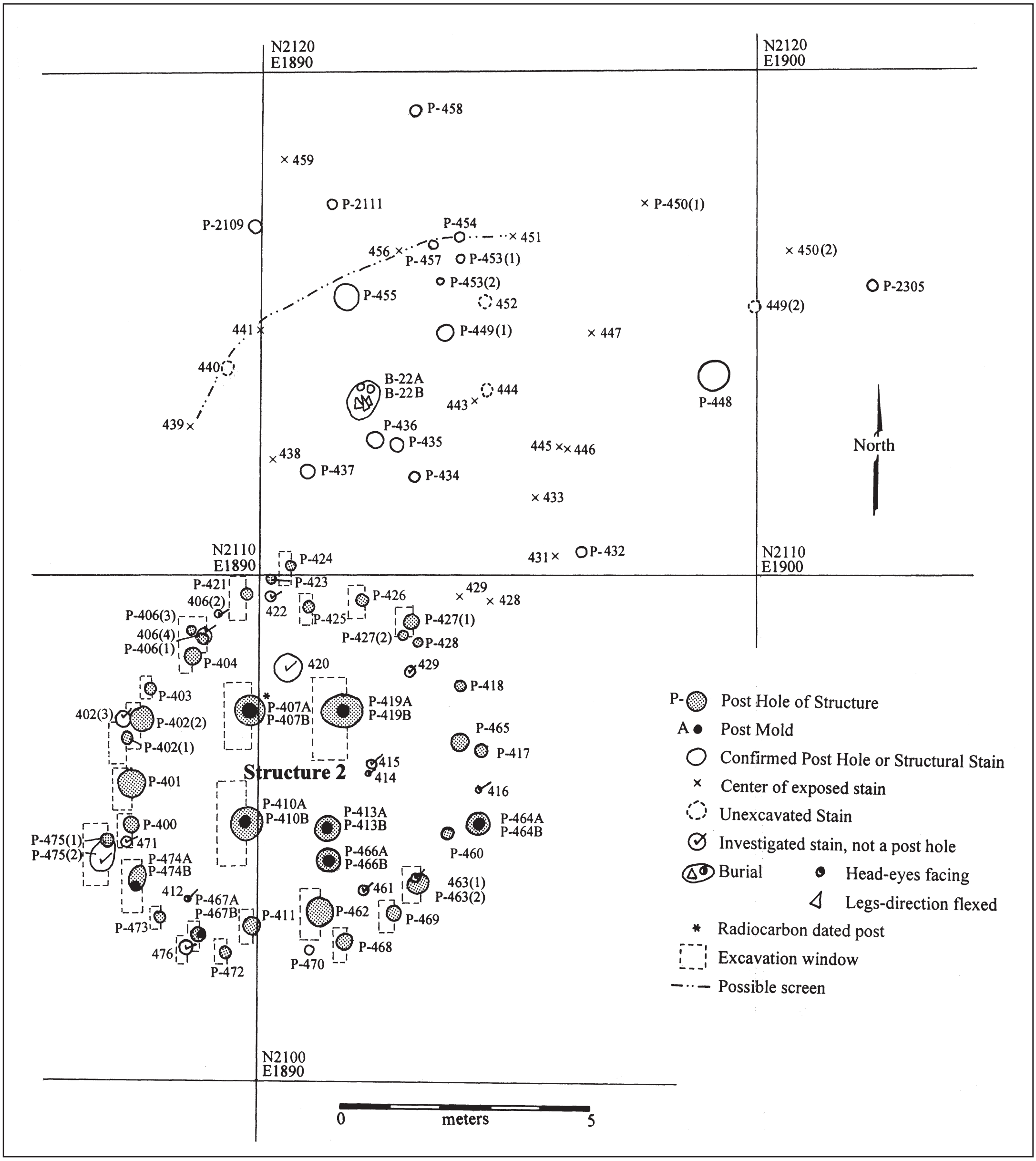


Figure 12.5 Structure 2, related burial, possible fence line and other post holes and stains of scraped Area 3 (manually recorded by Ken Wild and mapped in Autocad Release 9/10 by Travis Gray and Humphrey Ongondo, graphic by Julie Smith).

points which are indicated on maps by crosses. Stains that proved to be burial pits were assigned a "B" prefix, and an "H" subset was added to hearths. Kilns received a "K" and site features retained an "F" designation. "A" and "B" suffixes after a burial number denote two separate skeletons found in one burial pit.

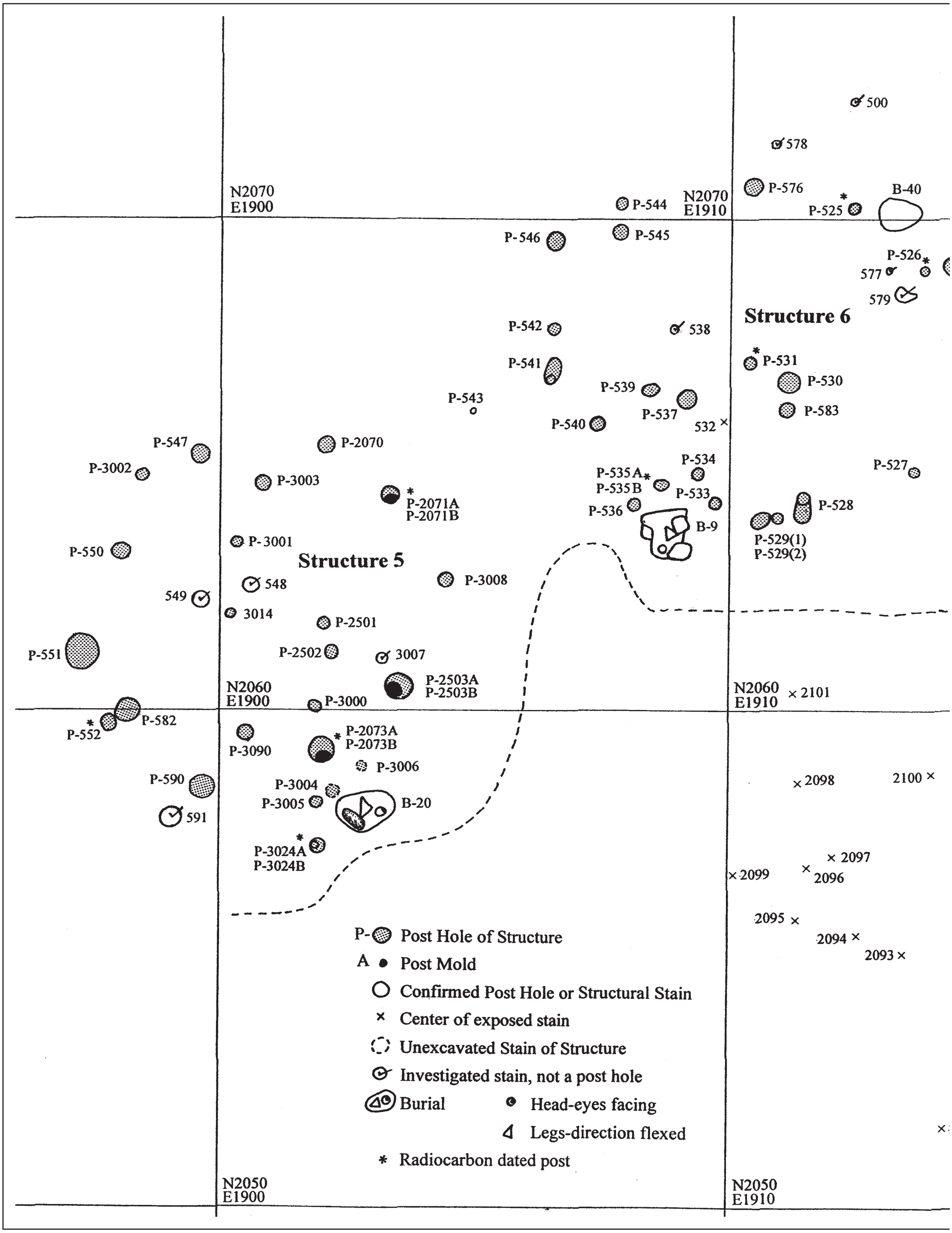
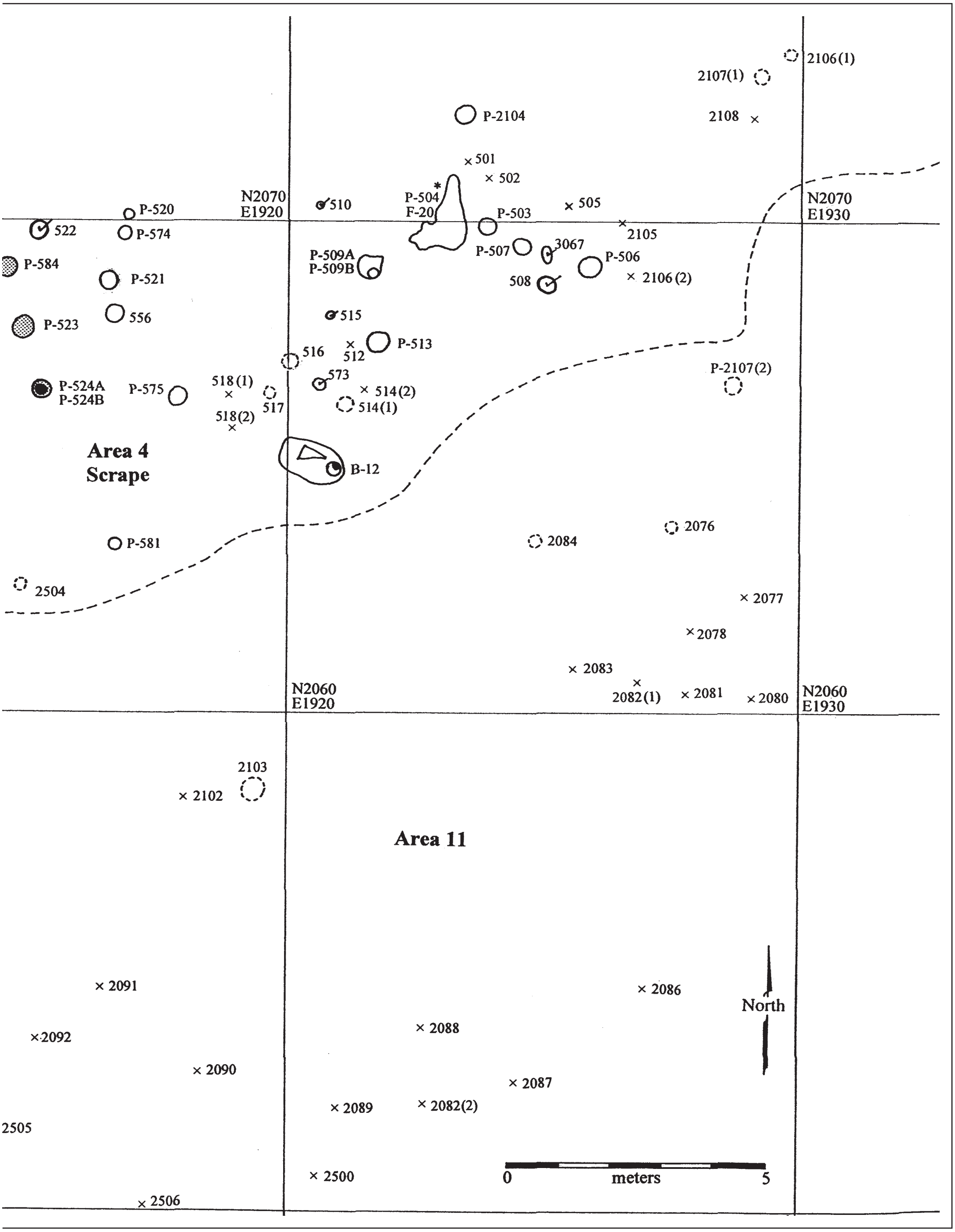


Figure 12.6 Post holes and stains, Structures 5 and 6, Feature 20, and burials of scraped Area 4; and post holes and stains of Area 11 (mapped in Autocad Release 9/10 by Travis Gray and Humphrey Ongondo).


2106(1)
2107(1)
P-2104
2108
501
502
N2070
E1920
510
P-504
F-20
505
P-520
P-503
N2070
E1930
522
P-574
2105
P-507
3067
P-506
P-509A
P-509B
P-584
P-521
508
2106(2)
515
P-523
556
P-513
516
512
P-2107(2)
573
P-524A
P-524B
P-575
518(1)
514(2)
517
514(1)
518(2)
Area 4
Scrape
B-12
2076
2084
P-581
2504
2077
2078
2083
N2060
E1920
2082(1)
2081
2080
N2060
E1930
2103
2102
Area 11
2091
2086
North
2092
2088
2090
2087
2089
2082(2)
2505
2500
0
meters
5
2506

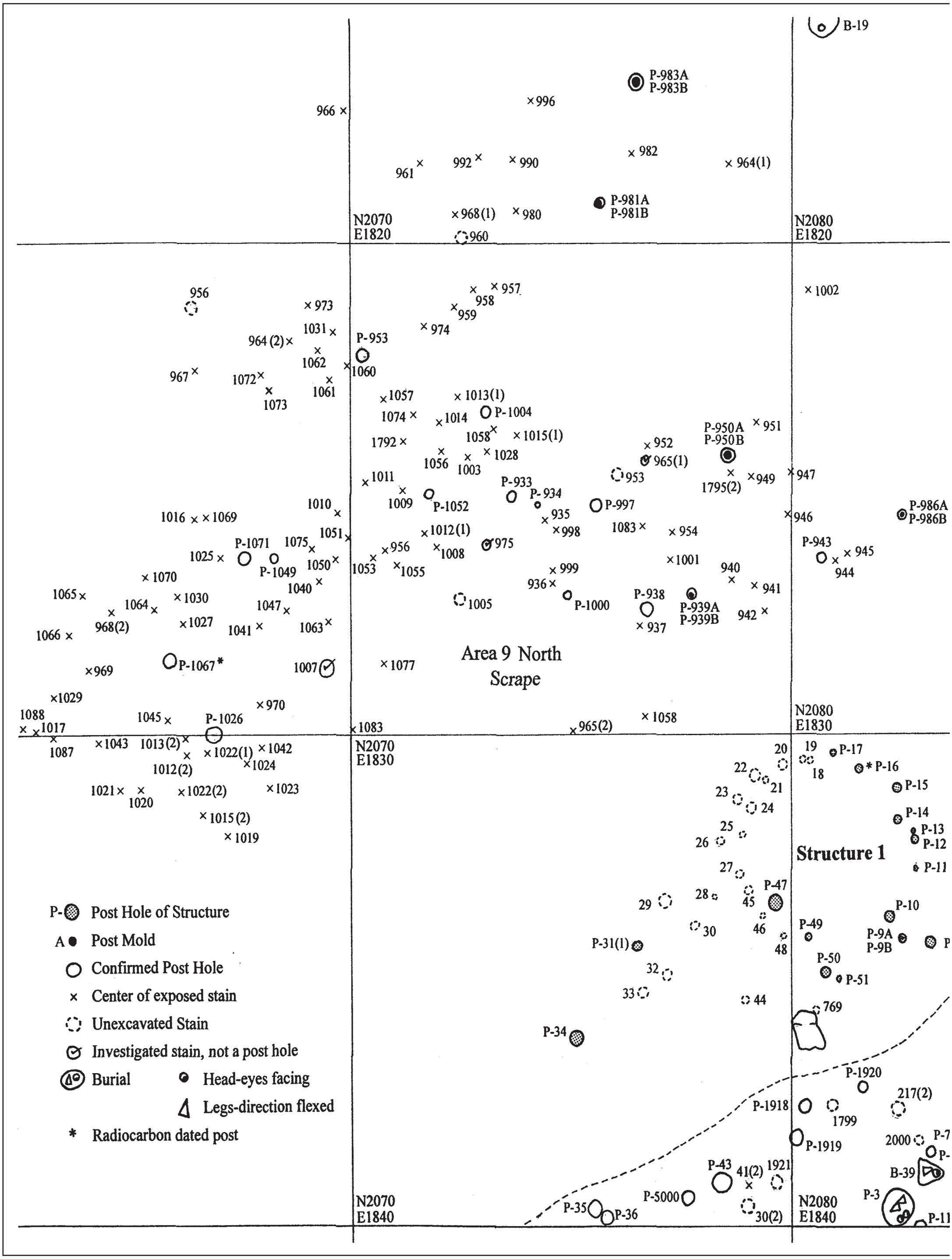
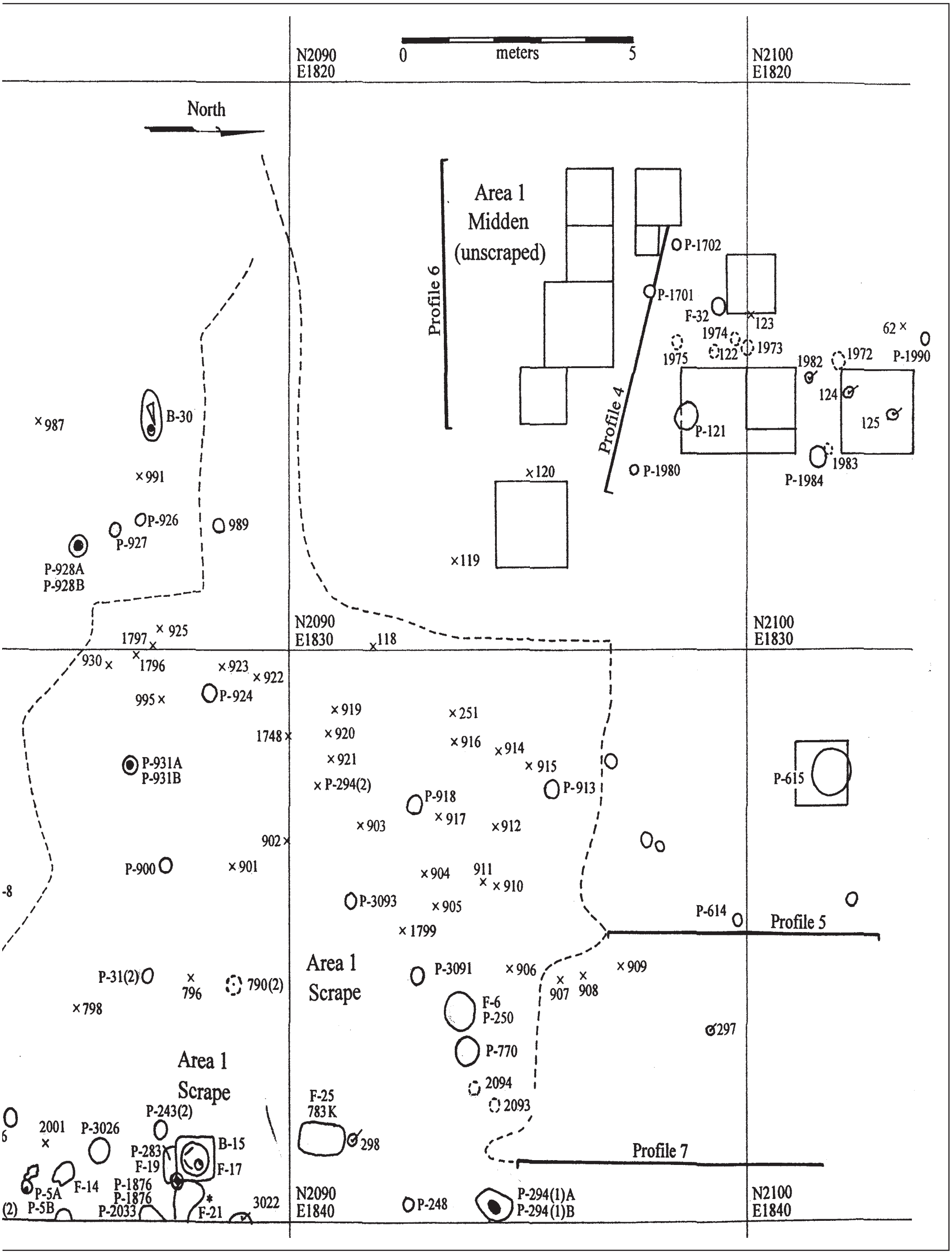


Figure 12.7 Structure 1, dated post, P-1067, and burials, among myriad other post holes and stains of scraped portions of Area 9N (mapped in Autocad Release 9/10 by Travis Gray and Humphrey Ongondo, graphic by Julie Smith).


N2090
E1820
0
meters
5
N2100
E1820
North
Area 1
Midden
(unscraped)
Profile 6
Profile 4
P-1702
P-1701
F-32
123
1974
1975
122
1973
62
P-1990
1982
1972
124
125
P-121
P-1980
1983
P-1984
120
119
987
B-30
991
P-926
989
P-927
P-928A
P-928B
N2090
E1830
118
N2100
E1830
1797
925
930
1796
923
922
995
P-924
919
251
1748
920
916
914
915
P-931A
P-931B
921
P-294(2)
P-913
P-615
P-918
917
903
912
902
P-900
901
904
911
910
-8
P-3093
905
P-614
Profile 5
1799
Area 1
Scrape
P-3091
906
909
P-31(2)
796
790(2)
907
908
798
F-6
P-250
297
P-770
Area 1
Scrape
2094
2093
P-243(2)
F-25
783K
2001
P-3026
B-15
298
Profile 7
P-283
F-19
F-17
F-14
P-1876
P-1876
P-5A
P-5B
P-2033
F-21
3022
N2090
E1840
P-248
P-294(1)A
P-294(1)B
N2100
E1840

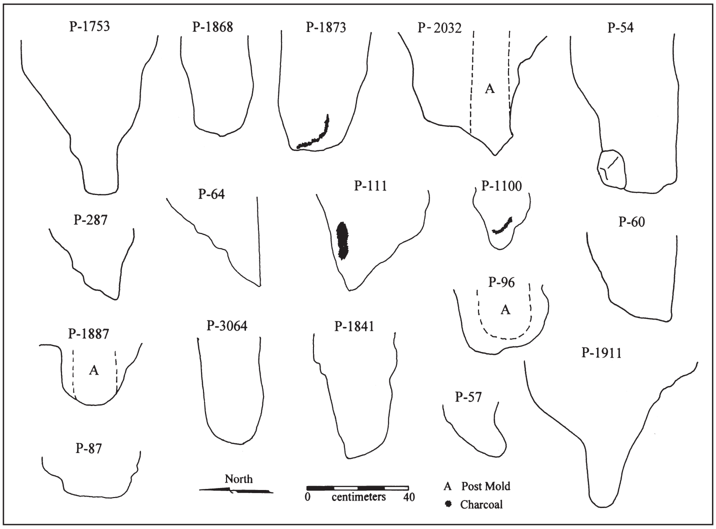


Figure 12.8 Various post hole profiles from the Tutu site (drawing by Elizabeth Righter, graphic by Julie Smith).

Excavation techniques

Each stain to be excavated was drawn to scale on graph paper, and Munsell colors of the stain, surrounding soil and any anomalies were recorded. In most cases, the stain was bisected in a north–south direction, and the western half was excavated, leaving the eastern half in place for profiling and for reference. When necessary a small "window" was opened in subsoil on the western side of a stain to allow the investigator access to the full length of the feature and to facilitate post removal when appropriate. When post molds were present, they were excavated separately, as were layers when visible. In some cases, a post mold was revealed in the east soil profile after excavation of the western half had been initiated. In profile, it was sometimes possible to surmise the location and approximate diameter of a post mold by the shape of the lower portion of the post mold, or by a slash of charcoal which marked the charred exterior of a former post. The tips of charred posts were sometimes outlined by rings of charcoal at post hole bases (Figures 12.8–12.10).

The top 4 cm of soil on the west half of each excavated feature were removed and screened separately. This precaution, which proved to be unnecessary in the majority of cases, separated any unrelated soils, that might have been compressed into a depression formed as a post hole decayed underground, from post hole fill proper. This method frequently allowed post molds to be revealed in the upper centimeters of a feature, which facilitated proper excavation of the feature.

Feature fill was either water screened or dry screened through 0.635 cm and 0.317 cm mesh screen; and initially, 15 l of soil were also screened through 0.159 cm screen. From each feature, as many as 15 l of soil were collected for flotation, and samples were also collected for phytolithic and pollen analysis.

Interpreting post holes

For a number of reasons, it is often difficult to interpret post hole information, and the features must be very carefully excavated. In scraped areas, the upper portions of post holes usually have been truncated and information critical to documenting the relative chronologies of post hole construction has been lost. The absence of such information can be misleading, as demonstrated in Figure 12.11. In such cases most archaeologists analyze a combination of post hole attributes to identify and interpret individual structures (Bartone & Versteeg, 1997; Curet, 1992; Schinkel, 1991). During analysis of post hole distributions at the Tutu site, consideration was given to interpretive methods applied by Curet (1992); however, his reconstruction of house configurations based on the distribution of "large" or wide post "molds" had no validity at Tutu. At Tutu, radiometric dating proved to be the most useful analytical tool for identification of discrete structures among a myriad of stains and post holes. Post hole depth was the second most important

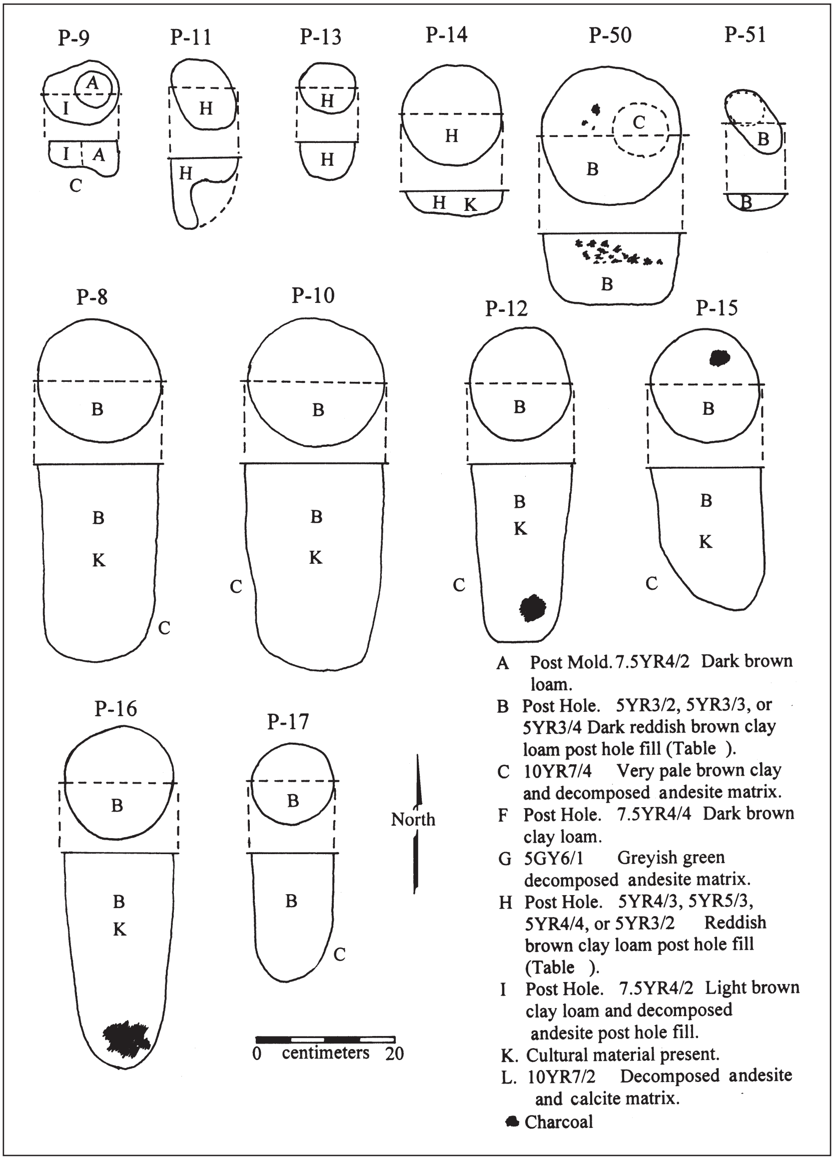


Figure 12.9 Individual excavated post holes of Structure 1 and appendages (P-8 through P-17, and P-50, P-51) in profile (recorded and drawn by David Anderson, graphic by Julie Smith).

interpretive variable (Schinkel, 1992: 151). Other useful analytical tools were unequivocal evidence of one or more structural types for the site, and spacing of post holes according to the type of structure that might be present. (For an extensive discussion of post hole excavation and interpretation, see Schinkel, 1991; 1992: 168, 169; and Bartone & Versteeg, 1997: 28, 29).

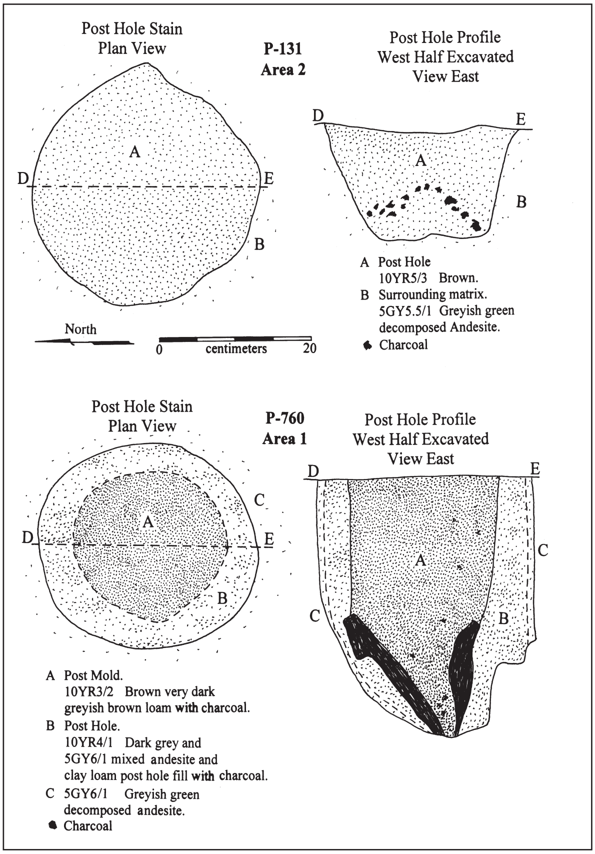


Figure 12.10 Typical charred post ends in plan and profile (P-131 and P-760) (graphic by Julie Smith).

Radiocarbon dating

Radiometrically dated carbon recovered from a burnt or charred post, or wood recovered from actual remains of a post, provides, with a 95 percent probability of being accurate, a range of dates within which carbon was no longer replenished in the living tree. This is usually considered to be an estimate of when a tree was felled for use as a post, and consequently a date for construction of a structure. However, special conditions may affect the reliability with which a radiocarbon date can be applied for such purposes.

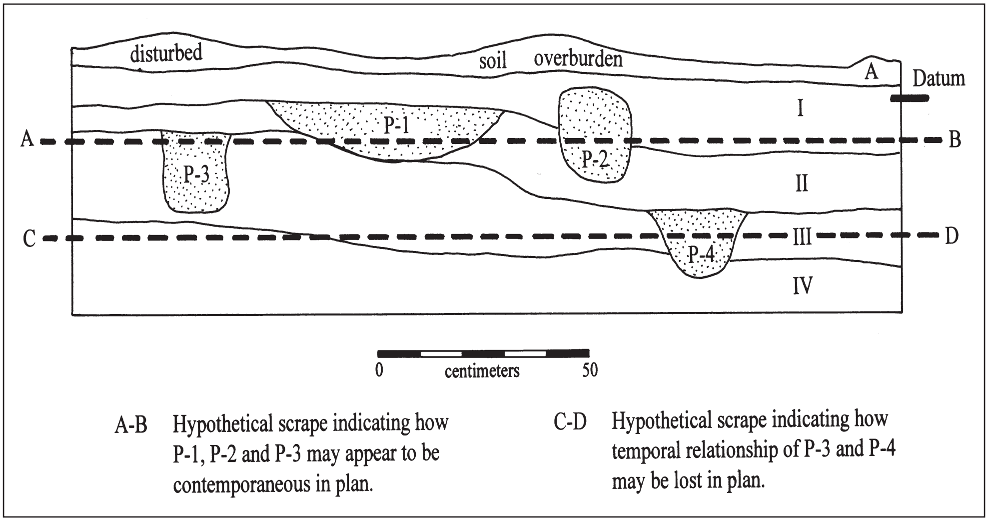
Tree growth is limited to the outer ten or twelve rings of a tree and, as the tree grows, carbon contemporaneous with the outer rings of the tree trunk or limb is ingested while carbon at the interior is stored and not replenished. If a very old tree is felled or an old branch is used for post construction, dates returned on carbon from the interior of the post may be many years older than those for carbon in the outer rings (personal communication, Dr. Ron Hatfield, Beta Analytic Inc.). For this reason, it is important to know the wood type of a sample (whether it is a slow-growing long-lived species, such as lignum vitae), and to know, also, whether inner or outer wood was collected for dating. Ideally, several samples from the same post should be submitted for radiocarbon dating. Because date ranges for post woods are usually wide, other evidence is also necessary in order firmly to establish chronological relationships between structures of a restricted time period.

Forty-four radiometric dates were obtained from charcoal samples recovered from post holes of the Tutu site (see Figures 1.27c and d; Table 12.1). Most samples were fragments of the charred post exteriors, and others were charcoal recovered from post molds. A single sample of uncharred wood also was radiocarbon dated. Many post woods were identified (Chapter 2; Pearsall, 1992) which assisted interpretation of radiometric dates. Financial considerations prevented the extra precaution of dating more than one sample from a feature. Nevertheless, because so many samples were charred wood from post exteriors, it was quite certain that the outer rings were dated, accurately reflecting time ranges after which carbon was no longer replenished in a tree or limb.

FINDINGS

Introduction

With few exceptions at Tutu, the functions of investigated features could be determined by excavation. By the end of the project, 1,375 potential post hole stains had been exposed and mapped; and, of these, 904 had been investigated and recorded. Of the investigated features, 655 (or 72%)



A-B Hypothetical scrape indicating how P-1, P-2 and P-3 may appear to be contemporaneous in plan.

C-D Hypothetical scrape indicating how temporal relationship of P-3 and P-4 may be lost in plan.

Figure 12.11 Schematic diagram showing how loss of post hole origins can obscure post hole relationships (drawing by Elizabeth Righter, graphic by Julie Smith).

were post holes. Other investigated stains were burials, site features or non-cultural stains. A minimum number of tree and plant roots and other intrusions appeared on scraped surfaces, indicating that historic land uses apparently had not seriously affected buried features on the site.

Tutu post molds tended to contain one or more of the following:

1 organic remains of a decayed post itself;
2 charcoal of a charred or burnt post;
3 soil, organic material and other cultural objects that fell into the post mold as the post decayed;
4 terrestrial gastropods and other organisms that post-dated the features and were not part of the prehistoric diet (see Chapter 4);
5 cultural material that leached or drifted into a post mold from the surrounding post hole as the post decayed; or
6 mixed fill resulting from post removal.

In the text of this chapter, unless specified otherwise, the generic reference to a "post hole" includes both the post hole and post mold of a feature.

Charred posts

In Tutu post hole profiles, charred post remnants frequently appeared as

1 charred residue on the exterior lower portion of a post which still occupied a feature;
2 a concentration in the bottom of a post mold;
3 a ring or convex pattern at the bottom of a post mold; or
4 vertical or slanted slashes near one or two sides of a post mold profile (Figures 12.8–12.10).

The pattern of charring was distinct and separate from that observed on burnt post remnants or when charcoal was randomly distributed in a post hole. The discovery of this phenomenon occurred during examination of charred post, P-407A, in Structure 2. When charcoal was

Table 12.1 Radiometric and Accelerator Mass Spectrometry (AMS) dates obtained on charred post wood

Beta no.	*Feature no.*	*Structure no.*	*Calibrated age, 2-sigma or 95% probability*	*Calibrated age, 1-sigma or 68% probability*
Post holes in Area 1				
112967	P-4A	Str 7	AD 1265–1415	AD 1285–1395
108887	P-41A	Str 7	AD 960–1410	AD 1030–1290
108908	P-53A	Str 8	AD 1270–1420	AD 1290–1400
108895	P-54A	Str 8	AD 1305–1445	AD 1395–1425
108910	P-59	Str 7	AD 1295–1470	AD 1325–40 AD 1390–1435
108901	P-61		AD 1215–1405	AD 1265–1310 AD 1365–75
108906	P-77	Str 7	AD 1175–1405	AD 1245–1305
108909	P-78(2)A	Str 7	AD 1025–1515 AD 1585–1625	AD 1225–1425
112969	P-81A	Str 8	AD 1165–1310 AD 1355–85	AD 1220–90
108912	P-82A		AD 415–855	AD 550–685
108900	P-92	Str 8	AD 1300–1650	AD 1405–95
108904	P-101	Str 3	AD 1290–1410	AD 1300–1400
111454	P-103		AD 1170–1315 AD 1345–1390	AD 1225–95
108919	P-111A		AD 600–780	AD 640–90
108885	P-114	Str 7	AD 1225–1400	AD 1270–1305
108894	P-116(2)A	Str 8	AD 1305–1445	AD 1395–1425
108898	P-283A	Str 8	AD 1405–95	AD 1420–55
108905	P-294(1)A	Str 8	AD 1395–1650	AD 1420–1505 AD 1595–1620
112968	P-601A	Str 3	AD 1055–90 AD 1150–1405	AD 1220–1300
108896	P-760A	Str 8	AD 1310–1355 AD 1385–1475	AD 1405–45
108893	P-1763A	Str 7	AD 1025–1400	AD 1175–1295
111456	P-1764A	Str 7	AD 1055–90 AD 1150–1305	AD 1205–85
108921	P-1822		AD 855–1285	AD 980–1215
111463	P-1841	Str 8	AD 1285–1430	AD 1300–1410
108913	P-3063A	Str 8	AD 1310–55 AD 1385–1435	AD 1400–25
108915	P-3078		AD 1410–1650	AD 1435–1520 AD 1570–1630

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Table 12.1 (cont.)

Beta no.	*Feature no.*	*Structure no.*	*Calibrated age, 2-sigma or 95% probability*	*Calibrated age, 1-sigma or 68% probability*
Post holes in Area 2				
108891	P-131A		AD 1180–1410	AD 1250–1310 AD 1365–75
108899	P-146		AD 330–775	AD 430–660
108890	P-192		AD 885–1275	AD 995–1205
108903	P-214A		AD 890–1300	AD 1010–1260
Post holes in Area 3				
43437	P-407A	Str 2	AD 1040–1300	AD 1180–1280
Post holes in Area 4				
108892	P-552	Str 5	AD 655–990	AD 690–890
108911	P-2071A	Str 5	AD 670–990	AD 720–35 AD 760–895
108916	P-2073A	Str 5	AD 620–775	AD 650–690
111458	P-3024A		AD 1205–1300	AD 1245–1290
111460	P-526	Str 6	AD 995–1235	AD 1020–1180
111455	P-531	Str 6	AD 1245–1420	AD 1280–1395
111457	P-535A	Str 6	AD 1290–1435	AD 1305–1420
65469	F-20		AD 640–875	AD 665–780
Post holes in Area 8				
108897	P-830	Str 4	AD 1035–1270	AD 1065–75 AD 1155–1235
108907	P-834	Str 4	AD 1305–1445	AD 1395–1425
112965	P-884A(2)	Str 4	AD 1300–1425	AD 1310–55 AD 1385–1410
Post holes in Area 9N				
42277	P-15	Str 1	AD 1175–1405	AD 1245–1305
112964	P-1067		AD 1250–1395	AD 1275–1305
Post holes in Area 13				
111453	P-3, Tr-1		AD 1020–1245	AD 1035–1205

Note
Except for AMS dates, $^{13}C/^{12}C$ ratios are estimated with an average value value of –25.0°/oo.

removed from the exterior of its tip, marks left by tools that felled the tree and shaped the post tip were present, confirming that intentional charring took place after the tree was cut and the post tip was shaped.

One purpose of such charring, especially of resinous woods, such as lignum vitae, might be to bring resins to the surface of the wood to create a protective coating (personal communication, Dr. Lee Newsom) that would strengthen the underground portion of the post, protecting it from

Figure 12.12a Aerial view of scraped portion of Area 3, after excavation of Structure 2. View east (photographs by Elizabeth Righter).

Figure 12.12b Aerial view of scraped portions of Areas 1, 2 and 9N with stains and posts of Structure 1 in foreground. View northeast (photographs by Elizabeth Righter).

rot, wood boring insects and other destructive pests. Charring technology, if recognized at other Caribbean sites, may have other interpretive applications as well.

Terrestrial gastropods

Frequently, at Tutu, especially in Area 3, Structure 2, there were instances when great numbers of terrestrial gastropod shells, the most abundant of which were the sublinid snail, *Opeas pyrgula*, were recovered from sealed contexts in post hole fill, even though no post mold or other visible faunal or cultural material was present. Little is known of the habits, preferred habitats or diets of these animals in the Virgin Islands (personal communication, Dr. Elizabeth Wing, Curator, Florida Museum of Natural History, and Michael Russo, Environmental Specialist, National Park Service), but the animals are not known to have burrowing capabilities. It would appear that the animals may have traveled along a post as it rotted, feeding on micro-organisms in the decaying post, dying, and becoming sealed in a feature. If such is the case, concentrations of terrestrial gastropods in a post hole might indicate an otherwise undetected post mold. Findings at Tutu suggest that further study of terrestrial gastropods and their habits may reveal a useful interpretive tool for archaeologists.

Documenting Tutu structures

At the Tutu site, post holes of Structures 1 and 2 (two very clearly defined structures) isolated from any adjacent or interrupting post holes, stood out clearly against the scraped subsoil (Figures 12.12, a and b). Appendages also were clearly defined. Post holes of three other structures either could be seen clearly in pale subsoil or were identified by the configuration of their outer walls. After post hole analysis, Structures 3, 7 and 8 were identified. Structures 7 and 8 spatially overlapped each other in Area 1, an area crowded with post holes (Figures 1.7, a–d). Many 2-sigma date ranges for their post wood samples also overlapped. To separate post holes of the two structures, the first step was to identify post holes with mutually exclusive 2-sigma date ranges. Once these were identified, patterns of vacant space in relation to posts were analyzed (Versteeg, 1997).

Table 12.2 Stain and post hole attributes; Structures 1–8

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
Structure 1: exterior post holes								
P-10		20	30	11	2		58.91	
P-11		9 × 10	10	3	0		58.93	
P-12		14	26	26	5	present	58.79	CP
P-13		8	5	0	0		58.76	
P-14		16	3	1	369 (clay)		58.78	
P-15	See Tab. 12.1	16 × 17	21	14	4	present	58.77	CP
P-16		16 × 17	32	<1	0	present	58.71	CP
P-17		12	18	54	125	present	58.60	
P-47		33	15	0	0		58.58	
P-49		15	16	5	0	present	58.65	CP
Structure 1: unexcavated stains								
18		12					58.57	
19		14					58.54	
20		15					58.55	
21		12					58.52	
22		26					58.52	
23		20					58.44	
24		17					58.47	
25		7					58.45	
26		15					58.48	
27		14					58.48	
45		18					58.54	
46		9					58.58	
48		8					58.61	
Structure 1: northeastern extensions: post holes								
P-8		18	28	59	64	present	58.95	
P-9A		6	4	0	0	present	58.94	CP
P-9B		10	4	0	0		58.94	
P-50		20	10	?	0	present	58.75	CP
P-51		7 × 9	2	0	0		58.79	
Structure 1: southeastern extension: post holes								
P-34		30	28	0	0		58.48	
P-31(1)		19	10	0	0		58.52	
Structure 1: southeastern extension: unexcavated stains								
28		12					58.53	
29		26					58.49	
30		18					58.55	
32		15					58.50	
33		19					58.47	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
Structure 2: exterior post holes								
P-400		32	14	8	0		60.65	
P-401		52	62	58	225	present	60.73	CP
P-402(1)		16	28	0	0	present	60.70	CP
P-402(2)		40	50	51	81		60.71	CP
P-403		18	11	0	0		60.77	
P-404		20	9	2	3		60.75	
P-406(1)		17	44	6	2		60.76	
P-406(3)		16	4	0	0		60.76	
P-411		25 × 29	41	883	393	present	60.52	
P-417		23 × 21	27	3	1	present	60.48	
P-418		18	18	<1	6		60.57	
P-421		20 × 17	21	<1	1	present	60.80	
P-423		16	7	0	0		60.59	
P-424		20 × 18	25	4	32		60.70	
P-425		20	3	1	0	present	60.58	
P-426		22	10	0	0		60.79	
P-427(1)		27	47	2	0		60.55	
P-427(2)		15	8	0	0		60.58	
P-428		12	7	0	0		60.56	
P-460		22	20	0	0	present	60.38	
P-462		54	47	2	0		60.49	
P-463(2)		40	19	0	0	present	60.40	
P-464A		20	22	5	0	present	60.44	
P-464B		37	37				60.44	
P-465		31	31	8	27		60.51	
P-467A		14		0	0	present	60.37	CP
P-467B		24	7	8	0		60.37	
P-468		30	21	1	0	present	60.37	
P-469		36	16	1	0	present	60.39	
P-470		18	13	0	0	present	60.37	
P-472		20	13	6	0	present	60.37	
P-473		20	18	2	0		60.37	
P-474A		14	20	3	0		60.20	
P-474B		47 × 31	40	3	16		60.20	
P-475(1)		25	14	19	5		60.56	
Structure 2: central post holes								
P-407A	See Tab. 12.1	24	130	8	19	present	60.76	CP
P-407B		63	130	71	64	present	60.58	
P-410A		20	121	6	4	present	60.61	CP
P-410B		60	121	11	25	present	60.61	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
P-413A		18	88	8	4	present	60.48	CP
P-413B		44	88	14	99	present	60.48	
P-419A		21	110	16	39	present	60.62	CP
P-419B		60 × 79	114	59	181	present	60.62	
P-466A		20	51	1	3	present	60.51	CP
P-466B		42	51	3	19	present	60.51	
Structure 2: stains that were not posts								
xP-402(3)		30	2					
xP-406(2)		30	5					
xP-406(4)		13	5					
xP-412		7	11					
xP-414		26	4					
xP-415		25 × 14	3					
xP-416		10	2					
xP-420		64 × 56	8					
xP-422		12 × 16	3					
xP-429		8	2					
xP-461		24	5					
xP-463(1)		20	5					
xP-471		27 × 15	5					
xP-475(2)		62 × 53	40					
xP-476		25	8					
Structure 5: exterior post holes								
P-547		34	54	11	0	present	59.41	
P-550		30	55	11	19		59.28	
P-551		69 × 60	37	32	19	present	59.22	
P-552	See Tab. 12.1	40 × 30	44	335	274		59.25	CP
P-582		45	42	20	0		59.29	
P-590		45	45	2	0		59.30	
P-2070		33	46	15	0	present	59.41	
P-2071A	See Tab. 12.1	16	65	0	0	present	59.41	CP
P-2071B		40	65	323	217	present	59.32	
P-2073A	See Tab. 12.1	18	62	0	0	present	59.29	CP
P-2073B		48	62	41	180		59.29	
P-2503A		26	50	3	0		59.45	
P-2503B		50 × 26	50	20	4	present	59.45	
P-3003		26	32	26	0		59.34	
P-3002		20	25	0	0		59.35	
P-3008		24	27	5	5		59.38	
P-3090		22	37	0	0		59.30	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
Structure 5: interior post holes								
P-2501		19.5	13	7	0	present	59.27	
P-2502		20 × 23	20	0	0		59.32	
P-3000		20	30	0	0		59.30	
P-3001		18	18	0	0		59.30	
P-3014		14	20	0	0		59.30	
Structure 5: investigated stains that were not post holes								
xP-548		30 × 20	7	0	0		59.31	
xP-549		40	26	3	3		59.24	
xP-591		40	3	0	0		59.30	
xP-3007		20	15	0	0		59.40	
Post holes adjacent to Burial 20								
P-3005		16	6	0	0		59.65	
P-3024A	See Tab. 12.1	12	12	0	0	present	59.70	CP
P-3024B		30	15	1	0		59.70	
Unexcavated stains adjacent to Burial 20								
3004		20					59.60	
3006		12					59.35	
Structure 6: exterior post holes								
P-523		40	39	41	0	present	59.24	
P-524A		20	35	900	0		59.18	
P-524B		35	50	5	0		59.18	
P-525		20	43				59.18	
P-526	See Tab. 12.1	15	30	2	0	present	59.26	
P-527		17	11	1	0	present	59.27	
P-528		27	31	1	0	present	59.24	CP
P-528 (Slide)		63 × 35	13	2	0		59.24	
P-529(1)		24	41	0	0		59.23	
P-529(2)		52 × 40	36	0	0		59.24	
P-533		23	5	<1	0		59.23	
P-534		21 × 25	39	6	75		59.25	
P-535A	See Tab. 12.1	12	15–20	0	0	present	59.26	CP
P-535B		25 × 17	25	2	1	present	59.26	
P-536		23	11	1	0		59.29	
P-540		31	54	2	0	present	59.24	
P-541		20	4	0	0	present	59.25	
P-541 (Slide)		44 × 25	26	43	8		59.25	
P-542		17	30	2	0		59.29	
P-544		19	16	24	0		59.38	
P-545		26	7	0	0		59.35	
P-546		32	8	<1	0		59.36	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
P-576		30	13	<1	0	present	59.29	
P-584		38	8	1	0		59.22	
Structure 6: interior post holes								
P-530		38	38	3	0		59.23	
P-531	See Tab. 12.1	20	20	4	4		59.25	
P-537		36	12	2	0	present	59.30	
P-539		35 × 22	44	6	3		59.29	
P-583		26	20	5	0		59.34	
Structure 6: excavated stains that were not post holes								
xP-522		22	2	50	0		59.22	
xP-532		14	—	0	0		59.26	
xP-538		2	—	—	—		59.32	
xP-577		10	2	<1	0		59.28	
xP-578		15	4	—	—		59.31	
xP-579		30 × 40	10	—	—		59.28	
Structure 3: exterior post holes								
P-83		22	16	5	0		59.86	
P-84		30	41	36	3	present	59.85	
P-85A		15	27	1	0	present	59.99	
P-85B		30	27	0	0	present	59.99	
P-86		16	22	4	0	present	59.72	
P-100(1)		34 × 22	7	<1	0		60.32	
P-623		25	12	13	39		61.25	
P-2023		22	10	<1	4		61.36	
Structure 3: interior post holes and stains								
P-101	See Tab. 12.1	30	12	5	25	present	60.25	CP
P-102		25	16	0	0		60.70	
P-601A	See Tab. 12.1	12	15	0	0	present	60.99	CP
P-601B		25	15	3	28		60.99	
P-608A		10	21	0	0		60.38	
P-608B		20	28	<1	0		60.38	
P-609		21	48	0	0	present	60.21	
1800		24					61.00	
P-2032A		20	52	0	0	present	60.38	
P-2032B		60	52	0	0		60.38	
Structure 3: unexcavated exterior stains								
780A		16					59.80	
780B		30					59.50	
1801		25					60.91	
1802		15					60.97	
1803		20					60.95	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
1805		15					60.96	
1806		15					60.92	
1807		12					60.91	
1808		16					60.99	
1809		12					60.92	
1810		18					60.93	
1811		23					60.92	
1815		30					60.96	
1816		20					60.93	
1817		20					61.21	
1818		20					61.13	
1848(1)		45					61.41	
1852		23					61.48	
1854		12					61.50	
1855		12					61.50	
1857		20					61.43	
2018		26					61.10	
2019		20					60.97	
2020(1)		22					60.93	
2020(2)A		20					60.97	
2020(2)B		30					60.97	
2021		20					61.19	
2022		24					61.49	
2029		15					51.53	
2030		25					61.53	
2031		33 × 23					61.49	
2049		15					60.26	
2050		25					60.26	
2051		10 × 15					60.01	
2054		18					59.80	
2302		15					59.81	
Structure 3: excavated stains that were not post holes								
xP-1814		20	2	0	0		60.93	
xP-2024		20	6	0	0		61.42	
xP-2028		18	10	0	0		61.49	
Structure 8: exterior post holes								
P-53A	See Tab. 12.1	18 × 20	77	381	529	present	59.62	
P-53B		54	77	1066	954		59.62	
P-54A	See Tab. 12.1	11	23–38	0	0	present	59.19	BP
P-54B		43	43	20	0		59.19	
P-67(2)		57 × 62	40	20	<1		58.80	

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Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
P-81A	See Tab. 12.1	20	8	0	0	present	59.79	BP
P-81B		37	23	4	3		59.79	
P-87		30	35	7	0		59.80	
P-88		40	18	25	8		59.89	
P-89A		16	30	0	0		59.92	
P-89B		22	35	5	7		59.92	
P-90A		20	28	0	0	present	59.92	
P-90B		28	42	174	223	present	59.92	
P-91(1)		24	23	12	23		60.01	
P-92	See Tab. 12.1	25	32	296	194	present	60.02	
P-116(1)		30	11	162	228		59.01	
P-116(2)A	See Tab. 12.1	20	68	0	0	present	59.01	
P-116(2)B		42	68	108	204	present	59.01	
P-630		23	45	13	5	present	59.33	
P-760A	See Tab. 12.1	16	32	0	0	present	59.23	CP
P-760B		30	32	74	61		59.23	
P-1841	See Tab. 12.1	40	54	254	197	present	59.61	
P-1878		24	24	0	73		59.01	
P-1911		70 × 80	68	26	217		59.98	
P-1915		54 × 63	43	813	761	present	59.52	
P-1916		60 × 80	32	218	220	present	59.52	
Structure 8: possible interior post holes								
P-76		20 × 30	76	2	1		59.35	
P-105A		17	27	0	0	present	59.63	
P-105B		30	38	26	7		59.63	
Structure 8: unexcavated stains								
1780		46					59.25	
1812		20					60.87	
1813		18					60.85	
1819		20					60.87	
1820		20					60.81	
1821		18					60.74	
1840		28					59.57	
1843(2)		14					59.81	
1881(1)		15					58.93	
1891		40					58.93	
1910		27					59.22	
1922		12					59.67	
Structure 8: appendage post holes and stains								
93		15	Unexcavated					
P-94		31	47	265	9	present	59.00	

(continued on next page)

Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
P-294(1)A	See Tab. 12.1	20	50	21	0		59.89	
P-294(1)B		48	54	54	176	present	59.89	
P-770		48	38	34	18		60.01	
1901		25					60.02	
Structure 8: entrance appendages								
P-283A	See Tab. 12.1	20	62	0	0	present	59.07	
P-283B		33 × 37	62	10	28		59.07	
P-1868		24	42	28	4		58.92	
P-3063A	See Tab. 12.1	20 × 30	45	2	0	present	59.10	
P-3063B		40 × 75	27	60	22		59.10	
Structure 7: exterior post holes								
P-3		45 × 33	54–112[a]	2771	83		59.10	CP
P-4A	See Tab. 12.1	19	20	0	0	present	59.15	CP
P-4B		38	22	6	8		59.15	
P-41(1)A	See Tab. 12.1	30	10	—	—	present	59.00	
P-41(1)B		30	47	29	67		59.00	CP
P-65(1)A		20	44	0	0	present	59.22	
P-65(1)B		40	44	1	0		59.22	
P-75		35	51	11	64		59.40	
P-77	See Tab. 12.1	50 × 70	58	191	298	present	59.35	
P-78(2)A	See Tab. 12.1	20	35	—	—	present	59.35	
P-78(2)B		50 × 30	35	192	126		59.35	
P-114	See Tab. 12.1	43	83	243	243	present	59.03	
P-117A		18	36	0	0	present	59.03	
P-117B		45	36	230	92		59.03	
P-1704		24	33	48	109		59.23	
P-1764A	See Tab. 12.1	20	52	0	0	present	59.35	
P-1764B		55	52	74	22		59.35	
P-1768		30	10	58	57		60.04	
P-1788		20	24	12	4		60.27	
P-1794		50	45	n.d.	n.d.		59.42	
P-1868		24	42	28	4		59.92	
P-2033		46	52	0	0		60.43	
P-3026		40	60	4	0		50.10	
P-3030		46	54	157	105		59.39	
P-3031		37	40	<1	1		60.41	
Structure 7: unexcavated stains								
1759		30					60.41	
1906		30					59.23	
3047		24					60.43	

(continued on next page)

Table 12.2 (cont.)

Feature no.	*Date*	*Surface width (cm)*	*Depth below scraped surface (cm)*	*Faunal weight (g)*	*Ceramic weight (g)*	*Charcoal*	*Elevation above mean sea level (m)*	*Charred post/burned post (CP/BP)*
Structure 7: central posts								
P-59	See Tab. 12.1	40 × 70	96	98	292	present	60.17	
P-1763A	See Tab. 12.1	20	20–30	—	[b]	present	50.28	
P-1763B		80 × 100	92	6	5[b]		50.28	
P-1798A		20	88	0	0	present	58.92	
P-1798B		60 × 140	88	52	36		58.92	
Structure 4: exterior post holes								
P-829		20	12	0	0		62.97	
P-830	See Tab. 12.1	24	17	<1	61		63.00	
P-832		21	16	<1	0		62.85	
P-833		24	17	1	78		62.50	
P-834	See Tab. 12.1	24	16	<1	7	present	62.57	
P-837		30	20	0	0		62.79	
P-852		18	13	0	0		62.79	
P-886		20	10	0	0		62.87	
P-887		30	20	0	0		62.96	
P-888		40	9	0	0		62.94	
Structure 4: unexcavated stains								
828							62.94	
831							62.83	
835							62.50	
836							62.71	
838							62.50	
840							63.08	
889							63.23	
890							63.12	
Structure 4: extension post holes								
P-884A(1)		10	8	0	0	present	62.83	
P-884A(2)	See Tab. 12.1	12	20	<1	0	present	62.83	
P-884B		15 × 20	20	3	0		62.83	
Structure 4: extension, unexcavated stains								
839							62.57	
880							62.52	
881							62.59	
882							62.56	
883							62.57	
885							62.57	

Notes

Types include radiometric standard or AMS (Accelerator Mass Spectrometry): 2-sigma = 95% probability, 1-sigma = 68% probability.

xP = not a post.

[a] burial in top 54 cm.

[b] sherds of disturbed burial not included.

Finally, radiocarbon dates, post hole attributes and spatial patterning of remaining features were analyzed to reveal the configuration of each structure.

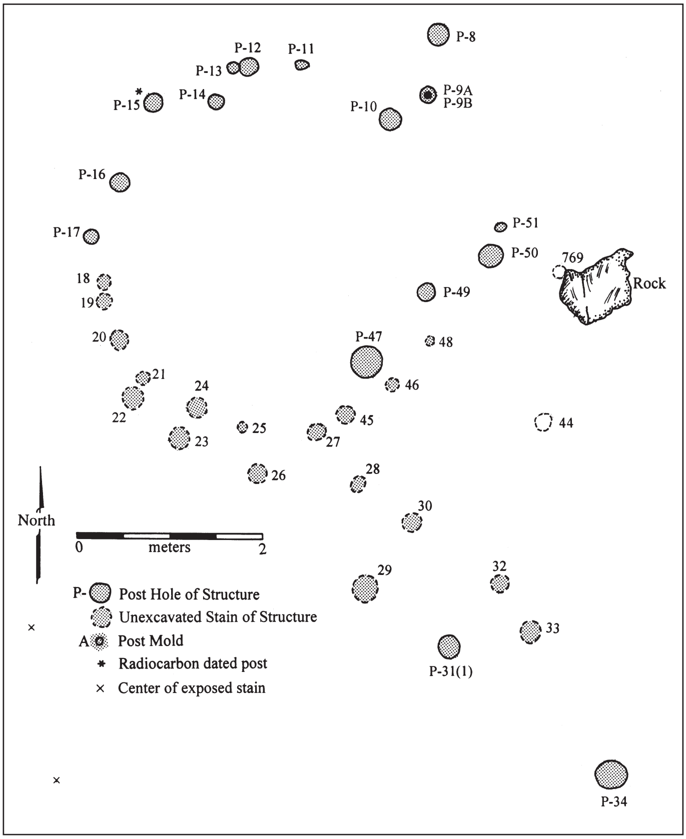

Figure 12.13a Plan view of post holes and stains of Structure 1 and appendages (composite of information mapped manually by Elizabeth Righter and David Anderson; and, in Autocad, by Travis Gray and Cameron Scobie. Diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

The Tutu structures

Introduction

Eight individual structures, one from the early occupation (Structure 5) and seven from the late (Structures 1, 2, 3, 4, 6, 7 and 8), were identified at the Tutu site. The single early occupation structure was round in shape, with deep outer post holes and shallower posts in the interior. Six of the seven late Ostionoid structures were either oval in shape, with interior post holes, round without interior post holes or round with deep central posts. A seventh late occupation structure was incomplete, and was either round or oval with deep central posts. The exposure of numerous other post holes and stains on the site indicates that the full extent of site development was not represented. Additionally about one-half of the probable habitation area was not scraped.

The two most clearly defined structures, Structures 1 and 2 (Figures 12.5, 12.7, 12.12a and b), were investigated and recorded by a team of archaeologists from the Southeastern Regional Office of the National Park Service. The confidence level of this documentation is excellent. Because, at Tutu, most post hole points of origin were lost, it is probable that some shallow structural post holes were scraped away by heavy equipment. This likelihood especially applies to Structures 4 and 6. It also is possible that interior post holes of some structures, such as Structures 3 and 5, may include superimposed post holes of another phase of construction.

Structures identified at the Tutu site are discussed below, in descending order according to the confidence level of identified configurations. Post hole attributes for Tutu structures are listed in Table 12.2. All post hole and post mold depths are those measured below the surface of machine scraped soils; horizontal measurements were taken on the scraped soil surface.

Structure 1

Overview

In Area 9N, a clearly defined circular pattern of dark stains, and alignments of appended post holes, stood out against the scraped subsoil. The configuration was at least 2 m from the nearest unrelated stain.

Twenty-three stains comprised the outer circle of Structure 1, and 11 additional stains were appended to it (Figures 12.13a and b). There was no central post hole stain. Appending stains consisted of two features: one composed of 7 stains, in a double row that extended in a southeasterly direction from the south wall of Structure 1; and another which consisted of two rows of 2 stains each, about 1.75 m apart, projecting from the northeastern perimeter of the outer circle of stains.

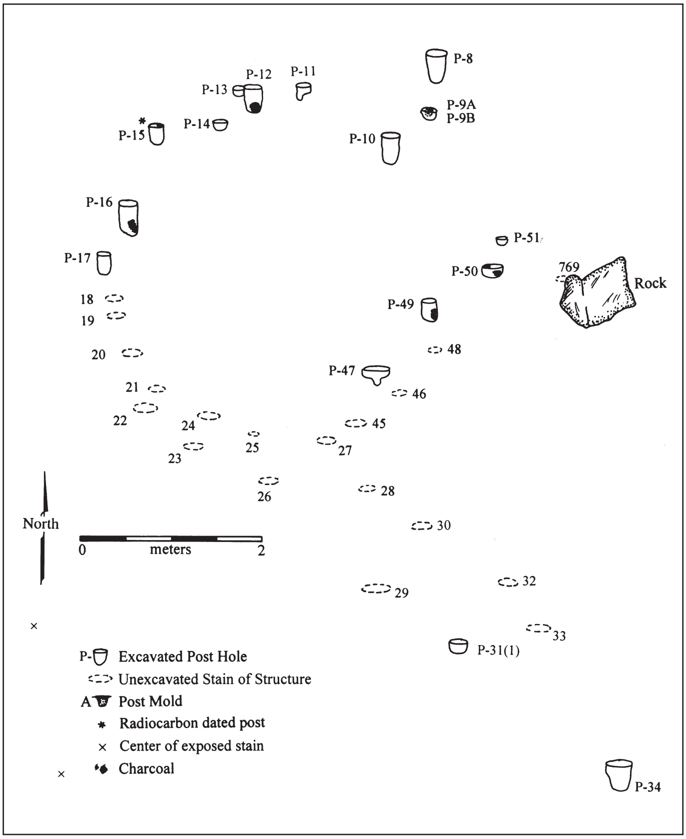

Figure 12.13b Schematic diagram of Structure 1 and appendages, showing post holes to scale in profile (composite of information mapped manually by Elizabeth Righter and David Anderson; and, in Autocad, by Travis Gray and Cameron Scobie. Diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

Sixteen stains were excavated (Figure 12.13b): 10 in the outer circumference of the structure and 6 in appendages. Fourteen stains were determined to be definite post holes, and another 2, P-47 and P-51, were less reliably identified as post holes, but were accepted as such (Table 12.2). Among excavated stains, the deepest post holes were interspersed with shallower post holes. Charcoal of a charred post remnant in P-15 returned a date of between cal. AD 1175 and cal. AD 1405 (2-sigma, Beta 42277) (Table 12.1). This range overlaps with that for all late period structures (Table 12.3) and most late period dated posts in Areas 1, 2, 4, and 9N. No burials were found in close proximity to Structure 1.

Post holes and stains in the outer circle of Structure 1

Figure 12.9 depicts twelve excavated post holes of Structure 1. Vertical charcoal stains and basal charcoal concentrations indicate intentional charring of post tip exteriors. In the majority of excavated post holes, the ratio of post hole diameter to post hole depth, and the shape of the post hole base, indicated a tight fit between posts and post hole walls. Average excavated post hole depth in the main structure was 17.60 cm below the scraped surface (bss). Post hole and stain diameters ranged between 8 cm and 33 cm (Table 12.2).

Fill of P-14 consisted almost entirely of lumps of hard clay (369 g), a site anomaly which may have been an intentional clay cache. A general variability in the amount of cultural debris in

Table 12.3 Chronological relationships between structures, burials and dated posts

Structure	*Burials with overlapping 2-sigma date ranges*	*Probably related burials*	*Posts with overlapping 2-sigma date ranges*	*Structures with overlapping 2-sigma date ranges*	*2-sigma date ranges*	*Number of related burial areas*
1	1, 2, 6, 9, 11, 12, 19, 22B, 26, 29, 30, 31, 33, 38	None	P-103, 131, 214, 1067, 3024, P-3 in Tr-1	2, 3, 4, 6, 7, 8	AD 1175–1405	0
2	1, 9, 19, 22B, 26, 29, 38	22A, 22B	P-61, P-103, P-131, P-192, P-214, P-1067, P-1822, P-3024, P-3 in Tr-1	1, 3, 6, 7, 8	AD 1040–1300	1
3	1, 2, 6, 9, 11, 12, 19, 20, 22B, 26, 29, 30, 31, 33, 38	6, 29	P-61, P-103, P-131, P-214, P-1067, P-3024	1, 2, 4, 6, 7, 8	AD 1290–1405	1
4	1, 2, 6, 8, 9, 11, 12, 20, 30, 31, 33	33, 34	P-61, P-103, P-131, P-1067, P-3078	1, 3, 6, 8	AD 1305–1425	1
5	4/7, 16, 23B		P-82, P-111, P-146, F-20	F-20	AD 670–775	0
6	1, 2, 6, 9, 11, 12, 19, 20, 22B, 26, 29, 30, 31, 33, 38	9, 40	P-61, P-103, P-131, P-214, P-1067, P-3024, P-3078	1, 2, 3, 4, 7, 8	AD 1290–1420	2
7	1, 6, 9, 12, 19, 22B, 26, 29, 30, 33, 38	38?	P-61, P-103, P-131, P-214, P-1067	1, 2, 3, 6, 7	AD 1295–1400	1?
8	1, 2, 5, 6, 8B, 11, 12, 19, 20, 26, 30, 31, 33, 38	5, 8A, 8B 11, 31, 38?, 39	P-61, P-131, P-3078	1, 3, 4, 6, 7	AD 1395–1445	2

remaining post holes suggests that refuse was unevenly distributed on the ground surface when Structure 1 was erected.

Appendages

Single alignments of two excavated post holes each flanked an open span on the northeast circumference of the structure. On the south side of Structure 1, 7 stains and post holes were aligned to form a narrow southeastwardly-projecting corridor with 4 stains on the northeast side, 2 on the southwest side and 1 at the southeastern tip. Of these stains, P-31 (1) and P-34 were excavated. Appendage stains were not interrupted or clouded by other stains and their pattern was very clear.

Interpretation

The spacing of deep post holes in the circumference of Structure 1, and the absence of a center post hole, suggest that its roof was conical or rounded (beehive-shaped), and side walls were closed-in, constructed of mats or interwoven thatch, twigs, vines or other material. Depths of shallow post holes on the outer circle of the structure suggest that side walls were not high, with the roof a short distance from the ground (Figure 12.14). Major members, beams, and rafters, would have been lashed together (Schinkel, 1992: 150).

The north–south interior width of the structure circle was 4.15 m, while the east–west dimension was 3.60 m, indicating a small interior area of about 12 m^2. Using Schinkel's formula, the diameter of the structure was multiplied by 0.80 to provide a roof height of 3.10 m for Structure 1 (Schinkel, 1992: 192).

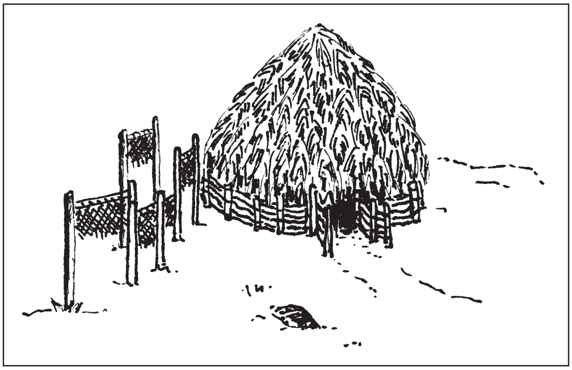

Figure 12.14 Artist's rendering of the possible appearance of Structure 1 and appendages; drawn to scale based upon the post hole plan (created by Julie Smith, re-interpreted by Elizabeth Righter and redrawn by Monique Purguy).

A span, 1.75 m wide, on the northeastern side of the outer Structure 1 circle was interpreted as an entrance. Projecting post holes on either side of the entrance probably supported a protective framework, perhaps either a portico or parallel fences of posts with interwoven branches, palm fronds, sticks or mats (Figure 12.14). Post holes and stains extending from the south side of the structure suggest an intentional division of exterior space for one or more specific purposes, both practical and ideological (Versteeg, 1991).

A corridor between the post holes of the southeastern appendage may indicate a passageway to a rear entrance on the structure.

Structure 2

Overview

When discovered, Structure 2 first appeared as an outer ring of 43 distinct dark stains and 9 stains that formed no clear pattern in the interior. The stains contrasted markedly with surrounding pale soils of decomposed andesite. There was no indication of intrusive prehistoric or historic human activity.

Of the 52 investigated stains, 15 (or 28%) were non-cultural anomalies, leaving a total of 32 true post holes in the outer ring and 5 in the interior. Four of the large interior post holes formed a rectangular pattern, and a fifth was situated just south of P-413. Despite some irregularities on the outer wall of Structure 2, there was a general cohesion to the structural configuration and the integrity of the post hole pattern was excellent. Alignments of two post holes each flanked an eastern opening in the structural wall, and there was a detached arc of stains and post holes north of the Structure (Figure 12.5).

Figure 12.15 Aerial view of Structure 2 after excavation. View southeast (photograph by David Anderson).

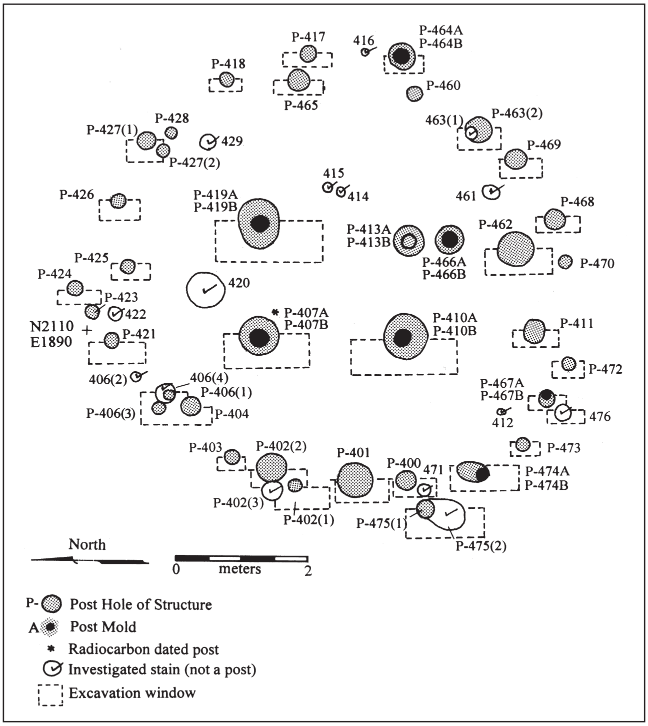

Figure 12.16a Plan view of post holes and stains of Structure 2, showing also stains that were not features of the structure (recorded manually by Ken Wild, and in Autocad by Travis Gray, graphic by Julie Smith).

Post molds, when present, were easily distinguished from post holes; some appeared as rings of charcoal surrounding dark cores of decayed organic material and fine gravel. During archaeological excavation, a "window" was opened outside the western edge of each deep post hole (Figures 12.15, 12.16a) to allow archaeologists access to a deep feature for recording and, occasionally, removal.

Except for P-411, an anomaly which had been intentionally backfilled with large ceramic sherds and 883 g of faunal refuse, Structure 2 post hole fill generally consisted of a fine gravel of greyish brown parent subsoil (Munsell color 10YR3/2), charcoal bits, very tiny fragments of faunal material, an occasional small ceramic sherd and concentrations of terrestrial gastropods. These last clusters were interpreted to mean that a post had rotted in place.

Nineteen post holes contained charcoal which included 9 charred post ends (Figure 12.16b). Three charcoal samples and one wood sample from posts of the interior central rectangle (P-407A, P-410A, P-413A, and P-419A) were identified as carbonized *Guaiacum* (lignum vitae), while P-466A (in the interior), P-463(2) and P-410 were *Acacia* wood (see Chapter 2; and Greg Miller, USDA Soil Conservation Service, personal communication).

Remnants of central post P-407A in Structure 2, had a date range of between cal. AD 1040 and cal. AD 1300 (2-sigma, Beta 43437), providing a time frame for this outstanding example of Virgin Islands prehistoric architecture. This time frame overlaps with the 2-sigma overlap for late period Structures 1, 3, 6 and 7 and with late period single posts in Areas 1, 2, 4, 9N and 13 except P-3078 in area 1 (Table 12.3).

Double infant burials, 22A and 22B, located about 3.5 m north of Structure 2 and 2.75 m south of a detached arc of post holes (Figure 12.5), provided a 2-sigma AMS date range of between cal. AD 1275 and cal. AD 1310 and between cal. AD 1365 and cal. AD 1375 (Beta 83005), indicating a likely association with Structure 2.

The outer circle of post holes

Post holes of the outer circle, generally shallower than central post holes, ranged in depth between 14 cm and 62 cm bss. The 11 deepest post holes were spaced more or less regularly around the perimeter of the structure. Twenty-one of the outer post holes were almost uniform in width from the scraped ground surface to their rounded bases, and others were gently tapered with rounded bases. None of the outer circle post holes contained rocks to support a post.

In the southern half of the outer circle, distances between deep post holes were not as uniform as in the northern half, but spacing between large and small posts was more regular. Shallow post holes tended to be placed between deeper post holes rather than grouped around them. Structure 2 could be divided into quadrants, with imaginary lines or corridors bisecting the structure in north–south and east–west directions. Openings in the outer wall were apparent at the ends of corridors on the south and east sides, with a rear opening providing access to the burial area north of the structure.

Central post holes

Exposed surfaces of deep central post holes ranged in width between 42 cm and 79 cm. In 3 cases, post hole surfaces were more than twice as wide as post molds; and, in 2 cases, they were three times as wide. Post holes tapered to pointed bases, where post ends were wedged into subsoil. Except in P-466, large flat rocks were wedged between posts and walls of central post holes. Probably because of pre-1990 machine scraping, there were no "slides" or small troughs at the tops of the central post holes to ease insertion of heavy posts.

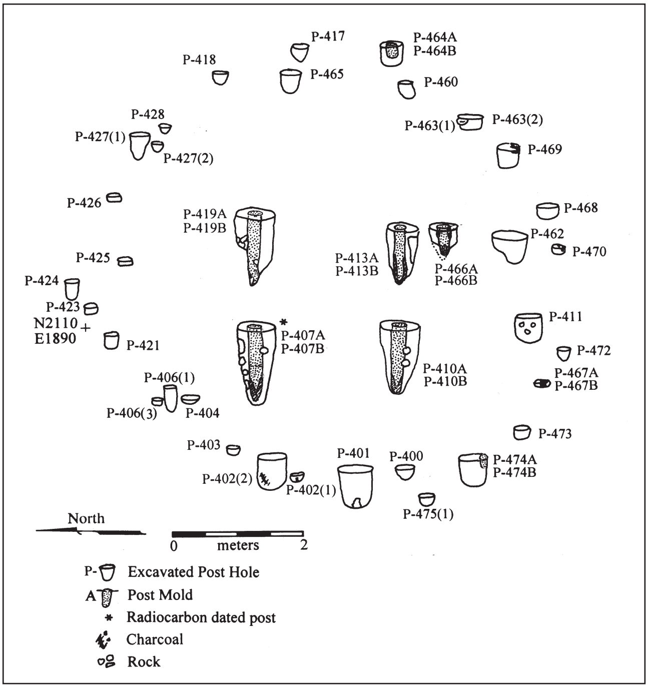

Figure 12.16b Schematic diagram of Structure 2, showing post holes to scale in profile (recorded manually by Ken Wild, and in Autocad by Travis Gray, graphic by Julie Smith).

A remnant of actual wood post, preserved in the bottom of P-407 (Figure 12.17), was recovered in its entirety by NPS archaeologists, David Anderson, Ken Wild and Douglas Potter. The thickest end of the post remnant, 23 cm in diameter, was hollow for a length of about 10 cm. Rotted wood and fibers filled the hollow, but the remaining 50 cm of the post were solid and tapered to a point. The exterior of the post tip was encased in a shell of protective charcoal, under which was a firm wood tip that retained marks of the instrument used to fell the tree and shape the point. The more than 800-year-old wood was extremely hard and dense, confirming that conditions for preservation of buried wood were excellent in this portion of the Tutu site, and perhaps also attesting to the efficacity of exterior charring of post tips.

Profiles of central post holes P-407, P-410, P-413 and P-466 are shown in Figures 12.18–12.21.

Figure 12.17 Lignum vitae post remnant recovered from P-407 of Structure 2 (photograph by Elizabeth Righter). Exterior charcoal has been removed revealing marks of instrument that shaped the post point.

Related detached feature and appendage to structure 2

An arc composed of 7 post holes and stains was located north of Structure 2; and on the eastern side of the structure, a single post hole projected from each side of an opening.

Interpretation

Shallow post holes between deeper post holes of the Structure 2 periphery indicate smaller posts between framing members and suggest that side walls did not rise far from the ground and were closed in. A circular configuration and deep central post holes suggest a tall conical roof (Figure 12.22). Revised dimensions of the interior circle of Structure 2 are 6.75 m in a north–south direction, and 6.40 m in an east–west direction (Righter & Lundberg, 1991). An average interior diameter of 6.58 m provides an area of about 34 m^2 and an estimated roof height of 5.26 m (Schinkel, 1992: 192). The floor of the structure and any extant interior hearths had been lost during pre-1990 scraping.

Post hole alignments flanking an entrance on the east side of the structure were the only appendages observed. A detached arc of post holes and stains north of the structure appeared to have supported a fence that marked the northern limit of a burial area that contained a double infant burial. An absence of adult burials associated with Structure 2 suggests that it may have been occupied for less than a generation.

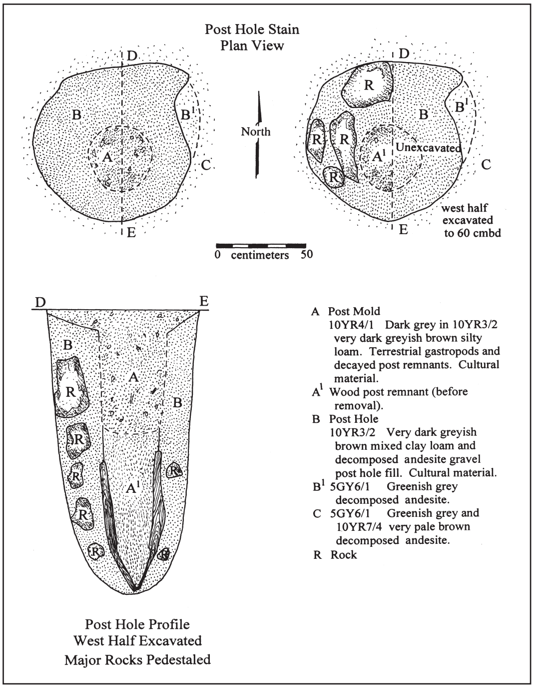

Figure 12.18 Surface plan view, plan view after partial excavation, and profile of P-407, central post hole of Structure 2, after excavation of west half (field drawings re-drafted by Sean Krigger, graphic by Julie Smith).

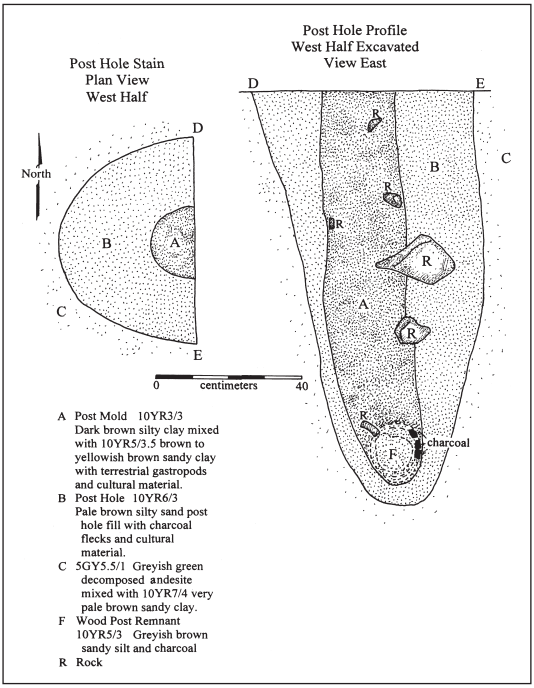

Figure 12.19 Plan view of P-410, central post hole of Structure 2, and east profile of post hole after excavation of west half (field drawing redrafted by Sean Krigger, graphic by Julie Smith).

A predominance of subsoil gravel with scant cultural material in Structure 2 post holes, and an absence of early occupation material in these and post holes to the north, suggest that the area was undeveloped when Structure 2 was built.

Structure 5

Overview

Structure 5 appeared as 15 stains arranged in a circular formation surrounding 8 interior stains in no particular pattern. Horizon B soils had been mottled by the intrusion of small weedy plant roots, and stains were not easily seen against surrounding soil. When present, post molds were clearly defined within features. Nineteen of the stains, fourteen on the exterior and five of the interior, proved to be post holes of Structure 5 (Figures 12.23a and b). Four stains (or about 7%) were non-cultural (Table 12.2).

Traces of charred post recovered from two post molds and one post hole of the outer structural ring returned 2-sigma radiocarbon dates that overlapped between cal. AD 670 and cal. AD 775, indicating that they were posts of the same structure dated to the end of the early occupation of the Tutu site. The maximum 2-sigma range for all posts was between cal. AD 620 and cal. AD 990 (Beta 108892, 108911, 108916), and the maximum 1-sigma (68% probability) date range was between cal. AD 650 and cal. AD 895 (Beta 108892, 108911) (Table 12.1).

The 2-sigma overlap for Structure 5 is within 2-sigma ranges for single early occupation posts in Areas 1, 2, and 4; Levels D, F and I of N2044/1837E, Lundberg's ceramic Assemblage 3, and dated burials, B-16 and B-23B. These findings place Structure 5 on the eastern edge of the village's central open space or burial precinct/plaza during the late Saladoid occupation of the site.

Burial 20, dated to between cal. AD 1400 and cal. AD 1485 (2-sigma, Beta 109072), was not associated with Structure 5.

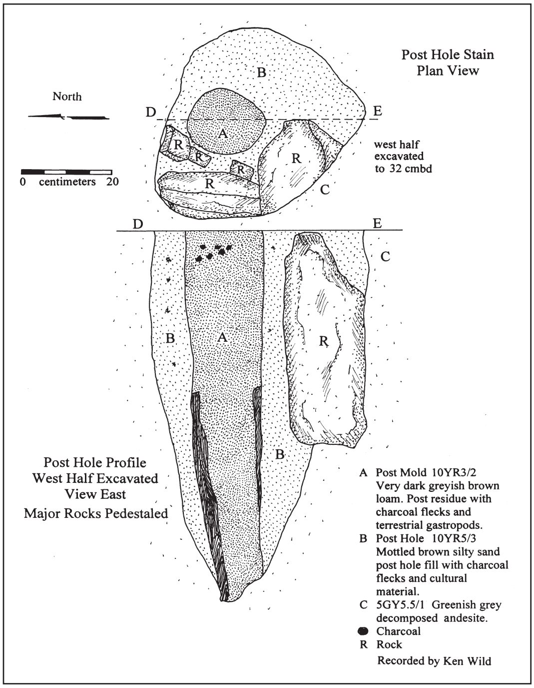

Figure 12.20 Plan view of P-413, central post hole of Structure 2; and east profile of post hole after excavation of west half (field drawing redrafted by Sean Krigger, graphic by Julie Smith).

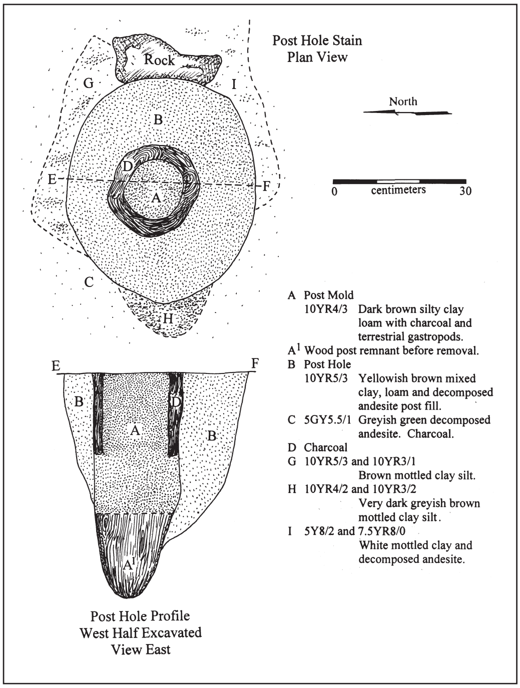

Figure 12.21 Plan view of P-466, central post hole of Structure 2; and east profile of post hole after excavation of west half (graphic by Julie Smith).

Post holes in the periphery and interior of structure 5

Of verified post holes of Structure 5, double post hole P-552 and P-582, and six single post holes, were 40 cm or greater in depth bss. A shallow trough or "slide" on the southern side of P-551, which was 40 cm in diameter at its base, must have facilitated implantation of a thick heavy post. P-2071A and P-2073A, which contained traces of charred posts, were situated against the south walls of their post holes. Cultural material in post hole P-2503B included thin-walled ceramics, terrestrial gastropods, shell fragments and a complete *Strombus gigas* (conch) shell, suggesting cultural refuse of an earlier occupation. Bone of *Trichecus manatus* (manatee) was present in P-3003.

Figure 12.22 Artist's rendering of the possible appearance of Structure 2. Structure is drawn to scale based upon the post hole plan (created by Julie Smith, redrawn by Monique Purguy).

Interior post holes of Structure 5 generally were shallow, extending between 13 cm and 20 cm bss. Given the number of other small shallow post holes in the vicinity, there is a possibility that some, or all, are overlapping features of a later small structure in the area.

Interpretation

An interior diameter of 7 m in a northeast–southwest direction and a northwest–southeast diameter of 6.75 m indicated an interior area of 37.17 m^2 for Structure 5. Schinkel's (1992: 192) formula provided a roof height of 5.50 m.

There were no shallow post holes interspersed between the deep outer post holes of Structure 5, although shallow post holes may have been scraped away prior to the investigations at Tutu. Visible post molds were positioned against one side of a post hole wall, a construction technique also observed at the late Saladoid Golden Rock site in St Eustatius (Schinkel, 1992: 148, 159). These aspects of the Structure 5 post holes at Tutu relate the structure more closely with structures at Golden Rock than with late occupation structures of the Tutu site. No entrance could be identified in the post hole configuration of Structure 5. Deep outer post holes suggest that side walls may have been taller than those of Structures 1 and 2, and there were no indications that the outer wall was closed in. The functional use of Structure 5 could not be determined, and it is not certain that the structure was a domicile.

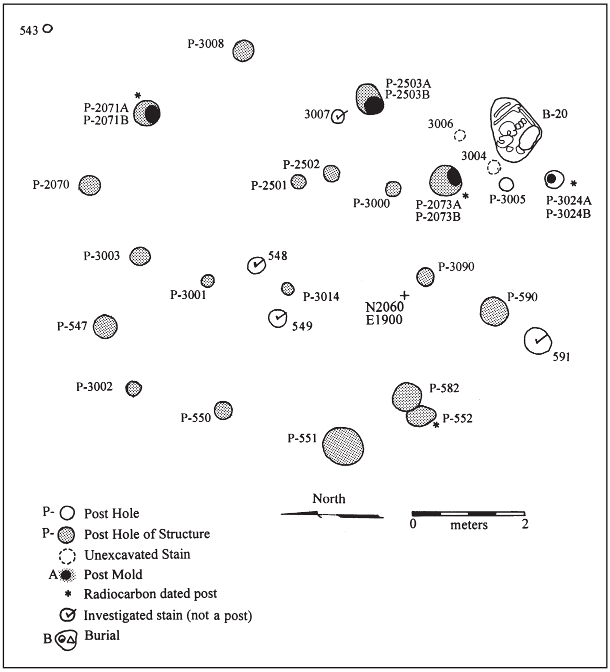

Figure 12.23a Plan view of post holes and stains of Structure 5, showing also stains that were not features of the structure (mapped manually by Elizabeth Righter and in Autocad by Travis Gray. Diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

Proximal but unrelated features

The center point of Burial 20 was located 1.50 m southeast of the outer wall of Structure 5. An additional four stains formed an arc around the northwest side of the burial and appeared to be associated with it (Figures 12.23a and b). A charred post of the arc, however, yielded a radiocarbon date of between cal. AD 1205 and cal. AD 1300 (2-sigma, Beta 111458), indicating mutually exclusive dates for Structure 5, Burial 20 and the arc of stains and post holes. This example points up the importance of radiometric dates for verifying an apparent relationship between post holes and burials. (Other instances where small posts appeared to be associated with burials of the Tutu site are discussed in Chapter 1.)

Evidence of another early occupation structure in Area 4

A large deep post hole, Feature 20, located east of Structure 6 (see Figure 1.7d), was dated at between cal. AD 640 and cal. AD 875 (2-sigma, Beta 65469), suggesting the presence of another early occupation structure in Area 4. Two large complete *Strombus gigas* shells were buried in the feature. *Strombus* sp. artifact preforms and shell residue were found elsewhere on the site, but whole shells were found only in features of Area 4. The scarcity of whole shells at the site suggests that subsistence *Strombus* sp. were processed at the shore, and shells were brought to the site for special purposes such as the fabrication of tools, beads, gorgets and other artifacts. The buried shells in Feature 20 may have supported posts, or the whole animals may have been buried in post hole fill in order to let insects and micro-organisms clean them, a method practiced in tropical environments today.

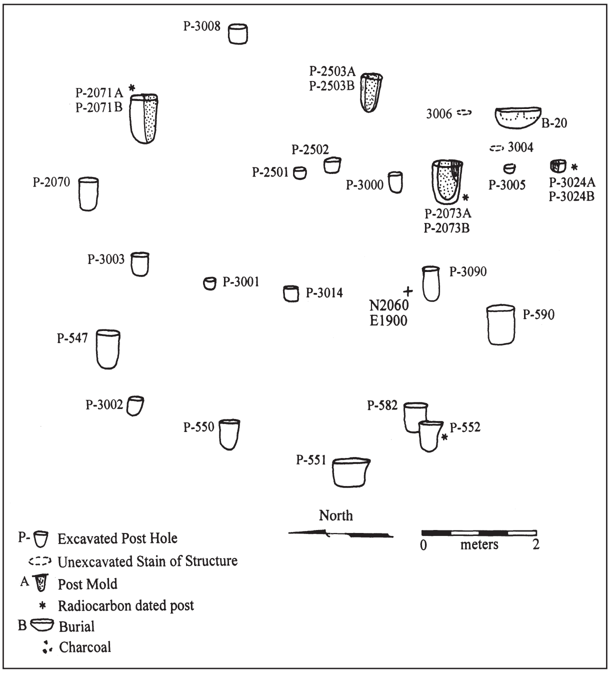

Figure 12.23b Schematic diagram of Structure 5, showing post holes to scale in profile (mapped manually by Elizabeth Righter and in Autocad by Travis Gray. Diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

Structure 6

Overview

Structure 6 was first recognized on the basis of regular spacing of shallow post holes among a group of 31 investigated dark stains that were almost masked by the scraped reddish Horizon B clay soils and oxidized andesite bedrock of Area 4. Of the 31 stains, 25 (or 81%) were post holes. Twenty post holes comprised an outer oval of deeper post holes, somewhat irregularly spaced, perhaps owing to the hardness of bedrock; and five shallower interior post holes clustered, in the southwest portion of the structure (Figures 12.24a and b). Additional interior post holes may not have been identified. No post holes indicative of appendages or detached fence lines were observed.

Charcoal samples from P-535A and P-531 returned 2-sigma dates that overlapped between cal. AD 1290 and cal. AD 1420 (Beta 111455, 111457). This range indicates that interior post holes probably belong to Structure 6. The 2-sigma date overlap for Structure 6 corresponds with dates for late occupation single posts in Areas 1, 2 except P-1822, P-192 and 9N, all dated late period burials except Burials 5 and 8A, 8B (Table 12.3) and all late occupation structures. Two sigma date ranges for Structures 6, 3, 4 and 7 are especially similar.

The center of Burial 9, which had a 2-sigma radiometric date range of between cal. AD 1210 and cal. AD1390, was situated 2 m south of the outer wall of Structure 6, very close to the structure. Dates for the structure and burial overlap. Burial 40, situated in line with the northeastern wall of Structure 6, was not dated.

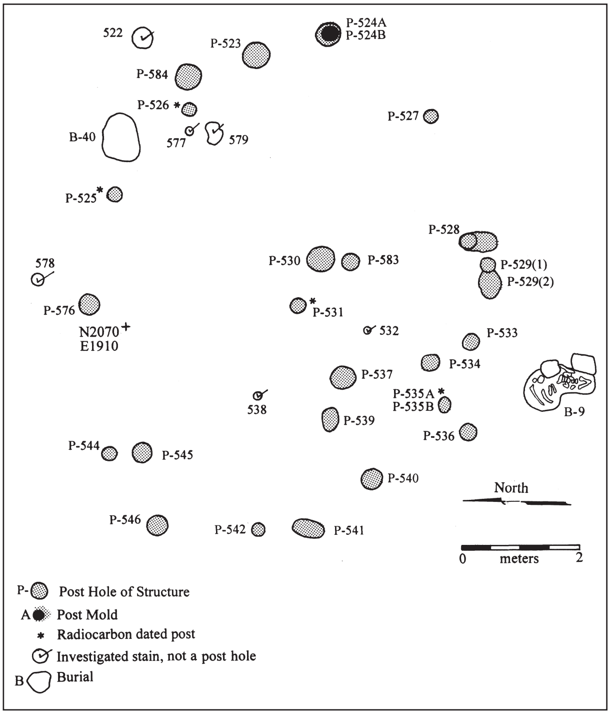

Figure 12.24a Plan view of post holes and stains of Structure 6 (mapped manually by Elizabeth Righter and in Autocad by Travis Gray, graphic by Julie Smith).

Exterior and interior post holes of structure 6

In the outer periphery of structure 6, two of the deepest post holes stood 1.30 m apart at the east end of the oval, and a pair of shallower post holes was situated opposite them at the west end (Figures 12.24a and b), suggesting major framing members. P-530 stood almost at the center point of the interior, with P-583 and P-531 on either side. It is not certain whether deep post hole P-534 contained an interior support post or was part of the outer structural wall.

Interpretation

Measured in an east–west direction the interior width of Structure 6 was 8.60 m and in a north–south direction it was 6 m. Using an average width of 7.30 m, the area of the interior was 41.85 m^2. Schinkel's formula (1992: 192) for circular floor plans was not suitable for calculating the roof height of Structure 6.

Although there was a gap of about 4 m between P-524 and P-528, with a shallow post hole between, suggesting a large double doorway, it is possible that one or more post holes were missing in this area.

Overlapping date ranges for Structure 6 and Burial 9 suggest that the structure was a domicile of the interred individual (see Curet & Oliver, 1998, for a discussion of house-related burials in late prehistoric Puerto Rico). The presence of Burial 40 on the opposite side of the structure suggests that it was occupied by members of two families.

Structure 3

Overview

In the vicinity of Structure 3, 99 stains stood out against the subsoil of the northeastern section of Area 1 (Figure 12.25). Of these, 51 formed an oval of closely-spaced stains surrounding 7 interior stains. Sixteen stains were excavated: ten on the periphery and six in the interior. Three (or 17%) of these were non-cultural. The outer post hole pattern is good but, because so few stains were excavated, the configuration of Structure 3 is considered less reliable than those of previously described structures.

An arc of post holes and stains projected from the northwest edge of the structure and alignments of two post holes projected from either side of an opening on the eastern side of the periphery. Burials 6 and 29 were situated south of the northwest-projecting arc.

Despite a very large error margin for P-601, 2-sigma radiocarbon dates returned on samples from charred posts P-101 and P-601A overlapped between cal. AD 1290 and cal. AD 1405 (Beta 108904, 112968), corresponding well with overlapping 2-sigma radiocarbon dates of between cal. AD 1300 and cal. AD 1390 (Beta 109071, 73394) for Burials 6 and 29, located 0.75 m northwest and 3 m west of P-101 respectively. Overlapping date ranges for Structure 3 also overlap with those for all late period structures, both round and oval, and late period single posts in Areas 1, 2, 4 and 9N (Table 12.3). Two-sigma date ranges for Structure 3 overlap with those for all late occupation burials except Burials 5 and 8A, 8B. One-sigma date ranges for the two dated posts do not overlap.

Exterior and interior post holes of structure 3

Since the majority of stains were not investigated, stains and excavated post holes are discussed together as features of the structure.

Although oval in shape, the outer wall configuration of Structure 3 was similar to that of Structure 1. Paired and double posts on the southern periphery had the effect of double arc segments and other pairs were in line with the outer wall. A cluster of closely-spaced small post holes on the southern wall of the structure may indicate either repairs or wall construction of tightly spaced thin vertical posts.

Of excavated post holes in the interior of the structure, P-2032 and P-609, extending to 52 cm and 48 cm bss respectively, were the deepest (Table 12.2) and presumably contained major supporting posts. There is insufficient information to document further the interior post hole configuration of Structure 3.

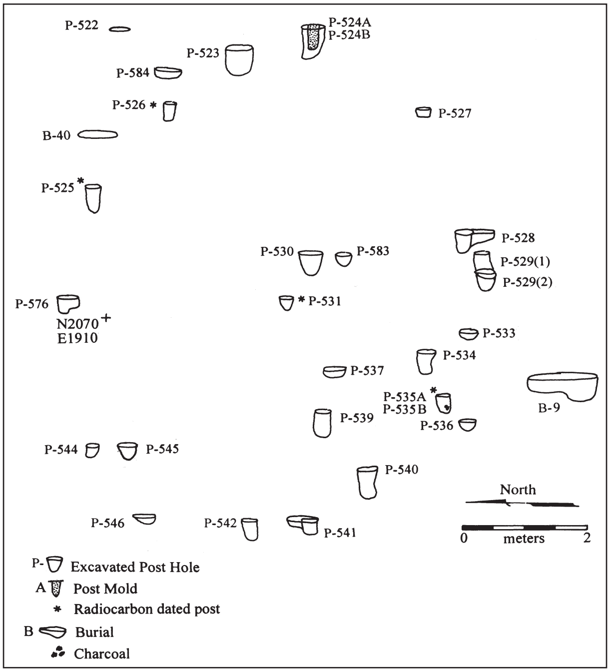

Figure 12.24b Schematic diagram of Structure 6, showing post holes to scale in profile (mapped manually by Elizabeth Righter and in Autocad by Travis Gray, graphic by Julie Smith).

Appendages

On the eastern side of the outer wall of Structure 3, stain 2029 projected eastward from stain 2049, and stain 2030 was to the north. Between 2.00 m and 2.40 m south of the stains, stain 2022 projected eastward from stain 2051, with P-2023 to the northeast (Figure 12.25). This configuration was similar to that on the northeastern side of Structure 1.

An arc of three deep post holes, one shallower post hole, and one stain (P-1858, 1850, P-1849, P-603 and P-1846(1), see Figure 12.2), extended in a westward direction from the northwest wall of Structure 3.

Interpretation

In a northwest–southeast direction Structure 3 was 5.25 m wide, and in a northeast–southwest direction it was 7 m. Using an average width of 6.13 m, the area of the structure was 29.42 m^2. Roof height was not calculated.

Post hole patterns on the periphery of the oval structure suggest a closed-in structural outer wall, perhaps of vertical posts with interwoven palm thatch or other material. Interior posts may have supported a tall conical peak that extended above a roof that sloped outwardly toward the side walls, terminating not far above the ground surface.

In an area clouded with stains of post holes and roots, a northwest-projecting arc of posts and stains marked the northern limit of a burial area to the south which contained Burials 6 and 29,

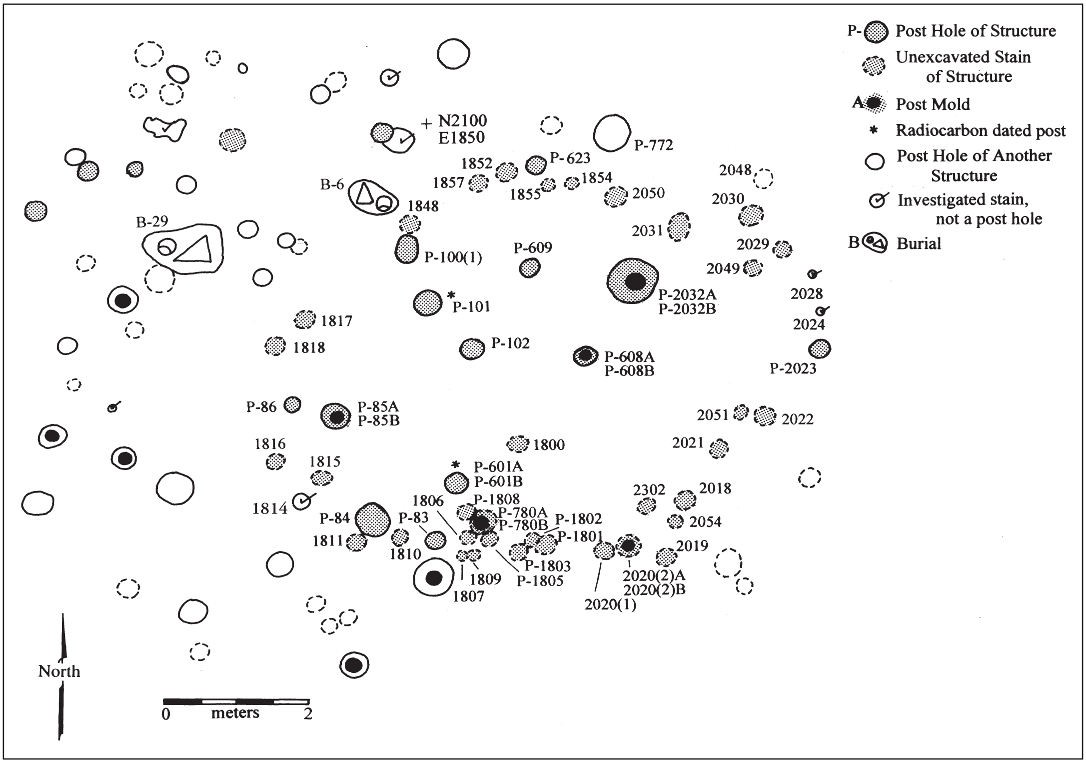

Figure 12.25 Plan view of post holes and stains of Structure 3 and probable appendage, showing also stains that were not features of the structure (mapped in Autocad by Travis Gray, graphic by Julie Smith).

contemporaneous with Structure 3. A probable rear opening from the structure into the burial area was observable on the northwest wall. Projecting post holes flanking an opening on the eastern side of the structure were interpreted to support an entrance feature similar to that on the northeastern side of Structure 1.

A general paucity of cultural material in post holes of Structure 3 suggests erection of the structure in an area that previously had not been used for midden disposal.

Structures 8 and 7

A myriad of exposed stains, indicative of dense occupation, re-occupation and repair, was present in the southern two thirds of Area 1 (Figure 12.26, Figure 1.7a). In these conditions, identification of discrete structures was a challenge. Many post holes did not contain charcoal, and could not be assigned a chronological or structural position on the basis of other attributes. Therefore, it is possible that some post holes and stains assigned to structures were not cultural or were not part of the structure to which they seemed to belong.

In general, remains of earlier structures appeared to have been obliterated by re-occupation of house sites and numerous repairs. Later structures were more readily identified.

Despite frequent re-occupation of the area, areas free of post holes often remained consistent. This phenomenon, a combination of post hole attributes, spacing of deep and shallow post holes, configurations of other structures at the site and 27 radiocarbon dates were analyzed to identify two late period structures which were spatially superimposed. A very few stains of these structures were not excavated.

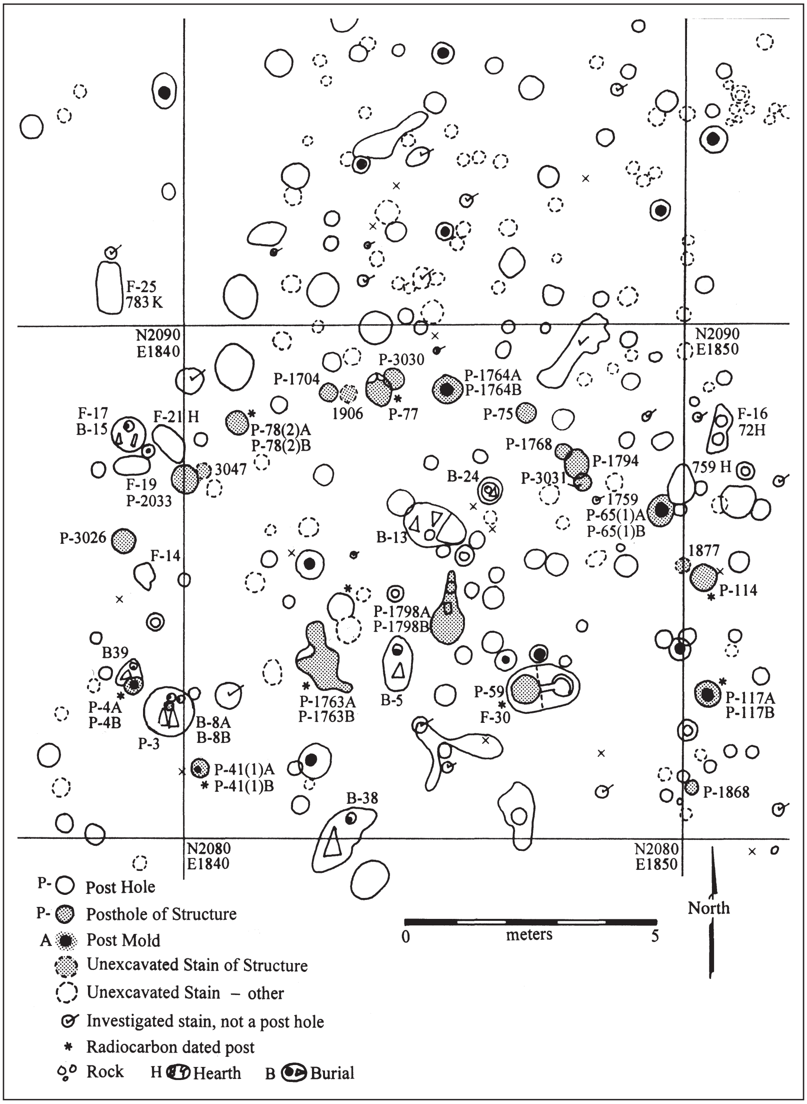

Figure 12.26 Post holes and stains of Structure 7, Scenario 1, showing overlapping Structure 8 post holes and surrounding myriad post holes, stains and features of Area 1 (mapped manually by Elizabeth Righter and in Autocad by Travis Gray and Cameron Scobie with assistance from Alan Perry, graphic by Julie Smith.)

Almost all excavated deep post holes in the southern portion of Area 1 could be identified with either Structure 7 or 8, which were the largest structures identified at Tutu, and it is likely that all or most of the burials in their vicinities were related to one or the other domicile. AMS dates for Burial 38 overlap with those of both Structures 7 and 8; and, because the configuration of Structure 7 was incomplete, the burial's relationship to either of the two structures could not be firmly established.

Because the confidence level of Structure 8 is greater, it is discussed first, even though, chronologically, it superseded Structure 7.

Structure 8

Overview

Stains and post holes of Structure 8 exhibited a wide variety of Munsell colors which stood out among the grey and white decomposed andesitic subsoil. In the northern part of the structure, post hole patterns were quite clear and free from interference by other features. In the southern portion of the structure, however, where post holes of Structure 8 and Structure 7 overlapped, the pattern was more difficult to discern (Figure 12.26).

About 1 m inside the outer wall of Structure 8, an oval of small stains and post holes mirrored the oval of the outer wall and was tentatively identified as a series of interior post holes (see Figure 12.26). Since these are conjectural, they are not included in Figures 12.27 and 12.28. P-105 and P-76 (Figure 12.2) are conjectural as possible interior support posts for the structure. Burial 13, 13A and Burial 24, in the interior of Structure 8, pre-dated the structure and were not related to it.

Dates for posts which could be assigned with confidence to Structure 8 overlap between cal. AD 1395 and cal. AD 1445 (2-sigma, Beta 108905, 108894). Maximum ranges are between cal. AD 1270 and cal. AD 1650 (Beta 108908, 108900, 108905). These dates also coincide with those for dated posts of appendages to Structure 8, discussed below. The 2-sigma overlap range for Structure 8 also overlaps with those for all late period structures except Structure 2; and overlaps with date ranges P-131, P61 and P-3078 (in Areas 2 and 1 respectively), Burials 11 and 31, north of the structure, and Burials 5, 8A/8B, 38 and 39 to the south (Table 12.3).

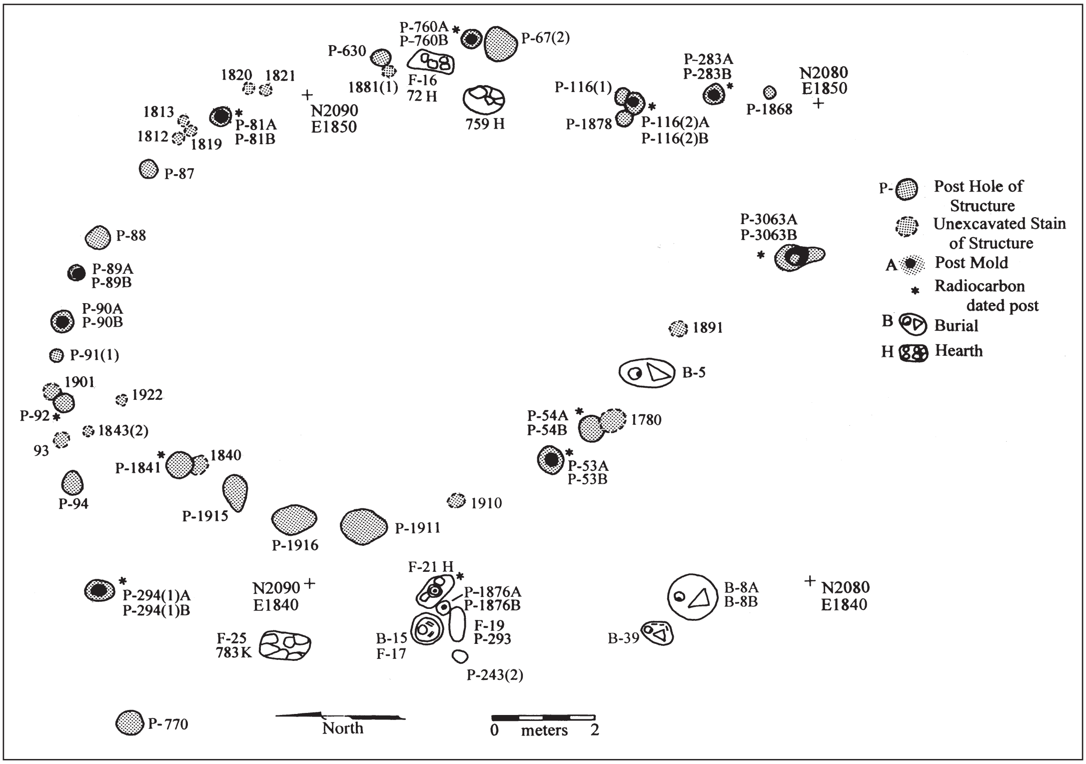

Figure 12.27 Plan view of post holes and stains of Structure 8, Scenario 2, in which Burial 38 is not among related burials. Post holes of northwest appendage and entrance appendages are shown, but burials north of Structure 8 are not (recorded manually by Elizabeth Righter and mapped in Autocad by Travis Gray and Cameron Scobie, with assistance from Alan Perry, graphic by Julie Smith).

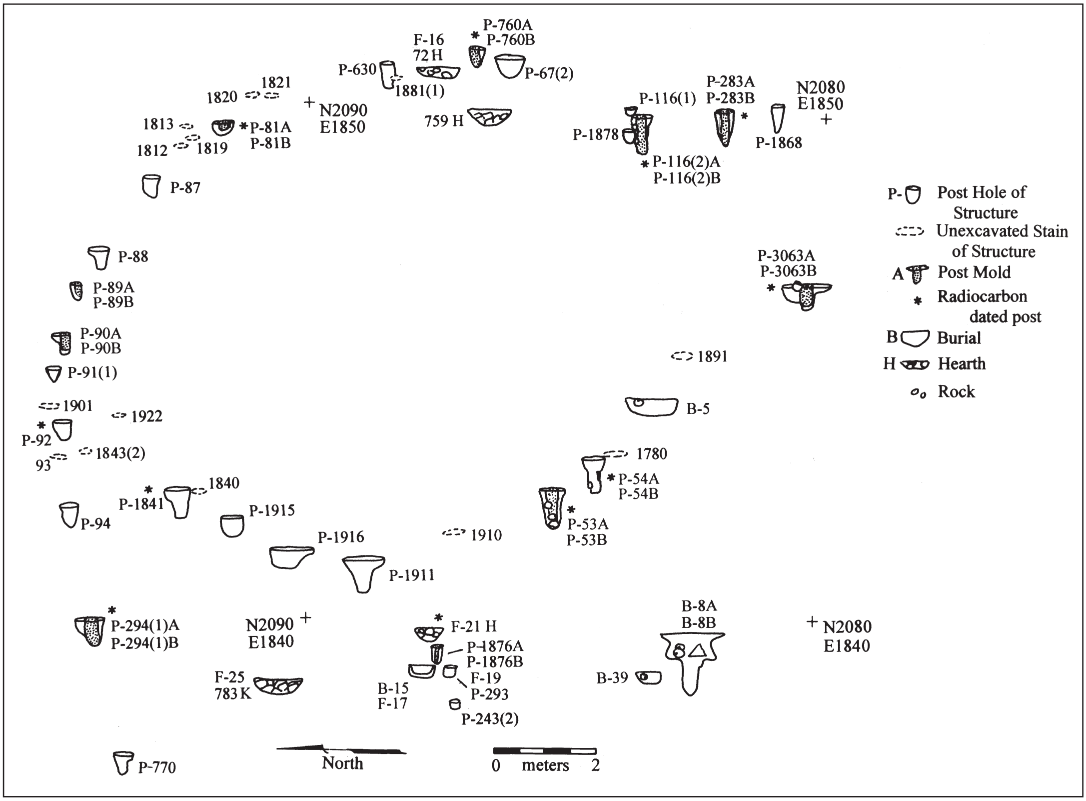

Figure 12.28 Schematic diagram of Structure 8, Scenario 2, showing post holes and stains of structure and appendages, to scale, in profile. Burial 38 is not included among related burials (diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

The configuration of Structure 8

Post holes of a possible entrance feature, Burial 38 and interior post holes may or may not have been associated with Structure 8. These varied independently of each other in three scenarios. Of these, Scenario 2 (Figures 12.27, 12.28) had the highest confidence level.

In all scenarios for Structure 8, the outer wall consisted of 19 post holes and 13 stains. Deep posts were located opposite each other in the northern and southern halves of the periphery.

Features on the northwest wall contained primary midden of both occupation periods. A rich mix of early and late period refuse, including spindle whorls and a “cache” of Sapotaceae seeds, was found in P-53 on the southwest wall. Post holes on the southeastern periphery of Structure 8 also were rich in midden material, while post holes on the outer northeastern wall were relatively free of cultural material.

Appendages

In a configuration similar to those of Structures 1 and 3, post holes flanked an opening 2.50 m wide on the southeast side of Structure 8. P-283 and P-1868 formed an alignment projecting from post cluster P-116(1), P-116(2), P-1878 on the eastern side of the opening; and P-3063 was located southeast of stain 1891 on the west side of the wall opening. Two-sigma dates for P-283 and P-3063 overlapped with those for the structure.

A second attached appendage, consisting of an arc of three post holes and one unexcavated stain, extended westwardly from the north side of Structure 8, just north of an apparent rear opening in the structural wall. Two-sigma dates for P-294 of the post hole arc overlapped with maximum 2-sigma date ranges for Structure 8.

Interpretation

Structure 8, 9.25 m wide and 12.25 m long, was oriented in a generally northwest–southeast direction. Its area, based on an average diameter of 10.75 m, was about 90.75 m^2. The structure's roof height was not estimated.

Two-sigma date ranges for Burials 11 and 31 to the north of Structure 8, and those for Burials 5, 8A, 8B, 38 and 39 to the southwest, overlap with those of Structure 8. Their dates, as well as their physical proximity to Structure 8, suggest an association between the burials and the structure. The date range of Burial 39, dated to the late occupation, was not reliable, but its proximity to Burial 8A/8B suggests a relationship with that burial. Burial 38 may have been associated with Structure 7.

Appendages to Structure 8, distributions of burials and other features and patterns of open space relative to Structure 8 indicate that the exterior grounds around the structure were divided into at least five intentionally separate functional areas. An arc extending westwardly from the north side of Structure 8 apparently separated a burial area to its north from a work area to its south (Figure 12.2). The work area contained a pottery kiln (F-25) and a hearth (F-21) (Figures 12.27, 12.28; see Chapter 1). To the south of the work area was another burial area, which included Burial 5, situated in line with the structure's outer wall; a common feature at Tutu. Burial areas situated on separate sides of Structure 8 suggest occupation by two or more families. Southeast of the burial area and southwest of the entrance feature was an open or formal space. Post hole alignments projecting from either side of an opening on the southeast side of the structure indicated a portico or sheltering fences of woven mats or other plant material. Northeast of the entrance was another formal or empty space.

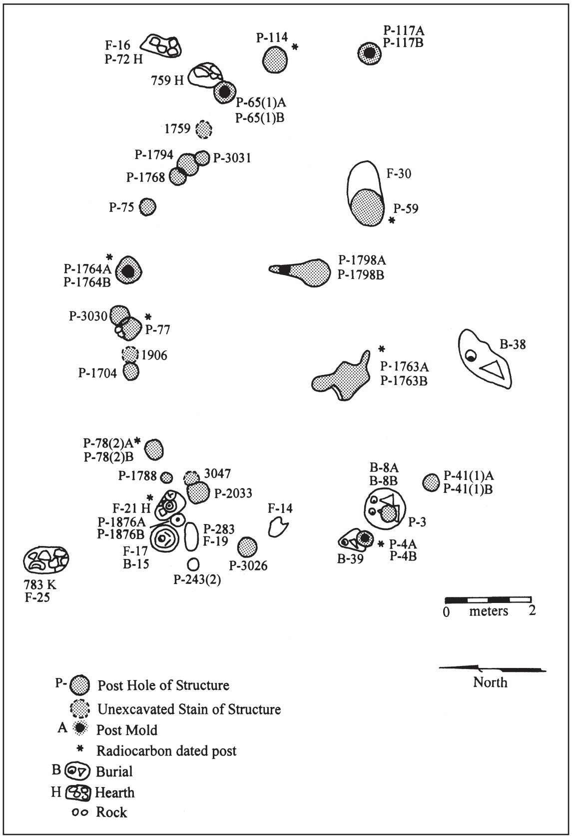

Figure 12.29 Plan view of post holes and stains of Structure 7, Scenario 2, with Burial 38 present near central post holes (mapped manually by Elizabeth Righter and in Autocad by Travis Gray and Cameron Scobie with assistance from Alan Perry, graphic by Julie Smith).

An interior hearth, F759H, located just inside the eastern wall of Structure 8, may have been in use during occupation of the structure; while F72H, situated between posts of the outer wall of Structure 8, may have been a defunct hearth which, to mark the location of its former use, was included in the wall of Structure 8 (Versteeg & Rostain, 1997; Versteeg, 1997: 313).

Structure 7

Overview

Deep post holes that formed an arc in the southern portion of Area 1 were, at first, anticipated to be those of a Saladoid malocca, similar to one or more structures identified at the Golden Rock site in St Eustatius (Schinkel, 1992; Versteeg & Effert, 1987). Late Ostionoid radiocarbon dates returned on the Tutu posts, however, forced revised interpretations and assisted identification of late Ostionoid Structure 7. Because Soil Mound No. 4 obscured the southern portion of the structure, only post holes of the northern periphery could be investigated.

Charcoal samples from 8 posts of Structure 7, 2 of which were charred posts, were radiocarbon dated. Discounting the second 2-sigma date range for P-78(2)A, which was out of line with other dates, and the date for P-1764, 2-sigma dates overlap between cal. AD 1295 and cal. AD 1400 (Beta 108910, 108893). The 2-sigma overlap for Structure 7 corresponds with those for Structures 1, 2, 3, 4, 6 and 9. Overlaps of the majority of Structure 7 post dates indicate that the structure pre-dated Structure 8. Two-sigma dates for Burials 5 and 8A/8B do not overlap with the Structure 7 overlap. Dates for Burial 38 overlap with the overlap for both Structures 7 and 8 (Table 12.3). In Figures 12.29 and 12.30, Scenario 2 for Structure 7, Burial 38 is associated with the structure.

The outer periphery of Structure 7

Nineteen post holes were excavated and recorded on the northern periphery of Structure 7. Except for shallow post holes P-4, P-41 and P-1768, and deep posts P-3 and P-114, post holes ranged in depth between 35 cm and 60 cm bss. The two deepest post holes, P-3 and P-114, opposed each other on east and west sides of the periphery. In the center of the northern periphery, P-3030/P-77, a double post hole, apparently supported two strong posts, either simultaneously or sequentially (Figures 12.29, 12.30).

Interior post holes of Structure 7

In the interior of Structure 7 three large central post holes of similar construction and configuration were excavated (Figures 12.31–12.33). A number of other excavated stains in the interior of Structure 7 could not be confidently associated with the structure (Figure 12.26). At either end of P-1763, the top of the post hole consisted of a "slide" for the insertion of a large post. The post hole, which was 92 cm deep, had disturbed early occupation Burial 27. A slide was also present at the top of P-1798, which was 88 cm deep and terminated in a point where digging stick marks were evident. The character of the fill of P-59 suggested that a post had been pulled out.

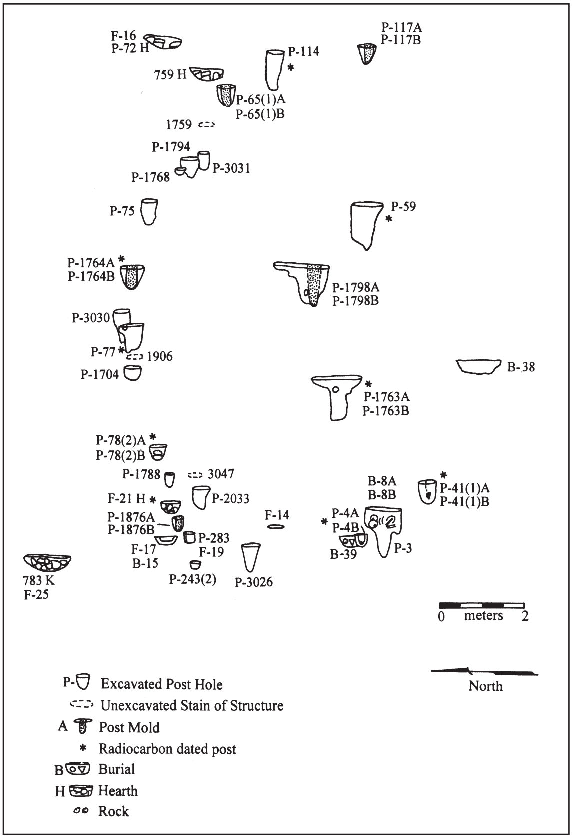

Figure 12.30 Schematic diagram of Structure 7, Scenario 2, showing post holes and stains to scale in profile. Burial 38 is present near central post holes (diagrammatic scheme composed by Elizabeth Righter, graphic by Julie Smith).

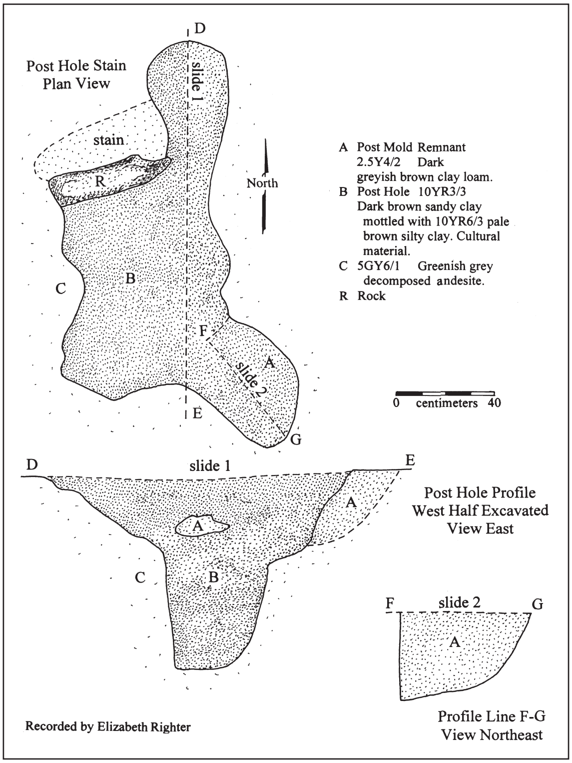

Figure 12.31 Plan and profile of central post hole, P-1763, Structure 7 (graphic by Julie Smith).

Interpretation

It was uncertain whether Structure 7 would have been circular or oval, or whether the complete structure had more than three major central posts. It is also uncertain whether Burial 38 was associated with the structure. If Structure 7 were oval, Burial 38 may have been in or near the outer wall. If circular, Burial 38 may have been, atypically, in the interior of the structure, near the central posts.

The width of Structure 7 in an east–west direction was 10.75 m, and, if the structure were circular, its area would have been 90 m^2. Using a formula of 0.80 x diameter (Schinkel, 1992: 192), roof height would have been 8.60 m.

Hearth features 759H and 21H were too close to the outer walls of Structure 7 to have been used by its inhabitants. Undated Feature 72H, situated 2 m northeast of the outer wall of Structure 7, may have been in a designated workspace northeast of the structure. Feature 25, a kiln located to the northwest of Structures 7 and 8 may have been used by occupants of either structure.

Structure 4

Overview

Eighteen stains that formed a rough circle and seven stains of an appendage on the west side of the circle (Figures 12.34a and b) stood out clearly in a northern portion of Area 8. Ten stains of Structure 4 proper and one in the extension, or 44 percent of the 25 stains, were excavated (Table 12.2). All were shallow post holes, and there was no center stain to indicate a center post. Burials 33 and 34 were located 3 m south of the appendage.

It is likely that exposed stain remnants were the deepest post holes of the structure, and an unknown number of shallower post holes had been lost to mechanical scraping. Excavated post holes, except for two, were free of measurable cultural material. The confidence level of this structure is the lowest for the site.

Charcoal samples from P-834 and P-884A(2) returned 2-sigma date ranges that overlapped between cal. AD 1305 and cal. AD 1425 (Beta 108907, 112965). This overlap is shared by all late occupation structures except Structure 2. The overlap corresponds with those for most late period posts in Areas 1, 2 and 9N, and with B-1 in Area 9N and late period burials in Areas 1, 4 and 8, except for B-5 (Table 12.3).

Post holes of Structure 4

Of the ten excavated post holes of Structure 4 proper, the six deepest extended to between 16 cm and 20 cm bss. Because few stains were excavated in the northern half of the circumference, and some were probably missing, the true pattern of deep and shallow post holes and stains could not be discerned (Figures 12.34a and b).

Appendage

A double row of stains, four on the south side and two on the north, extended in a westerly direction from the southwest side of Structure 4 and terminated in stain 880 at the tip of the appendage. A narrow corridor was created by the post hole spacing.

Interpretation

The irregular circle of Structure 4 was 6.20 m wide in an east–west direction, and its north–south width was 6 m. Using an average diameter of 6.10 m, the area of Structure 4 would have been about 30 m^2. Multiplying the same average diameter by 0.80 (Schinkel, 1992: 192), roof height would have been about 4.88 m.

Structure 4 was located at the very northern extreme of the site and was not surrounded by post holes indicative of other episodes of construction. The paucity of cultural material in excavated features suggests little use of the area before Structure 8 was built. Post holes were shallow, however, and it is possible that upper soil levels had been scraped away, removing evidence of shallower post holes.

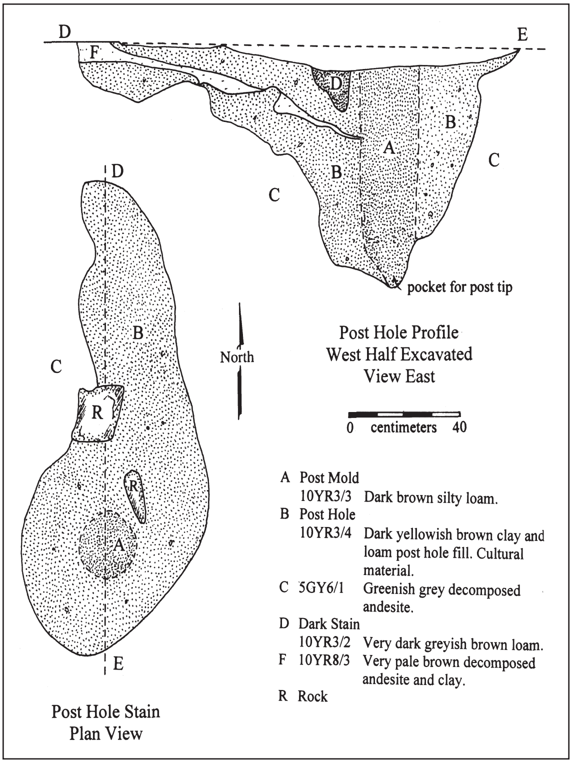

Figure 12.32 Plan and profile of central post hole, P-1798, Structure 7 (graphic by Julie Smith).

No specific entrance could be identified at Structure 4. Projecting from the southwest side of the structure was an appendage comprised of 7 post holes, in two alignments with a narrow corridor between them. The appendage to Structure 4 was identical to that of Structure 1, except that the appendage to Structure 4 separated it from a burial area containing Burials 33 and 34. Strong evidence for an association between Structure 4 and Burials 33 and 34 is provided by overlapping dates and the absence of any other burials or structures in the vicinity.

Other post holes of Areas 1–13

A number of additional post holes and stains were hand-excavated in the vicinity of the Area 1 midden (Figure 1.10). The origins of P-1701 below upper levels of the midden, and P-614 beneath topsoil in Profile 5, indicate the presence of structures in Area 1 that were, perhaps, the source of midden traces which produced the earliest dates for the Area 1 midden. Post holes that penetrated thin midden deposits north of the Area 1 midden suggested construction of structures that post-dated the midden.

Additional stains also were hand-excavated in unscraped portions of Areas 9S and 13.

Patterns of interspersed open space and numerous small stains and post holes suggest that many small structures were present in scraped areas of Area 9N. No structures, other than Structure 1, could be identified among the post hole patterns, however. Other evidence of structures in Area 9N was provided in Features 7, 9 and 34 (see Figure 1.7c).

Of three post holes exposed in the south profile of Trench 1 in Area 13, P-3 returned a 2-sigma date of between cal. AD 1020 and cal. AD 1245 (Beta 111453). This time range overlaps with the 2-sigma overlap for Structures 1 and 2 in Areas 9N and 3 respectively, and with some late period posts in Areas 1, 2 and 4.

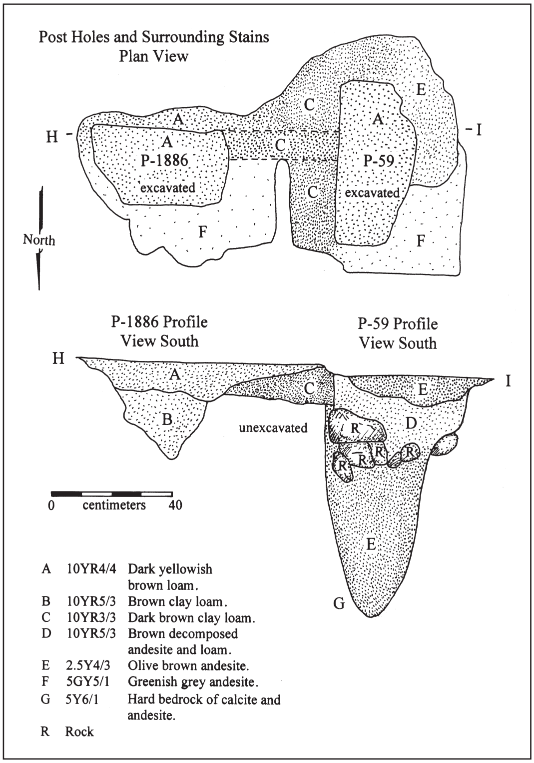

Figure 12.33 Plan and profile of central post holes, P-59 and P-1886, Structure 7 (graphic by Julie Smith).

Because of time constraints, logistical considerations, and research design priorities, in some sections of the site, not all stains were cleaned, investigated and recorded. Uninvestigated stains indicative of post holes also were present in unscraped sections of Area 2; Area 4N; northeastern sections of Area 6; southern portions of Area 8; the western end of Area 10, Area 11 and Area 12 (Figures 1.7a–d). Two post holes were present in the southern portion of Area 6.

INTERPRETATION: VILLAGE STRUCTURE

Village configuration

At Tutu, structures and other features related to the earliest dates for lowest levels of the Area 1 midden were not found. The configuration of the settlement at this time is unknown; however, based on ethnohistorical and ethnographic analogy (Las Casas, 1929; Riviere, 1994), it might be conjectured that one or two structures were present with a plaza or open space in front of them.During the period between *c.* AD 350 and AD 960, the Tutu village was a horseshoe-shaped settlement of dispersed structures around an open space which also functioned as a cemetery (Figures 12.35, 12.36). The habitation area was outside the central open space/cemetery, and, in general, midden or refuse areas were on the fringes of the habitation area, presumably having emanated from nearby houses. Because (in all but Areas 9N, 9W and 9S) middens had been surficially scraped prior to 1990, and the full extent of overlying midden, if any, is unknown, interpretation of site structure is necessarily limited to evidence recorded and deduced from midden distributions identified during the 1990–91 investigations of the site.

The village conformed to a basic plan of open space surrounded by structures, with midden deposits to the rear, which has been interpreted as a "a cognitive model of the cosmos in general, and representative of the social structure of a community" (Curet & Oliver, 1998: 229; deJosselin deJong, 1947; Siegel, 1989, 1992, 1996; Versteeg & Schinkel, 1992). Using ethnographic analogy, Siegel (1996: 319) stresses that archaeological residues of Saladoid sites are similar in structure to extant villages of lowland Native American communities in South America, that are constructed as physical models of the universe (Siegel, 1996: 319). He asserts that the village plan as representative of a cosmic concentric world view was brought with the Saladoid settlers from their ancestral South American homeland.

Although this argument is persuasive, the number of Caribbean island Saladoid sites that have been investigated sufficiently to identify village layout is extremely small, and uniformity in village plan from island to island or intra-island is not yet firmly established. There is some evidence to suggest that coastal sites were, in fact, linear in arrangement (Boomert, 1999: 2). Additionally, because of the impacts of European contact, ethnographic analogy must be used with extreme caution.

Evidence suggests that the layout of the Tutu site was, in part at least, a response to the topography and physiography of the site. For example, the original horseshoe shape of the early settlement was a function of its location on the rim of a swale or small watershed above Turpentine Run. The densest occupation of the site was in northwestern sections which were slightly elevated, caught the breeze, and were closest to a fresh water supply. The vantage point of this location also was excellent for viewing visitors approaching by land or canoe.

During the occupation between *c.* AD 65 and AD 660, at least two burials were placed in the central open space or burial precinct, and other burials were present in habitation areas of the site.

Details of the Tutu village plan during the late extension of the Saladoid occupation (*c.* AD 660–960, at 2-sigma) cannot be deduced from the paucity of archaeological evidence (Figure 12.36). At some point during the period, two structures apparently were present in Area 4, and structures may also have been present in Areas 2 and 9N. Burials 16, 23A and 23B were placed in the burial precinct and other burials were present in habitation areas. Burial 3, an anomaly among Tutu burials, was placed in the late Saladoid midden on the southwestern slope of the site. Feasting on the plaza, or in houses northwest of the plaza, can be inferred from thick primary episodic midden in Units N2044/1837E and Trench 10 in Area 9W.

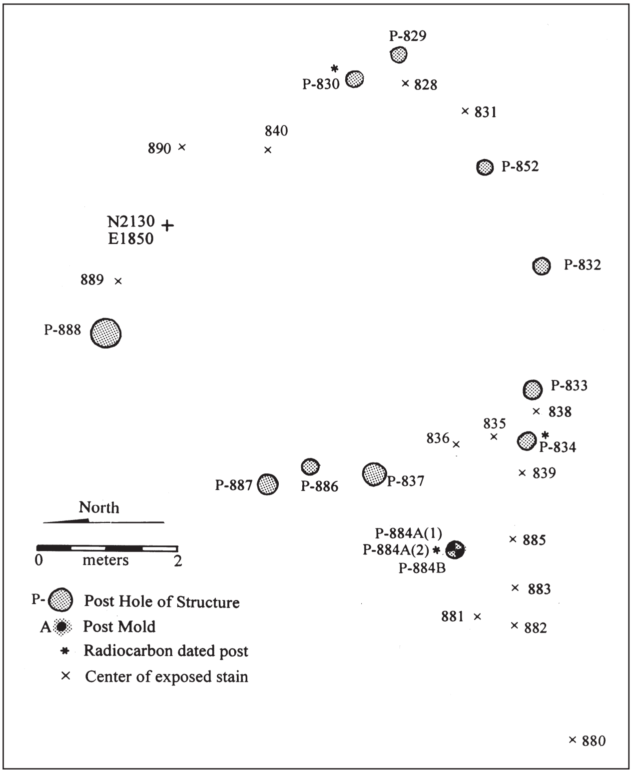

Figure 12.34a Plan view of post holes and stains of Structure 4 (recorded in Autocad by Travis Gray, graphic by Julie Smith.

During a period between *c.* AD 900/960 and AD 1150/1200, the Tutu site was either abandoned or very sparsely settled.

Upon re-settlement, the site was structured on the same basic plan as the previous settlement. The distribution of late midden on the site, however, could only be deduced from a single deposit southwest of the plaza and primary midden deposits in post holes of Areas 1 and 2. The late midden remnant in Area 9S suggests continuation of previous disposal patterns southwest of the plaza; and deep middens and changes in elevation on the western portion of the site indicate that upper portions of the swale had been filled in with debris creating additional flat land.

The late Ostionoid village plan was generally circular (Figure 12.37), a pattern similar to that found at Anse à la Gourde in Guadeloupe (Hofman, Hoogland & Delpuech, 2001: 5). There is some evidence that the site expanded to the north, northwest and northeast, with perhaps a second open space, a dance or ball court, in Area 10. Concomitantly, the northern boundary of the plaza may have "migrated" northward. The village plan was not static, and as noted by Roe and Siegel (1982: 106) during their study of the taphonamy of a Shipibo village, as structures were abandoned and rebuilt the arrangement of structures around a central plaza changed, and there was an amoeba-like quality to the village's ever-changing shape within the "skin" of its general form.

Seven Ostionoid structures were identified. These were either oval in shape with interior post holes (Structures 3, 6 and 8), round without interior post holes (Structures 1 and 4) or round with deep central post holes (Structure 2) (Table 12.4). Structure 7 had deep central post holes but its shape could not be determined.

Diameters of round structures ranged between 3.10 m and 6.75 m. Oval structures ranged in size between 6.00 by 8.60 m and 9.25 by 12.25 m.

Intentional divisions of exterior space for specific purposes were evidenced by

1. post hole patterns indicating entrance features;
2. post holes of attached appendages and detached linear features;
3. discrete burial groupings;
4. cleanliness of burial soils compared to post hole fill, indicating ground surface areas kept free of debris;
5. the distribution of open spaces around structures and
6. discrete work areas.

The greatest number of activity areas could be recognized around Structure 8, where 5 spatial divisions were recognized (Table 12.4). An appending arc of Structure 8 separated a northern burial area from a workspace to the south; and another burial area on the southwest side of Structure 8 was separated by an open space from an entrance feature on the southeast side of the structure. Another open space was observed northeast of the entrance.

Division of exterior space around Structure 1 was indicated by an entrance feature, clean spaces to either side and an appendage which apparently separated activity areas on either side of it. A similar appendage on Structure 4 separated a burial area to the south from the structure.

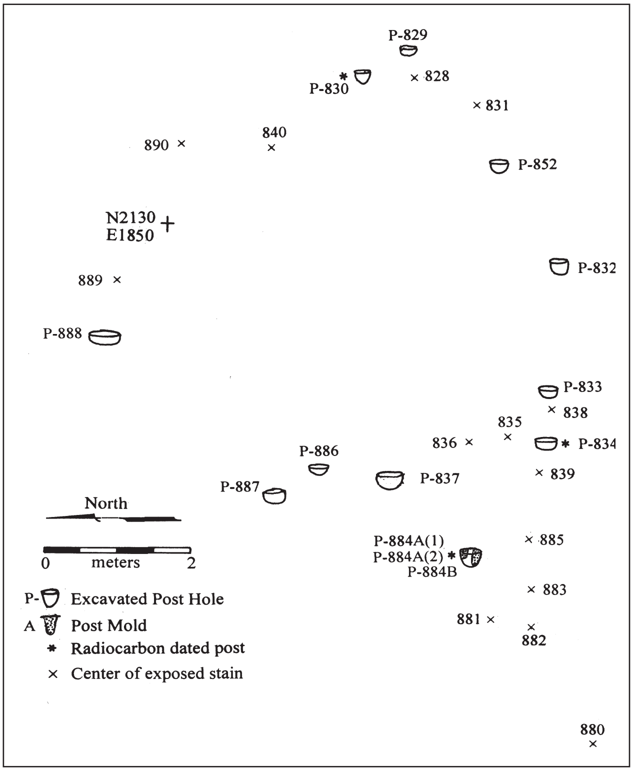

Figure 12.34b Schematic diagram of Structure 4, showing post holes to scale in profile (recorded in Autocad by Travis Gray, graphic by Julie Smith).

An entrance feature with formal or open space on either side was identified at Structure 3, to which an arc was appended on the northwest side. This arc delimited a burial area to the south.

An entrance feature was also observed on Structure 2 and a detached arc of post holes indicated a fenced area delimiting a burial area to the south. No divisions of exterior space could be observed around Structures 5 and 6.

In the late Ostionoid Tutu village, graves appeared to be grouped in family units in specific burial areas related to the houses. Associations between burials and structures were inferred on the basis of radiocarbon dates and proximity to structures. Family groupings were inferred from dated burial clusters that included both male and female adults with infants and subadults. Spatial separation based on age or gender was not apparent and location of a burial by status was not observed.

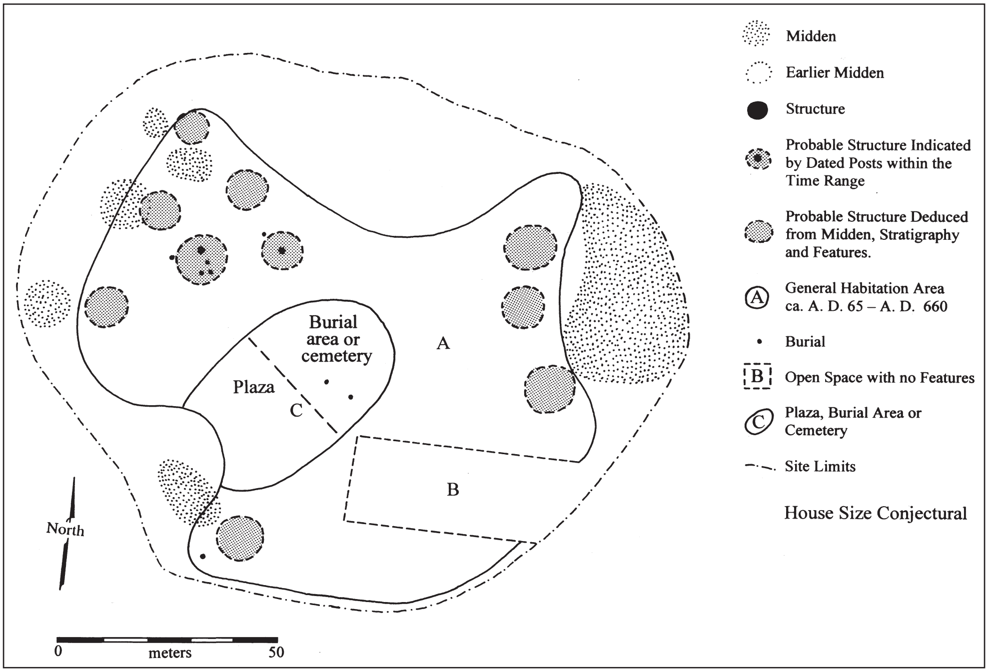

Figure 12.35 Diagram of the Tutu settlement layout, *c.* cal. AD 65–660 (2-sigma date range) (drawn by Elizabeth Righter, graphic by Julie Smith).

INTERPRETATION: ETHNOGRAPHIC, ETHNOHISTORIC AND ARCHAEOLOGICAL COMPARISONS

Ethnographic comparisons

Limited ethnographic analogy may provide some insights to structure types, sizes and life spans in the Tutu village. In its variety of structure types, the Tutu village appears to resemble the Trio village of Guiana, where eight main types of dwelling house, and variants, are distinguished. In a Trio village, only one structure type, however, is the proper house (Rivière, 1994: 191) for filling certain social, spatial, ritual and symbolic specifications. Such houses are usually round. It is unknown whether, at Tutu, a difference between round structures with central posts, round structures without central posts, and oval structures, reflected functional differentiation also. In addition to houses, a Trio village contains other buildings as well, such as workhouses where women process food, temporary shelters for visitors, shamans huts, menstruation houses and birth huts (Rivière, 1994; Roe & Siegel, 1982). Such structures were probably part of the Tutu village configuration also.

Among the ethnographic Panare, house size can be important as indicative of the status and standing of the leader. The largest conical house in an ethnographically recorded Panare village is 25 m in diameter and 12 m high, and the smallest is 7 m in diameter and 5 m high (Henley, 1982: 15). At Tutu the largest structures were Structures 7 and 8 which probably housed persons of status. The smaller Panare house diameters correspond with diameters of Tutu Structures 5 and 2, an early occupation and a late period structure respectively.

In present day French Guiana, a traditionally built house may last 7 years if the house is lived in and there is smoke in the house. If the roof is repaired as needed, the house may last 15 years (personal communication, Hugue Petitjean Roget, French Guianan anthropologist). Life spans

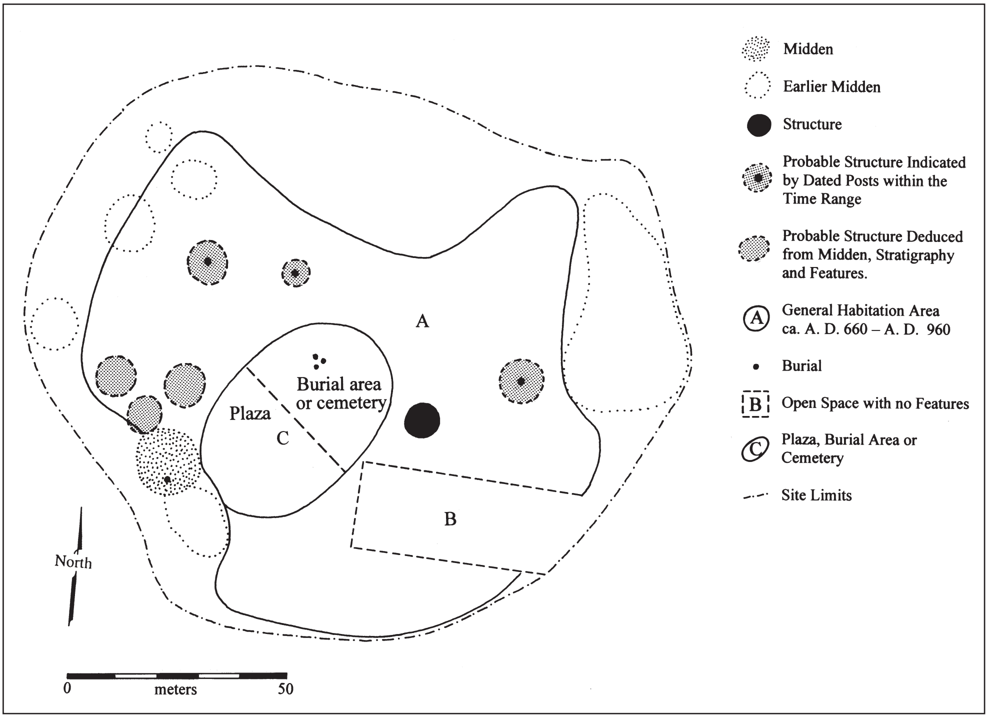

Figure 12.36 Diagram of the Tutu settlement layout, *c.* cal. AD 660–960 (2-sigma range) (drawn by Elizabeth Righter, graphic by Julie Smith).

of between 1 and 15 years have been recorded for structures built of organic materials in humid tropical environments, while estimates of between 10 and 50 years might be appropriate for drier less humid coastal environments such as that in St Thomas (Schinkel, 1992: 188).

Among ethnographically recorded northern South American groups, and even more recently recorded Amazonian tribes (Ricciardi, 1991), villages might be abandoned for a number of reasons, ranging from excessive waste accumulation to a number of infant deaths(Hugh-Jones, 1978, 1985; Rivière, 1994: 197; Roe & Siegel, 1982:111; Schinkel, 1992: 188). It would appear that the life span or occupancy of a structure may be as much affected by cultural and spiritual beliefs as by environmental conditions.

Ethnohistoric comparisons

Eye-witness accounts of Taíno villages may assist reconstruction of aspects of the late Ostionoid village at Tutu. According to Fray Bartholomé de Las Casas (1929), in the Taíno village there was a plaza, three times longer than it was wide, that faced the door of the cacique's (chief's) house and was swept clean. The plaza was surrounded by "lomillos" [earth embankments? stone-alignments?] (Oliver, 1992). The villages that Las Casas observed (in Cuba, Hispaniola and the Bahamas principally) were not arranged in streets, except that the cacique's house was built in the best place and there were other houses very near it. If the village was a very large one, there were other plazas, or courts, which were of lesser size than the main one (Las Casas cited in Alegría 1983: 8; Oliver, 1992; Oliver & Righter, 1998). The Royal Chronicler/Historian of Castille and Leon, Gonzalo Fernandez de Oviedo y Valdes (1944[1]: 293, 296–300) noted that each Taíno village had a plaza where the

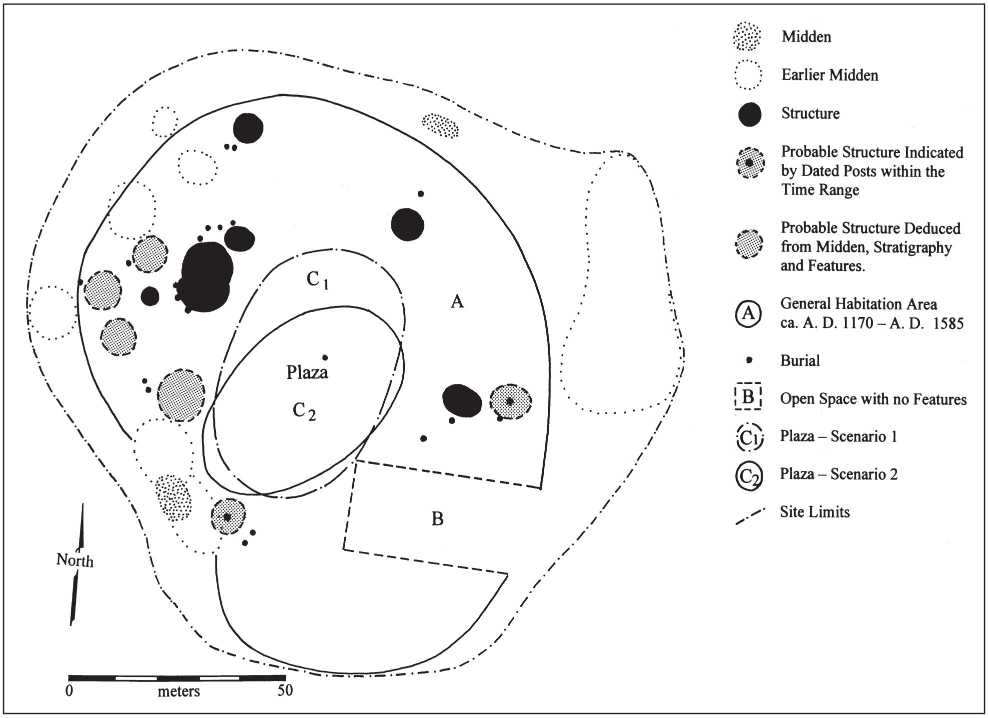

Figure 12.37 Diagram of the Tutu settlement layout, *c.* cal. AD 1170–1585 (2-sigma range) (drawn by Elizabeth Righter, graphic by Julie Smith).

Antillean rubber ball game, also called batey, was played and adds that in the outskirts of the villages were larger courts with seats to watch the game (Oliver, 1992: Oliver & Righter, 1998).

At Tutu, a central open space or plaza in the settlement was surrounded by houses and related structures, and there is some indication that Structures 7 and 8, built in the “best place” on the site, housed minor caciques and their household members. Although there is no direct evidence of an earthen or stone-lined ball court, the presence of an open space in Area 10 and rumors that a stone alignment had been observed on the site prior to mechanical scraping are suggestive of such.

Ethnohistoric accounts by such chroniclers such as Las Casas (1929, 1951, 1967), Gonzalo Fernández de Oviedo y Valdés (1944, 1959) and Pedro Mártir de Anglería (1964) provide more or less similar descriptions of Taíno houses at the time of European contact in the Greater Antilles and Bahamas (Curet, 1992: 161). Houses are described as circular in plan, constructed of frame posts, reed walls and straw roofs, with two doors and no windows. Door locations are not specified. Houses also are described as generally conical in shape (Cummins, 1992: 131; Curet, 1992: 161). Variation in the quality but not shapes of houses from island to island was observed by Columbus, and Cummins notes that during a stopover in an island believed to be Cuba, Columbus observed: “ I saw one beautiful house, not very large, with two doors like all the rest, and when I went in I found a marvelous construction, divided as it were into chambers in a way that I can not describe, with shells and other things hanging from the roof.” This description implies that there may have been two doors at the front of the house, a vernacular style on some islands today.

Table 12.4 Attributes of Tutu structures and related burials

Str. no.	*Shape*	*Area (m^2)*	*Est. roof height (m)*	*Period of occupation*	*Probably related burials*	*Entrance location and openings*	*Structure orientation*	*Attached appendages and detached arcs*	*Central posts*	*Exterior spatial divisions*
1	round	12	3.10	late	—	NE	NE–SW	2	—	3
2	round	34	5.26	late	22A, 22B	E and S	E–W or N–S	2	4	1
3	oval	29.42	—	late	6, 29	NE and NW	NE–SW	2	—	2
4	round	30.18	4.88	late	33, 34	not evident	not known	1	—	1
5	round	37.17	5.50	end of early	3? 16? 23A? 23B?	not evident	not known	no known	—	no known
6	oval	41.85	—	late	9, 40	not evident	NW–SE	no known	—	no known
7	(if oval)	unknown		late	38?	not evident	E–W	no known	3?	1?
7	(if round)	90	8.69	late	38?	not evident	E–W	no known	3	1?
8	oval	90.76	—	late	5, 8A, 8B, 11, 31, 39, 38?	SE and NW	NW–SE	2	—	5

Ethnohistorically eported house sizes vary and it is believed that larger houses were those belonging to village chiefs. According to Las Casas (1967: I: 243), the diameters of houses ranged between 9 m and 12 m. If the structures were round, floor areas would have been between 64 m^2 and 113 m^2. Larger, apparently chiefly, houses were reported by Mártir de Anglería (1964) as about 32 paces (between 26 m and 32 m) in diameter (Curet, 1992: 162). Despite the uncertainties of ethnohistorical accounts, and the fact that they refer to houses in the Bahamas, Cuba and Hispaniola, it is remarkable how well descriptions of structure and household sizes coincide with archaeological evidence from the Tutu site. Structures 7 and 8 at Tutu, with average diameters of 10.75 m (the dimensions of Structure 8 were, in fact, 9m by 12 m), fall within the 9m by 12 m size range reported by Las Casas.

Spanish ethnohistorical accounts indicate a considerable variability in residential practices among the Taíno (Keegan, 1989: 614, 620, 621). Keegan suggests that, in the Taíno system, both elites and commoners were likely to change their places of residence several times during their lifetimes. A high-ranking polygynous man tended to live in the village of his designated mother's brother, and brought his wives with him (Keegan, 1997). At the bottom of society, there was a variety of residential arrangements and the ultimate choice of residency might be decided by a mixture of political advantage, practical expedience and personal preference. If such were the case, the household of a powerful man might contain members of several different nuclear families, including nephews and sons of half-sisters, as well as several wives.

Las Casas reported that a number of related families lived in villages, but the details of the relationships between the residents are not clear from the accounts (Curet, 1992: 162). About 10 or more residents (neighbors/residents/citizens) per house are cited in one case and between 10 and 15 residents with wives and children in another. According to Curet, the implication is that the first description refers only to adult men in the household. Pané (1974: 48, 55) refers to a chiefly household of 16 or 17 people; but, again, Curet points out that the household is probably that of a low-status chief, and it is not clear whether everyone lived in the same house.

At Tutu, Structure 6 probably domiciled two family units, and Structure 8 apparently housed two or more family units. Estimating an indigenous family size of 5 people (Curet, 1992: 192; Siegel, 1989: 195), the number of occupants in a two-family-unit structure was about 10. Structure 8 may have housed three family units, or at least 15 individuals, close to the numbers supplied by Las Casas. The sizes of Structures 7 and 8, relative to other structures at Tutu, suggest occupation by persons of higher status than other villagers. Supporting this notion is the presence of subsoil caps that sealed the graves of Burials 8A, 8B and 11, associated with Structure 8, and Burial 38, probably associated with Structure 7 (Chapter 1). Graves of Burials 8A, 8B and 38 also contained hollowed out niches in clean subsoil, where heads and feet were placed. Such special configuration of the grave suggests intentional attempts at preservation of the deceased, an intent similar perhaps to that indicated by the opening and drying of a cacique's body by the fire, as described by Pané for the Taíno of Hispaniola (Bourne, 1906: 6). Special grave construction may be another indicator of special status of occupants of Structures 7 and 8. Skeleton 38 may have been that of a lower-status chief of the Tutu village, while the adult female and subadult burials related to Structure 8 may have been members of a chiefly household.

Comparison to other archaeological sites

The early occupation

Aspects of midden distribution and site configuration at Tutu may be compared with those of other Saladoid period sites in the region. Although the Tutu Saladoid artifacts bear many resemblances to those of Hacienda Grande, midden remnants at Tutu did not form a continuous ring around the site, as reported at Hacienda Grande (Rouse & Alegría, 1990), but were discrete deposits on the outside of the habitation area (Hugh-Jones, 1985; Rivière, 1994; Schinkel, 1992: 201–2). In this respect, although not oval in shape, the Saladoid Tutu village resembled the Indian Creek site in Antigua, the Golden Rock site in St Eustatius, and the Ostiones and Maisabel sites in Puerto Rico (Rouse, 1974: 168; Schinkel, 1992: 211; Watters, 1994: 292). At the Maisabel site there was a series of Saladoid midden mounds placed in a horseshoe-shaped configuration (Siegel, 1989: 193; 1995), and, like the Tutu site, the central area was a cemetery. The Maisabel site, however, was much larger than the Tutu village. In both midden distribution and shape, the Tutu village configuration also resembled the horseshoe-shaped Cuevas component at the Punta Candelero site in Puerto Rico (Rodríguez, 1991; Siegel, 1995; 1996: 319; Watters, 1994: 293). Cedrosan Saladoid sites at Cane Bay and Judith's Fancy in St Croix (Joseph, 1989; Payne & Thomas, 1988) are believed to be horseshoe-shaped in configuration, arranged around a semi-circular swale or hollow just inland from the seacoast. This pattern resembles that at Tutu, where fresh water, rather than the sea, is present at the base of the swale. Both a central burial area and house-related burials appeared to be present at Cane Bay, while at Judith's Fancy, only a central burial precinct was investigated.

Although some structures at the Saladoid Golden Rock site in St Eustatius had dimensions similar to those of the Tutu site, only Structure 5 at Tutu was similarly constructed.

The late occupation

In the Virgin Islands, late occupation sites archaeologically comparable to the Tutu site are few. In Puerto Rico, however, documented late Ostionoid sites provide evidence for settlements ranging from single structures (Rivera & Rodríguez, 1991) to villages organized around ball courts and/or central plazas, which served as the foci for social and religious gatherings (Alegría, 1983; Curet & Oliver, 1998; Oliver, 1992; Oliver & Righter, 1998; Rouse, 1992).

Structures with a circular pattern of exterior post holes and symmetrically placed deep central post holes, such as Structures 2 and 7 at Tutu, are known for neither the Saladoid Golden Rock site in St Eustatius, nor the post-Saladoid Tanki Flip site in Aruba. A structure, larger but very similar to Structure 2 at Tutu, however, has been reported from the Ostionoid period Lujan site in Vieques (Rivera, 1997). Details of this structure are not yet published. A structure with post holes in an oval pattern and four large central post holes was recorded by Jose Oliver at FAL–7 in the Matícora Valley of Venezuela (Oliver, 1997: Figures 287, 288). Although this structure is about three times the size of Structure 2 at the Tutu site, sets of three grouped post holes are present in the exterior wall and central "corridors" are present, as they are in Structure 2. The house at FAL–7 is associated with the Maticora ceramic style, found only at interfluvial sites and with an estimated chronological range of between *c.* AD 600 and AD 1400. Dates for Structures 2 and 7 at the Tutu site fall within this range, but there are no known direct cultural connections. Oliver (1997: 363) raises the question of the degree to which house plans are conceptual and spatial (or cognitive blueprints), regardless of associated ceramic styles.

At the Playa Blanca site in Puerto Rico, a structure 7.14 m long and 6.64 m wide, with an area of about 37 m^2, was investigated (Curet, 1992; Rivera & Rodríguez, 1991). The dimensions of the structure, dated to between AD 1200 and AD 1500, are similar to those of Structures 2 and 6 at Tutu. The Puerto Rican structure is significant in that it supports the Tutu evidence of small to medium-sized houses during the late occupation. This pattern is quite different from a settlement of large and smaller maloccas observed at the earlier Saladoid period Golden Rock site in St Eustatius or the large malocca reported by Siegel for the early Ostionoid period at the Maisabel site in Puerto Rico.

The oval configuration of outer post holes of Structures 6 and 8 at the Tutu site, and the circular configuration of outer post holes of Structure 4, may resemble oval maloccas and smaller circular houses identified at the Tanki Flip site in Aruba (Bartone & Versteeg, 1997; Versteeg & Rostain, 1997), but patterns of interior posts and other information are needed to make a full comparison.

Although the landscape of St Thomas has been significantly altered by development, and many prehistoric sites have been lost, it is possible that systematic survey of remaining undisturbed portions of the Turpentine Run watershed might reveal a series of settlements and settlement types extending along Turpentine Run from the coast to the inland valley of Tutu. At the same time, investigation of a known late Ostionoid site at Botany Bay and additional survey of the east end of St Thomas may yield evidence of hierarchically stratified villages similar to those reported in eastern Puerto Rico (Curet & Oliver, 1998; Wild, 1999).

Evidence for social change

Using a chronological chart, Curet & Oliver (1998: Figure 2, 223–27, 233) suggest that, as chiefdoms emerged in eastern Puerto Rico, sometime between the period assigned to the Cuevas style (*c.* AD 400–600) and the Santa Elena style (AD 900–1200), there was a change in burial practices along with a shift in household size and composition from extended to nuclear families. The authors argue for the emerging importance of the household in the management of communal resources, and suggest a hierarchy of households in which management of resources and political leadership of the community were passed only to particular elite individuals or families. Although not defined, a "household" is the most important social unit below the level of community.

Similar patterns may be observed at the Tutu site. The archaeological evidence from Tutu suggests a change in burial patterns at the end of the early occupation of the site (sometime between *c.* AD 640 and AD 870), a time when Saladoid series ceramics were still evident at Tutu, but the Monserrate ceramic style is present in eastern Puerto Rico (Curet & Oliver, 1998; Rouse, 1992). At Tutu, the observed burial distribution pattern of the early occupation carries into the later occupation, with a distinct shift in emphasis (Chapter 1). Use of the cemetery becomes minimal and burials are almost entirely house-related. Burials usually are grouped in areas just outside small to medium-sized structures which appear to be domiciles of the deceased. While consanguinal relationships of buried individuals at Tutu are not entirely unequivocal, the spatial closeness of the graves, and a lack of differentiation by age and gender, suggest persons closely related, i.e. nuclear families or "family units" which might include more than one wife and closely related kin (Keegan, 1997). Burial groups present in distinctly separate burial areas related to one house, or on opposite sides of a single structure, suggest occupancy by at least two household units. The propinquity of older adult burials to infants suggests a grandparent, great-aunt or great-uncle relationship.

Saladoid villages have been characterized as egalitarian, highly structured, self-contained and sedentary (Siegel, 1989: 318; 1991; Spencer, 1987). At Tutu, however, use of a central burial precinct at the same time that house-related burials occur suggests symboling of a special group, most likely a unilinear descent group, in the cemetery (Curet & Oliver, 1998; Kingsley, 1985). Curet & Oliver (1998: 229) assert that, "it is reasonable to infer that central cemeteries reflect the presence of some kind of corporate group with a social organization based on lineal descent among the Saladoid people of Puerto Rico." Boomert (1999: 4) also notes a "worldwide cross-cultural association between localized cemeteries and the importance of exogamous unilineal descent groups."

At Tutu, use of the cemetery persists, at least for certain members of society, as indicated by the interment of Burial 26 in the central area or plaza. Nevertheless, house-related burials predominate and represent a significant change from the previous Saladoid period.

In Kingsley's Chiefdom II societies, the importance of unilineal descent groups declines markedly, along with the incidence of burial in disposal areas, and house-related burials increase (Kingsley, 1985: 43, 210). Unilineal descent groups have no power and the family, or extended family, has probably become the important kin-based unit. The normative mode of disposal for commoners is house-related, in family or extended family groups, and spatial differentiation probably reflects differences in vertical status. Findings at Tutu conform to this description, except that there is no indication of social differentiation by spatial separation of burials by age or sex, and there is no evidence of dietary privilege (see Chapter 10).

In summary, a village structure of houses arranged around a central plaza, a pattern of house-based burials indicative of a complex chiefdom level of social organization (Kingsley, 1985; Wilson, 1997: 46), evidence of substantial permanent population, and the presence of ball belts and a massive stone zemi in process of manufacture (Chapter 1), are among indications that the late occupation inhabitants of the Tutu site participated in the same social and ceremonial life as the Taínos of eastern Puerto Rico (Oliver, 1998; Rouse, 1992). The absence of indicators of a village with a high or paramount chief (Curet, 1992: 162; Las Casas, 1967) suggests that Tutu probably was a minor village in a hierarchy of villages under a paramount chief who lived elsewhere.

Chapter Thirteen

Site analysis

Elizabeth Righter

INTRODUCTION

The Tutu site is the only known major inland site on St Thomas, USVI, and its setting and topography must have been important factors in selection of the site for settlement. Located at the vortex of two upland tributaries of what, in the past, was probably a continuously flowing water course, the site provided access to a wide variety of terrestrial and marine resources. Among the many favorable attributes of the Tutu setting was the availability of a broad expanse of flat land suitable for establishment of a settlement in which structures were dispersed around a central open area (common ground, cemetery and/or plaza). Other attributes included proximity to fresh water for drinking and bathing, access to large trees for house construction, coastal access via a major water course, adequate rainfall and fertile land (most likely in the nearby mountains and foothills) for gardening, a consistent cooling tradewind, and seclusion from enemies.

As a result of investigations at the Tutu site, a portrait of site ecology and human adaptation to the physical environment of the site and its environs has emerged. Within this environment, the human occupants of the site exploited the natural resources, and carried out their cultural, social, political and spiritual lives. The natural environment provided subsistence and, at the same time, constrained the lifestyles and health of the Tutu residents. Results of analytical studies presented in this volume point up the complex and constantly changing feedback interrelationships between the natural environment, human behavior and human health between initial site settlement about AD 65 and termination of the village at or about the time of Columbus' arrival in the New World.

SYNTHESIS OF FINDINGS FROM ANALYTICAL STUDIES

Trees and plants were used in almost all aspects of Tutu life, supplying materials for shelter (houses and other structures); transportation (canoes); food and fuel (fires for cooking, pottery firing, insect control and, probably, at some times for warmth); tools and implements; containers; body adornment; hallucinogens; and religious objects (Chapters 2 and 3). Decoration of the body with plant-derived dyes and the use of plants in burial ceremonies, or to accompany the dead, is inferred from recovered artifacts and from two of the Tutu burials (Chapter 1). Table 13.1 indicates the types of Tutu charred plant and tree samples analyzed by Pearsall (Chapter 2) and their temporal contexts.

Wood species that were present as posts at Tutu included cf. *Acacia, Cassine, Croton, Guaiacum* posts and one post of Tutu Type 6 wood (Chapter 2). *Guaiacum* was predominant among woods used as posts (especially prominent as the large central posts of Structure 2), and cf. *Acacia*, which was also used for other purposes, was the second most commonly occurring post wood.

A major category of plant remains found in the Tutu phytolith record (but probably too soft to survive in any abundance as charred plant remains) derive from the Palmae (palms). These could not be identified below the subfamily level, but all of the palm phytoliths were the "spherical, spinulated" variety, which could have been contributed by such genera as *Scheelia*, *Sabal*, and *Elaeis* (Chapter 3). Palms most likely were used as roof thatching and perhaps in the construction of mats used for a variety of purposes including as wind screens (Figure 12.14) and baskets. At the same time that these plant materials were useful in the construction of shelters, they also needed constant repair and replacement. Factors, such as infestation of the roof by vermin and post decay, led to short structure life spans and impermanency, which resulted in a fluid and ever-changing architectural landscape within the general village configuration. Events, such as a series of misfortunes, infant deaths or death of the village leader, also probably contributed to ongoing replacement of structures, and fluctuations in village occupancy.

Pearsall's recovery of probable cotton seeds in the Tutu flotation samples (Chapter 2) and the presence of artifacts identified as ceramic cotton spindle whorls (in post-Saladoid contexts) suggest the spinning and weaving of cotton to fashion a number of items, such as body ornaments, hammocks, sacks and mats.

Like Pearsall, Piperno found evidence for the use of root crops as subsistence foods. Piperno found one of the most abundant plant families to be herbaceous Marantaceae to which *Marantha arundinacea* (arrowroot) and Calathea belong. Piperno also found abundant evidence of either wild or domesticated *Cucurbita*; while Pearsall found a wide array of food plants including tree fruits such as hackberry, wild fig, mastic and guava; passion fruit; ground cherry; wild beans; purslane; and root/tuber foods. There is also evidence of the consumption of maize during the late occupation of the site. Pearsall suggests that the lack of maize in the early samples may be attributable to differential preservation of the fragile charred maize remains. Endosperm fragments of smaller seeds dominated in the early period, while during the late occupation there is evidence for a very large increase in seed coat/rind fragments (Chapter 2). Combined with the doubling of dense cotyledon material and Sapotaceae fruit fragments, the evidence suggests increased use of tree fruits, including Sapotaceae, in the late period, where roots and tree fruits account for the majority of plant food remains.

Piperno has interpreted the rarity of grass and other weedy-type phytoliths, such as sedges (Cyperaceae) and Compositae, to mean that there was little environmental modification near the site. The preponderance of other evidence, however, suggests that major portions of the site were open and probably clear of vegetation (Chapter 12), perhaps accounting for the absence of grass phytoliths. The presence of seeds, of cheno-ams, purslane, *Talinum*, the mallow family and the grass family (Chapter 2), also suggests a site that was fairly open and disturbed by human activities. This finding coincides with evidence of the purposeful functional division of space around structures (space which was kept open and probably exposed to subsoil) and an open central plaza which was continually swept clean (Chapter 12). Ethnographic accounts describe South American villages as hot, dusty places (Rivière, 1994).

In addition to plant resources, Tutu's inhabitants relied for food on a variety of terrestrial and marine animals. The majority of these were fishes (Figure 13.1, lower), supplemented by smaller numbers of mollusks, crustaceans and echinoids, mammals, birds and reptiles (Chapter 4). Reef fishes, such as jacks and parrotfishes, were exploited consistently throughout the occupation of the Tutu site, comprising about 30 percent MNI of the fauna. In the early deposits at Tutu, the key

Table 13.1 Radiocarbon dates for structural post wood, other wood and other botanical remains found in post holes of the Tutu site[a]

Post	*Structure*	*Area*	*Post wood type*	*2-sigma date range*	*1-sigma date range*	*Other botanical remains in post hole*
P-1		1				Tutu seed type 22
P-3	7	1	*Acacia* post			
P-4A	7	1	*Acacia* post	AD 1265–1415	AD 1285–1395	*Brysonima* fruit
P-8	1	9N				Seed 4; porous root/tuber; cf. *Brysonima* (seed 21);
P-41(1)A	7	1	*Croton* post	AD 960–1410	AD 1030–1290	
P-53 A/B	7	1	Tutu type 6 post	AD 1270–1420	AD 1290–1400	*Acacia* (T1/2/4); *Bourreria* (T14); *Cassine* (T13); cf. *Savia* (T8); cf. *Chrysobalanus* (T7); seed 4, 13; Sapotaceae (seed 14/15); seed soat/rind fragments; cf. *Brysonima* (seed 21); cf. *Gossypium* (seed 10); Tutu seed type 17a; porous endosperm fragment; porous root/tuber; cf. *Ficus* calyx; Gramineae small elongated (Seed 6); Gramineae small (Seed 7/24); termite dung; *Malvastrum*; Tutu seed type 22; Tutu seed type 23
P-60		1				Seed 4, 13; porous root tuber
P-61	7	1		AD 1215–1405	AD 1265–1310, AD 1365–75	*Acacia* (T1/2/4); *Croton* (T5)
P-92	8	1		AD 1300–1650	AD 1405–95	*Acacia* (T1/2/4); cf. *Chrysobalanus* (T7); *Croton* (T5); cf. *Savia* (T8)
P-94		1				*Acacia* (T1/2/4); cf. Myrtaceae (T10); cf. *Phyllanthus* (T11); *Savia* (T8)
P-111A		1	*Acacia* post	AD 600–780	AD 640–90	
P-114	7	1		AD 1225–1400	AD 1270–1305	*Acacia* (T1/2/4); *Croton* (T5); *Guaiacum* (T9); cf. *Mastichodendron* (T3); cf. *Savia* (T8); cf. Myrtaceae (T10)
P-121		1	*Acacia* post	Modern		
P-131		2	*Acacia* post	AD 1180–1410	AD 1250–1310, AD 1365–75	
P-214A		2	*Acacia* post	AD 890–1300	AD 1010–1260	
P-294 (1)A		1	*Acacia* post	AD 1395–1650	AD 1420–1505, AD 1595–1620	
P-401	2	3	*Guaiacum* post			
P-402(1)	2	3	*Guaiacum* post			

(continued on next page)

Table 13.1 (cont.)

Post	*Structure*	*Area*	*Post wood type*	*2-sigma date range*	*1-sigma date range*	*Other botanical remains in post hole*
P-407A	2	3	*Guaiacum* post	AD 1040–1300	AD 1180–1280	
P-407B	2	3	*Guaiacum* post	Ditto	Ditto	
P-410B	2	3	*Guaiacum* post			
P-413A	2	3	*Guaiacum* post			
P-419A	2	3	*Guaiacum* post			
P-436		3				cf. *Mastichodendron* (T3); cf. *Savia* (T8)
P-442		3	(B-22A, 22B)	AD 1275–1310, AD 1365–75	AD 1285–1300	*Acacia* (T1/2/4); Tutu 6 unknown
P-455		3				*Acacia* (T1/2/4); *Bourreria* (T14); cf. *Savia* (T8), *Acacia* (T1/2/4); *Cassine* (T13); *Croton* (T5); cf. *Mastichodendron* (T3); cf. *Savia* (T8); Tutu 6 unknown; Tutu 15 unknown
P-457		3				
P-463(2)	2	3	*Acacia* post			
P-466A	2	3	*Acacia* post			
P-467A	2	3				*Acacia* (T1/2/4); Tutu 16 unknown
P-760A	8	1	*Acacia* post	AD 1310–1355, AD 1385–1475	AD 1405–1445	
P-783	Hearth	1				*Acacia* (T1/2/4); cf. *Savia* (T8)
P-924		1				*Acacia* (T1/2/4); cf. *Savia* (T8)
P-1768	7?	1	*Acacia* post			*Acacia* (T1/2/4); *Bourreria* (T14)
P-1841	8	1		AD 1285–1430	AD 1300–1410	*Croton* (T5)
P-1915	8	1				*Acacia* (T1/2/4); *Bourerria* (T14); *Cassine* (T13); *Croton* (T5); cf. *Savia* (T8); Tutu 15 unknown
P-3017		1	*Acacia* post			
P-3078		1				*Cassine* (T13); cf. *Chrysobalanus* (T7); cf. *Mastichodendron* (T3); cf. *Savia* (T8); cf. Myrtaceae (T10); *Piscidia* (T12)

Note
a Botanical information taken from Chapter 2 and associated work by Deborah Pearsall.

Figure 13.1 Upper left: *Trichechus manatus* (manatee) upper molar; Upper right: *Trichechus manatus* (manatee) ear bone; Lower left: Scombridae Tunini (tunafish) vertebra; Lower middle left: *Haemulon* sp. (grunt) vertebra; Lower middle right: *Halichoeres* cf. radiatus (pudding wife) upper pharyngeal grinding mill; Lower right: *Balistes* sp. (triggerfish) teeth.

species are jacks, which swim over reefs and feed on resident fishes but also are in the inshore habitats. In the later deposits, along with jacks, territorial reef carnivores such as grouper, snapper and grunts are less abundant, and are replaced by parrotfishes, which are territorial reef dwellers. The sizes of jacks and herrings do not change significantly through time at the Tutu site, but, in the later time period samples, two predatory fishes (grouper and snapper) have smaller mean sizes and ranges, and the numbers of reef omnivores and herbivores increase relative to reef carnivores.

Rocky intertidal zone mollusks (primarily marine gastropods, chitons, and limpets) average 18 percent MNI for the site as a whole. In the later deposits at Tutu, Gecarcinid crabs are smaller (the average weight estimated to be 188 g), and Wing *et al.* find that *Cittarium pica* (West Indian topshells, or welks as they are locally known) are only about half as large in the later deposits at Tutu as those gathered by the early occupants of the St Thomas Main Street site. Wing and collaborators also note that, in the late occupation of the Tutu site, despite a greater diversification in fishing and gathering, new resources were not incorporated into the food quest. As animal resources declined, fishing was intensified rather than expanded, and alternative exploitative methods, such as managing the *Isolobodon portoricensis* for food, were not undertaken. As a result, populations of many intensely exploited animals were affected, declining in numbers and individual sizes. As a response to these changes, the Tutu inhabitants more intensively exploited all three aquatic habitats (intertidal, inshore, and reef), and fewer animal resources from the land were used. This greater breadth in the quest for animals of generally smaller size during the late occupation of the site is evidence for increased stress on the Tutu population, which may be reflected, perhaps, in increased infectious disease and a higher incidence of child mortality.

Among remains of large reptiles and mammals recovered from the Tutu site were the carapace and major bones of a green turtle buried in a midden from the early occupation. The circumstances of disposal of this animal and its situation among flat rocks near a hearth are open to interpretation (Chapter 1). A finely crafted conch shell pendant, in the form of a swimming turtle, however, testifies to the importance of this animal in the symbolic life of the Tutu inhabitants. Other turtle remains found in early occupation middens indicate that the animal was an important source of food. Manatee remains (Figure 13.1, upper), widely dispersed at the site, were recovered from early post hole contexts and from late occupation midden deposits and post holes. Although it is unknown whether the entire animal was schlepped to the site, or was butchered at the shore and brought to the site in pieces, recovery of a manatee ear bone and teeth (Figure 13.1, upper) affirms the presence of the head at the site. Ribs also were recovered, and it is likely that, after an animal was killed, it was butchered and distributed among the site's inhabitants. The greasy quality of a late midden remnant in Area 9S, and the recovery of manatee ribs from Trench 9 fill, suggest manatee roasting and feasting nearby.

Studies such as those by Larsen *et al.* (Chapter 8) find a relatively high incidence of tooth caries at Tutu, compared to populations from eastern North America. The researchers suggest that this condition results from the utilization of domesticated plants in the diet, while Wing *et al.* (Chapter

4) attribute caries to "a diet that included sweet fruits and sticky starches … both presumed to be part of the Tutu diet". Among contributing factors also probably was the habitual consumption of manioc; the presence of stone grater teeth, ceramic griddles and a fire-dog used to support griddles on a hearth (Chapter 1) affirms this proposition. While maize may have been a contributing factor to tooth caries, there is little evidence for dietary dependence upon this crop (Chapters 2 and 3).

There is a slight decrease in caries in the late population at the Tutu site, which may be attributed to an increase in consumption of marine food (Chapter 8). The dental evidence is supported by the findings in Chapter 4 that, although land animals were important throughout the site's history, they comprised between 39 and 55 percent of edible fauna in early occupation faunal samples; and during the later Ostionoid period, only 17 percent of the edible faunal assemblage are land animals. Results of Farnum and Sandford's trace element analyses (Chapter 9) indicated that the Tutu people were consuming a mixed marine and terrestrial diet, with a shift from a lesser to greater reliance on marine foods in the later (AD 1170–1535) time period. Finally, as a result of stable isotope analysis of 24 human bone samples from Tutu, Norr (Chapter 10) found indications of a diet comprised of predominantly marine fauna plus terrestrial fauna and C^3 cultigens, but found no noticeable differences between early and late samples.

In some cases, food preparation methods may have affected the dentition of the Tutu inhabitants, which, in turn, affected their overall health. For example, occlusal surface wear, observed in the Tutu deceased population, most likely was related to the inclusion of hard particles that adhered to commonly eaten foods, such as fish, shellfish, and other marine foods, and to the consumption of foods prepared with grinding stones.

Age-at-death statistics during the early occupation of the Tutu site tend to support the notion of a generally healthy population that, similar to other indigenous populations of the area, had an expected maximum life span of about 55 years (Chapters1 and 7). During the late occupation of the site, however, there is an increase in deceased individuals between 2 and 9 years old and a decrease in the percentage that lived to between 35 and 55 years of age (Righter, 2001; Chapter 7, this volume), which may be the result of an increase in infectious disease and a general decline in health of the population due to food shortages (over-exploitation of certain faunal food resources; see Chapter 4). There is evidence also for sociopolitical change which may have led to socio-psychological stress related to increased sedentism and overcrowding (Chapters 1 and 12).

Normally, populations that are experiencing stress tend to have a generally high frequency of tooth enamel defects. Larsen and coworkers, however, found a quite low prevalence of tooth enamel defects among the successive Tutu populations, indicating relatively good health. The number of paleopathological conditions that were present, including treponematosis, non-specific skeletal infections, iron deficiency anemia, and a relatively high infectious disease rate that increased during the late occupation of the site (Chapter 7) suggest otherwise. Larsen *et al.* hypothesize that these paleopathological conditions may not have been expressed in tooth enamel defects; and perhaps infectious disease was not affecting the Tutu individuals during the critical years of growth and development of the tooth crowns (0–6 years), but rather, later in life when it was manifested on skeletal elements.

Analysis by Larsen *et al.* (Chapter 8), and artifact analysis (Chapter 1), provide clues to plants that were processed with manufactured implements and with human teeth, and the types of processing involved. The presence of multipurpose *Cypraea zebra* shell implements and scrapers and other implements of *Strombus gigas* nodes indicates such activities as scraping soft organic materials, including cassava and other root crops, cleaning and rubbing or scooping pulp from calabash and other gourd-like fruit, peeling rinds (perhaps *Cucurbita*) and vines, rubbing and smoothing clay objects and even spooning up contents of ceramic or calabash bowls. Larsen and coworkers found that, among the Tutu adult population, the microwear pattern indicates a front-to-back motion of material dragged across the anterior upper dentition. Teeth, therefore, may have been used in tasks similar or ancillary to those performed by multipurpose shell tools. Such tasks might include the shredding or peeling of manioc and other tuberous plants.

Faunal material was used to fashion a variety of artifacts at Tutu. A broken pendant fashioned from a *Monachus tropicalis* (monk seal) incisor suggests trade in monk seal teeth and perhaps mandibles (van der Klift, 1992) from which teeth were extracted to fashion ornaments and fetishes. Although the presence of the monk seal tooth at Tutu is not proof that the now-extinct monk seals formerly were available in St Thomas waters, monk seal remains were recovered from middens excavated by Elizabeth Righter on Guana Island (personal communication, Dr. James Lazell) and Wing (personal communication) has identified the animal's bones in samples from other Caribbean islands. Two brachiostegal fish rays, one of which had been fire-hardened, were used as awls or punches, and a drilled *Balistes* (triggerfish) tooth must have been used as a pendant (Chapter 1). Other bone artifacts were diverse and enigmatic.

Although whole *Strombus gigas* shells were rare at the site, suggesting that the meat was processed at the coast, *Strombus gigas* shell was used for a number of purposes including manufacture of discoidal beads and inlays, celts, scrapers, religious objects such as zemis, gorgets, pendants, and idols or fetishes. Beads, tinklers and other artifacts were fashioned from shells such as *Cypraea zebra*, *Cypraecassis testiculus, Conus* sp.*, Spondyllus americanus, Chama sarda, Astraea, Oliva* sp., and *Isognoman alatus*. It is likely that feathers were inserted for ornamentation in some beads (sometimes in transverse holes) and pendants. The variety of beads ranged from a large round perforated quartz bead to tiny flat discoidal beads crafted from several shell species. These, and *Strombus* sp. shell gorgets, *Oliva* sp. shell tinklers, and bone and stone pendants, attest to a strong cultural interest in body adornments, which included objects that made musical sounds. Among recovered items, also, were a number of raw crystals, some with smoothed ends, that may have been prized as religious objects or curing devices.

Important to food gathering, preparation and consumption are containers. In some cases, natural products such as calabash rinds, gourds or turtle carapaces could be used as containers, but for other purposes, such as stewing meals or broth over fires, transporting potable water or long-term storage, ceramic vessels were manufactured. Some fired clay vessels also were used in religious ceremonies; and others, included in graves, may have been heirlooms, specially produced grave goods, items with special meaning to the deceased, or items considered necessary in the afterlife.

While the process of producing ceramic vessels involved knowledge and skill brought to the Caribbean islands from the South American homeland, according to findings of the research team of Lundberg, Burton and Lynn (Chapter 6), there was no evidence for the importation of clays during either the early or late occupation of the Tutu site; only clays available at the Tutu site were identified.

During occupation of the Tutu site, stylistic ceramic attributes changed and evolved, reflecting technological innovation as well as a variety of cultural and social influences. The settlers of the Tutu site, who arrived fairly late in the period of initial Ceramic Age migration and settlement of the Caribbean islands, initially used a ceramic kit that included modes identified with early Saladoid styles such as the Hacienda Grande style in Puerto Rico. This assemblage is dated by Lundberg (Chapter 5) between approximately AD 100 and AD 400. As ceramic styles changed, a "Cuevas-like" Saladoid component, later than Assemblage 1 but having many similarities to it, evolved. Lundberg suggests that Assemblage 2 at Tutu can be considered a Tutu aspect of the Virgin Islands Coral Bay style which, unlike the Cuevas style in Puerto Rico (Rouse, 1992: Figure 14), continues to evolve into Assemblage 3 which Lundberg has identified as the Longfordian style. It is evident that, at Tutu, observable stylistic modes, in the Saladoid tradition, continued to evolve at the same time that new ceramic series were developing on Puerto Rico and neighboring islands, and perhaps on St Thomas itself (Rouse, 1992: Figure 14). Following an hiatus of about 200 years in site occupation, the final ceramic assemblage from Tutu conforms to the Chichan

Ostionoid subseries which has a temporal position of between *c.* AD 1200 and AD 1500, consistent with Puerto Rican chronology.

By applying an acid-extraction method of inductively coupled plasma emission spectroscopy (ICP), Lundberg *et al.* (Chapter 6) discovered technological changes in ceramic production at the Tutu site, and it was found that a distinction in mixed igneous sand and the felsic tempers could be attributed to clay selection. ICP analysis also showed that, running counter to the stylistic evidence during the period associated with Assemblage 3 at Tutu, one or more production recipes for mixed-temper ware were mostly abandoned, and another was adopted, or at least became more prominent. This change in ceramic production (which was not easy to detect) supports burial evidence that the Tutu population was undergoing cultural change at the end of the early occupation. Whatever the causes of this change, it apparently led to a period of site abandonment or severe population reduction for at least 200 years.

The clearest discontinuity in the chemical element data occurs between ceramic Assemblages 3 and 4, which are separated by a temporal gap, but this applies only to sherds of felsic temper. This apparent change in the process of pottery production may be explained by the gradual establishment of proven pottery recipes following experimentation with local resources, and/or by the introduction of new ideas (Chapter 6). In general, the Chican-Ostionoid pottery of the late Tutu occupation suggests a population that, by that time, was closely integrated with other Taínos in the region.

The Tutu flaked stone industry and artifacts (Chapter 11) provided a number of tools essential for daily life. Included in the inventory were a number of subdiscoidal and irregular flake cores, core tools, flakes retouched into scrapers, burins on flakes, utilized unretouched flakes, other unretouched flakes and blades, and a quantity of angular debris. Although there was a shortage of manufacturing debitage, found at the site, there is no doubt that flaking took place on site. Given the fact that many non-midden areas of the Tutu site, including lithic manufacturing areas, had been scraped of topsoil, it is likely that production debitage had been removed by the time of the archaeological investigations. The Tutu lithic collection also included fragments of ground artifacts (some of which showed signs of deliberate flaking), and "pecking stones" which may have been used in the manufacture of ground stone artifacts.

In order to cut large trees used in house and canoe construction, and to shape large post points, a diverse woodworking toolkit must have been necessary at Tutu. The early occupation stone toolkit included plano-plano and plano-convex rectangular stone adzes, and stone celts and chisels, which according to Walker (Chapter 1, p. 85) were manufactured on-site. An extensive amount of stone tool re-use suggests that, after initial phases of site occupation, necessary durable lithic materials became increasingly unavailable to the Tutu inhabitants. This supports other evidence of cultural change at Tutu.

The early settlers at Tutu may have arrived at the site after an hypothesized pan-Caribbean trade in semi-precious and exotic stones and objects had tapered off (Cody, 1991a; Rodríguez, 1991b; Chanlatte Baik & Narganes-Storde, 1983; Crock & Bartone, 1998; Rouse, 1992; Watters & Scaglione, 1994; Vescelius & Robinson, 1979). However, many Tutu artifacts, such as ceramic Assemblage 1 (Chapter 5), lithic toolkit types, green stone inlays, green discoidal beads, cylindrical calcite and quartz beads, shell beads, shell gorgets and small shell and coral zemis, are similar to those found at Hacienda Grande, Puerto Rico (Alegría, 1981; Narganes-Storde, 1995; Payne & Thomas, 1988; Rouse, 1992) and indicate that the people of Tutu shared in the same general culture. The difference was that the Tutu people tended to fashion their objects on-site, re-used their durable stone tools, and obtained raw lithic materials either on-site, on St Thomas, or from islands to the east and northeast.

During the early occupation at Tutu, there is strong evidence for on-site production of small lapidary ceremonial and ornamental objects, which mimicked those in semi-precious stone on other islands. Cylindrical clear quartz and calcite beads and a single barrel-shaped amethystine quartz bead from Tutu may have been obtained in trade; however, the availability of quartz and calcite at the Tutu site, and amethystine quartz on Tortola (personal communication, Alan O'Hara), suggests a possibility of their manufacture on-site. Green chert is available locally on St Thomas, and calcium carbonate and green quartzite are present on Virgin Gorda. At Tutu, the occurrence of inlay preforms of these materials, so-called "cultural jade" (Cody, 1991a), is clear indication that finished objects were produced at Tutu.

During the late occupation at Tutu, the presence of massive stone ceremonial objects produced in batholithic rock available on Virgin Gorda indicates continuity in procurement and/or exchange patterns in an interaction sphere centered on Pillsbury Sound, Drakes Channel and today's British Virgin Islands.

Objects of ornamentation and magico-religious objects, such as green stone inlays, are found in dispersed midden at Tutu, associated with early occupation houses, and in thick midden just west of the plaza. This disposal pattern suggests ceremonial or sacred "ritual disposal" rather than a "Big Man" society (Boomert, 1999). It is likely that the majority of Tutu's inhabitants could not afford to participate in an expensive trade in semi-precious and exotic stone and objects, which might have allowed disposable wealth such as that hypothesized in a "potlatch"-like cultural expression. Rather, in order to support the ritual and ceremonial life which they shared with other Saladoid people, and to satisfy a desire for objects of bodily adornment, the inhabitants at Tutu produced the majority of the necessary objects from "inexpensive" raw materials that could be obtained locally or from islands to the east and northeast. These objects of spiritual and personal value most likely were offered during ritual feasting and disposal associated with human burial and ancestor worship.

Some aspects of the Tutu environment may not have been beneficial to the Tutu inhabitants. In their study of human skeletal remains from the site, Sandford *et al.* (Chapter 7) note the presence of cribra orbitalia and/or porotic hyperostosis. In subadults, these conditions are believed often to be indicative of an on-going iron deficiency, while their occurrence in adults is reflective of past episode(s) of the disorder, that may affect the overall health of the adults. Individuals from the Tutu site may have had difficulty maintaining iron homeostasis for a variety of reasons, including the synergistic interaction of environmental and dietary factors; i.e. parasitic burdens may have been responsible for iron losses; or the consumption of manioc (which contains fiber and phytate) may have hindered iron absorption by forming insoluble complexes with iron.

Sandford *et al.* (Chapter 7) also note upper body robusticity in several specimens, which often occurs in association with degenerative joint changes, which may reflect long-term stress on bones and articular surfaces. Also, bone inflammatory lesions, ranging from simple periosteal reactions to more dramatic presentations, and similar to those described in modern clinical cases of endemic treponematoses and in archaeological samples from the New World, were quite common among the inhabitants of the Tutu site. During the late period at Tutu, lesions typical of more severe infections were found among the population, and diffuse pitting (on both cranial and postcranial bones), periosteal plaques, and cortical thickening were more commonly encountered in late period skeletons. Differences between the Saladoid and Ostionoid peoples with respect to the severity and distribution of bone inflammatory lesions may be related to changes in disease-host evolution and interactions, and to apparent dietary and ecological changes that transpired during Ostionoid times, as suggested by studies of the Tutu botanical and faunal remains (Chapters 2, 3, 4 and 7; Sandford, Bogdan & Kissling, 1997).

Thus, while dental analysis suggested to some researchers (Chapter 8) that the Tutu population was generally healthy, Wing *et al.* (Chapter 4) point out the hardships of daily life: "Life does not appear to have been easy on St Thomas during prehistoric times. There is evidence from the human remains of stress as seen in the Harris lines … iron deficiency, substantial tooth wear, tooth loss, and caries (Chapter 7). The great upper body development observed among some of the deceased adult male population at Tutu results from heavy work which may have been the efforts involved in cutting lignum vitae trees, paddling canoes, pulling seines, transporting marine resources to the inland site, and all of the other hard physical work needed to maintain life at Tutu." Ball playing may account for enlargement of left ulnas in some males and for degenerative changes of the elbow (Moreau, 1985; Righter *et al.*, 1993; Sandford, Bogdan & Kissling, 1997).

Midden and feature distributions during the early occupation of Tutu suggest a village plan with a central plaza/burial precinct, structures dispersed around it, and discontinuous middens to the rear. The roughly horseshoe-shaped village configuration conformed to the contours of the site and wrapped around a swale which bordered the western edge of the central open area/burial precinct and extended to Turpentine Run. No structures apparently were present where the top of the swale met the western edge of the plaza.

When the second occupation began at the Tutu site, the swale west of the plaza had been partially filled with refuse. The configuration of the second village, which evidently was well populated and permanent, was more circular than previously, with the central open space still in the low, flat center of the site. There is evidence for expansion of the village to the north, northeast and northwest. It is uncertain whether there was a second plaza or ball court in an unoccupied large rectangular space in the southeastern portion of the site.

At the Tutu site, 8 post and thatch structures were identified – 1 from the early occupation and 7 from the late. *Guaiacum* was predominant among woods used as posts (especially for the large central posts of Structure 2), and cf. *Acacia* (which also was used for purposes other than house posts) was the second most commonly occurring post wood. House construction materials at Tutu, such as wood posts and palm thatch, probably were similar in both site occupations. An interesting feature of some house posts of both occupations was intentional exterior charring of post tips to strengthen them and protect them against decay and infestation by destructive organisms. Marks of stone tools used to sharpen points of post ends were evident under the exterior charring.

Although only one structure from the early occupation was identified at Tutu, several individually dated posts in areas crowded with post holes indicate the presence of a number of additional structures during this time period (Chapter 12). Unfortunately, there is not enough evidence from Tutu to make meaningful statements about the natures and sizes of early occupation structures or to make comparisons with structures from the Golden Rock site on St Eustatius or the few other structures reported from Saladoid contextsin the Caribbean islands.

Throughout the late occupation, two basic house shapes (round and oval) were present with differing internal post configurations. Because of machine scraping, most information about house floors was missing and interior configurations often could not be well interpreted. The largest structure at Tutu, a late period oval structure situated in the most advantageous location on the site, was about 90 m^2 in area. Small to moderately-sized structures (the majority) were between 30 m^2 and 40 m^2 in size, and the area of the smallest structure was 12 m^2.

Two structures had large central post holes: one a round structure with 5 large central post holes, and the other either round or oval with 3 identified large central post holes. North of the former was a detached arced row of post holes indicating the northern limit of a burial area. In smaller oval structures, only a random pattern of interior post holes could be identified. A single row of post holes projecting from two of the oval structures appeared to demarcate burial areas. Two circular structures with no central post holes supported identical attached projecting appendages represented by 7 post holes each that formed a double row with a corridor between. Burials were associated only with the largest of these two structure (Chapter 12).

During the late occupation there is evidence for the functional division of exterior space (including burial areas or "yards") around structures. The presence of more than one discrete burial area associated with larger structures indicates housing of at least two family units. Other spatial divisions included sheltering post alignments abutting entrances; unoccupied space on either side of entrances; discrete work/activity areas; and areas demarcated for unidentified activities.

There was no evidence for accumulated resources or wealth during the early occupation at Tutu, and subsistence appears to have been adequate. The early Tutu villagers shared with other Saladoid groups a belief system which included ancestor and zemi worship. Indications of zemi and ancestor worship are manifested in coral, shell and stone three-pointed objects found in several locations of the site, as well as in shell and greenstone inlays meant for insertion in idols, fetishes and religious and other objects. The concept of "zemi" applied to deities themselves, to spirits within living objects such as trees, as well as to idols and fetishes representing them. Idols probably were made from the remains of ancestors, from cotton, or from other natural materials and objects believed to be inhabited by spirits (Righter, 1997).

Burial distribution at the Tutu site during the early occupation suggests that kinship formed the basis of the social order, with a dominant unilineal descent group in the village (Kingsley, 1985). This group may have had control over important intangibles, as well as some tangible goods. The suggestion that the early Tutu village was organized at more than a simple tribal level of society (Kingsley, 1985) may support Petersen's (1996) speculation that the Saladoid settlers brought with them a higher level of social complexity than has been commonly believed or may indicate that on some islands a more complex social order was developing. At some contemporaneous Saladoid villages there is growing evidence for village specialization and perhaps ports of trade (Rouse, 1992), but the presence of a centralized authority, or a system of hierarchically arranged diversified villages, has not been demonstrated at Saladoid sites.

By the time of the Chican Ostionoid occupation at Tutu, substantial social and political change had occurred throughout the northern Antillean region. In eastern Puerto Rico, sociopolitical power had passed into the hands of an elite group, and villages of several types and functions were stratified in a hierarchical system of chiefdoms (Curet & Oliver, 1998). A similar sociopolitical change was reflected in a number of human behaviors at the Tutu site. A decline in power of the unilineal descent group and an increasing importance of the individual household (Curet & Oliver, 1998; Kingsley, 1985) are reflected in a change in burial patterns and burial distribution at the Tutu site. From a pattern in which each individual, regardless of age or sex, was buried with one or more ceramic vessels or vessel parts, and interment was both in a central cemetery and in habitation areas, there was a shift to burial of only a select few subadults and no adults with ceramic goods, and a general grouping of house-related burials in family units. Late occupation burials at Tutu generally were clustered in specific areas outside of domiciles, and single burials were sometimes placed in line with outer house posts. In exterior burial areas, subadults and female and male adults occurred adjacent to each other, and there was no evidence of sex or age differentiation by spatial distribution. Screened and unscreened burial areas related to domiciles apparently were kept open and free of debris and may have been exposed to subsoil. Use of the central cemetery was minimal. The change in burial patterns appears to have begun during the extended Saladoid period at Tutu, between about AD 660 and AD 960.

As observed by Curet & Oliver (1998), the shift from burial of the dead in a central plaza to burial in domestic locations appears to be related to other economic, social and political changes, including increasing importance of the individual household, elitism and a political system controlled by powerful caciques. Differential status accorded certain individuals at Tutu may be evident in aspects of grave construction of Burials 8A, 8B, 38 and 11 which appear intended to preserve the human remains (Chapter 1). These burials also are associated with two large and successive late occupation structures: Structures 7 and 8 at Tutu. Built in the most desirable location on the site (Chapter 12) and associated with burials that received special treatment, these structures may have housed members of successive chiefly households.

Although observed sociopolitical changes might suggest control over animal resources by elite and powerful groups, leading perhaps to poorer health among certain social groups, results of Norr's stable isotope analysis (Chapter 10) indicate essentially no temporal variation in bone isotope values between pre-AD 1000 and post-AD 1100 burials at Tutu, and there are no patterns to indicate that different diets were consumed, either by males and females, or by adults and children. The overall dietary pattern suggests that, during both early and late occupations, the range of available foods was accessible to all members of the society. There is no evidence of unequal access to food resources, which might be expected in a society where an elite class ruled. Norr's studies, however, did not address differentiation in the amounts of food or sizes of edible individuals available to households during the late occupation. The distribution of manatee remains in several loci of the site suggests either voluntary sharing or prescribed distribution and/or re-distribution of food resources among the population.

Sociopolitical change also corresponded with a change in the emphasis and intensity of ceremonial and artistic expression, and changes in some production modes. There was a shift from small lapidary art to massive stonework related to ceremonial aspects of a rubber ball game in which the Tutu inhabitants participated. Massive stone ball belts and zemis were crafted of lithic materials available on islands to the east and northeast, in this case indicating continuity of exchange and procurement patterns. Elaborately white-on-red decorated pottery of the early occupation is not present, but certain early ceramic stylistic motifs are revived with changes, such as from narrow to wide incision. Along with stylistic changes were changes in the pottery manufacturing process.

CONCLUSIONS

Like the early Tutu site occupants, the Chican Ostionoid inhabitants of Tutu relied greatly on local resources for both subsistence and production of artifacts. They exploited terrestrial and marine food resources within access of the site (Chapter 4); produced pottery predominantly from local clay (Chapter 6); utilized plant and tree resources that were harvested from the site and its environs and probably grew manioc, *Curcubita* and some corn. The late occupation inhabitants of Tutu participated in the rubber ball game, and most likely shared in the full range of the ceremonial, spiritual and sociopolitical life of the "classic Taíno" (Rouse, 1992). It is likely that during the late occupation the Tutu village was overseen by a minor chief in a system of hierarchical villages organized under a paramount chief whose headquarters were elsewhere.

Bibliographic references

Abbott, R. T. (1974). *American Seashells*. New York: Van Nostrand Reinhold Co.

Alegría, R. E. (1981). *El uso de la incrustación en la escultura de los Indios Antillanos* [The use of inlays in the sculpture of the Antillean Indians]. San Juan, Puerto Rico: Centro de Estudios Avanzados de Puerto Rico y el Caribe and Fundación Garcia Arévalo, Santo Domingo.

Alegría, R. E. (1983). Ballcourts and Ceremonial Plazas in the West Indies. *Yale University Publications in Anthropology 79*. New Haven.

Ambrose, S. H. (1990). Preparation and characterization of bone and tooth collagen for isotopic analysis. *Journal of Archaeological Science 17*, 431–51.

Ambrose, S. H. (1991). Effects of diet, climate and physiology on nitrogen isotope abundances in terrestrial foodwebs. *Journal of Archaeological Science 18*, 293–317.

Ambrose, S. H. (1993). Isotopic analysis: Methodological and interpretive considerations. In M. K. Sandford (ed.), *Investigations of ancient human tissues: Chemical analysis in anthropology* (pp. 59–130). Langhorne, PA: Gordon & Breach.

Ambrose, S. H. & DeNiro, M. J. (1986a). The isotopic ecology of East African mammals. *Oecologia 69*, 395–406.

Ambrose, S. H. & DeNiro, M. J. (1986b). Reconstruction of African human diet using bone collagen carbon and nitrogen isotope ratios. *Nature 319*, 321–4.

Ambrose, S. H. & Norr, L. (1992). On prehistoric subsistence in the Soconusco region. *Current Anthropology 33,* 401–4.

Ambrose, S. H. & Norr, L. (1993). Experimental evidence for the relationship of the carbon isotope ratios of whole diet and dietary protein to those of bone collagen and carbonate. In J. Lambert & G. Grupe (eds), *Prehistoric human bone: Archaeology at the molecular level* (pp. 1–37). Berlin: Springer-Verlag.

Andres, T. & Piperno, D. R. (1995). New evidence on the distribution and prehistoric exploitation of the Genus Cucurbita in the humid Neotropics. Paper read at the 36th annual meeting of the Society for Economic Botany, Ithaca, New York.

Armelagos, G. J. (1969). Disease in ancient Nubia. *Science 163,* 255–9.

Arnold, J. E. (1996). Emergent complexity: the evolution of intermediate societies. *Archaeological Series 9.* Ann Arbor: International Monographs in Prehistory.

Aufderheide, A. C., Wittmers, L. E., Rapp, G. & Wallgren, J. (1988). Anthropological applications of skeletal lead analysis. *American Anthropologist 90,* 932–6.

Baker, B. J. and Armelagos, G. J. (1988). The origin and antiquity of syphilis. *Current Anthropology 29*(5), 703–37.

Balee, W. (1989). The culture of Amazonian forests. In W. Balee & D. Posey (eds), *Resource management in Amazonia: indigenous and folk strategies* (pp. 1–12). Advances in Economic Botany, Vol. 7. New York: New York Botanical Garden.

Bardon, L. & Bouysonnie, A.(1906). Outils écaillés par percussion [Percussion tools]. *Revue de l'École d'Antropologie de Paris 16*, 170–5.

Bartone, R. & Versteeg, A. (1997). The Tanki Flip features and structures. In A. Versteeg & S. Rostain (eds), *The Archaeology of Aruba: the Tanki Flip Site*. Aruba and Amsterdam: Publication of the Archaeological Museum Aruba 8, Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Bass, W. M. (1987). *Human Osteology: a laboratory and field manual.* Columbia, MO: Missouri Archaeological Society.

Beard, J. S. (1949). *The natural vegetation of the Windward and Leeward Islands.* Oxford: The Clarendon Press.

Bement, L. C. (1994). *Hunter–gatherer mortuary practices during the central Texas Archaic.* Austin, TX: University of Texas Press.

Bender, M. M. (1968). Mass spectrometric studies of carbon–13 in corn and other grasses. *Radiocarbon 10,* 468–72.

Benfer, R. A., Jr. (1990). The Preceramic period site of Paloma, Peru: bioindications of improving adaptation to sedentism. *Latin American Antiquity 1*, 284–318.

Bertsch, K. (1941). *Früchte und Samen: Ein Bestinunungsbuch zur Pflanzenkunde der Vorgeschichtlicken Zeit.* Handbücher der Praktischen Vorgeschichtforschung Band 1. Stuttgart: Verlag Ferdinand Enke.

Bogdan, G. (1989). Possible treponemal skeletal signs in seven Pre-Columbian coastal North Carolina ossuary samples. Unpublished Master's thesis, Wake Forest University, Winston-Salem, NC.

Bogdan, G. & Weaver, D. S. (1992). Pre-columbian treponematosis in coastal North Carolina. In J. W. Verano & D. H. Ubelaker (eds), *Disease and demography in the Americas* (pp. 155–63). Washington, DC: Smithsonian Institution Press.

Bond, J. (1985). *Birds of the West Indies.* Boston: Houghton Mifflin Co.

Bonnefille, R. (1995). A reassessment of the Plio-Pleistocene record of East Africa. In S. Vrba, G. H. Denton, T. C. Partridge & L. H. Buckle (eds), *Paleoclimate and evolution with emphasis on human origins* (pp. 229–30). New Haven: Yale University Press.

Boomert, A. (1987). Gifts of the Amazons: "Green stone" pendants and beads as items of ceremonial exchange in Amazonia and the Caribbean. *Antropologica 65*, 33–54.

Boomert, A. (1999). Saladoid sociopolitical organization. In L'Association Internationale d'Archéologie de la Caraïbe (eds), *Proceeding of the XVIIIth International Congress for Caribbean Archaeology* (pp. 55–78). Grenada.

Borgesen, F. (1909). Vegetation of the Virgin Islands. *Bot. Tidskr. 22*, 1–114.

Bourne, E. G. (1906). Columbus, Ramon Pané and the beginning of American anthropology. Reprinted from the Proceedings of the American Antiquarian Society.

Bowden, M. J., Fischman, N., Cook, P., Wood, J. & Omasta, E. (1970). *Climate, water balance, and climatic change in the Northwest Virgin Islands.* US Virgin Islands: Caribbean Research Institute, College of the Virgin Islands.

Brooks, S. & Suchey, J. M. (1990). Skeletal age determination based on the os pubis: a comparison of the Acsadi-Nemeskeri and Suchey-Brooks methods. *Journal of Human Evolution 5*(3), 227–38.

Brooks, S. T., Haldeman, M. B. & Brooks, R. H. (1988). Osteological analyses of the Stillwater skeletal series, Stillwater March, Churchill County, Nevada. US Department of the Interior, Cultural Resource Series No. 2.

Brouwer, W. & Stählin, A. (1975). *Handbuch der Samenkunde für Landwirtschaft, Gartenbau, und Forstwirtschaft.* Frankfurt: DLG Verlag.

Budinoff, L. C. (1991). An osteological analysis of the human burials recovered from Maisabel: an early ceramic site on the north coast of Puerto Rico. In L. S. Robinson (ed.), *Proceedings of the Twelfth Congress of the International Association for Caribbean Archaeology* (pp. 117–33). Cayenne.

Buikstra, J. E. & Cook, D. C. (1980). Palaeopathology: an American account. *Annual Review of Anthropology 9,* 433–70.

Buikstra, J. & Milner, G. R. (1991). Isotopic and archaeological interpretations of diet in the Central Mississippi Valley. *Journal of Archaeological Science 18,* 319–29.

Buikstra, J. E. & Ubelaker, D. H. (1994). Standards for data collection from human skeletal remains. *Arkansas Archaeological Survey Research Series, No. 44*, Fayetteville, AR.

Buikstra, J., Autry, W., Breitburg, E., Eisenberg, L. & van der Merwe, N. J. (1988). Diet and health in the Nashville Basin: Human adaptation and maize agriculture in Middle Tennessee. In B. E. Kennedy & G. M. LeMoine (eds), *Diet and subsistence: Current archaeological perspectives* (pp. 243–59). Calgary: Archaeology Association, University of Calgary.

Bullen, R. P. (1962). Ceramic periods of St Thomas and St John islands, Virgin Islands. *William L. Bryant Foundation, American Studies, Report No.4.* Orlando, TX.

Bullen, R. P. (1963). The Krum Bay site, a preceramic site on St Thomas, US Virgin Islands. *The William L. Bryant Foundation American Studies Report*, 5. Orlando, FL.

Bullen, R. P. (1973). Krum Bay, a preceramic workshop on St Thomas. In R. Bullen & A. Bullen (eds.), *Proceedings of the Fourth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles (*pp. 110–14). St Lucia.

Bullen, R. P. & Sleight, F. W. (1963). The Krum Bay Site: a preceramic site on St Thomas, US Virgin Islands. *The William L. Bryant Foundation, American Studies, Report No. 5*. DeLand, FL: E. O. Painter Printing Company.

Burns, P. E. (1979). Log-linear analysis of dental caries occurrence in four skeletal series. *American Journal of Physical Anthropology 51*, 637–48.

Burns, P. E. (1982). *A study of sexual dimorphism in the dental pathology of ancient peoples*. Unpublished Doctoral dissertation, Tempe Arizona State University.

Burton, J. H. & Price, T. D. (1990). The ratio of barium to strontium as a paleodietary indicator of consumption of marine resources. *Journal of Archaeological Science 17*, 547–57.

Burton, J. H. & Simon, A. W. (1991). *Determination of intra-regional exchange through ionic-extraction analysis of ceramics*. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, New Orleans, LA.

Burton, J. H. & Simon, A. W. (1993). Acid-extraction as a simple and inexpensive method for compositional characterization of archaeological ceramics. *American Antiquity 58*(1), 45–59.

Burton, J. H. & Simon, A. W. (1996). A pot is not a rock: a reply to Neff, Glascock, Bishop, and Blackman. *American Antiquity 61* (2), 405–13.

Buxton, L. H. D., Trevor, J. C. & Julien, A. H. (1938). Skeletal remains from the Virgin Islands. *Man 38,* 49–51.

Calhoun, W. D. & Harper, M. K. (n.d.). *Pathological analysis of the burials at Calabash Boom*. Manuscript on file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Canalis, E. (1990). Regulation of bone remodeling. In *Primer on Metabolic Bone Diseases and Disorders of Mineral Metabolism* (pp. 23–6).

Capone, D. G. & Carpenter, E. J. (1982). Nitrogen fixation in the marine environment. *Science, 217,* 1140–2.

Carini, S. P. (1991). Mineralogical analysis of West Indian Saladoid ceramics: A preliminary report. In E. N. Ayubi & J. B. Haviser (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology*, Part 1 (pp. 187–200). Reports of the Archaeological-Anthropological Institute of The Netherlands Antilles, No. 9. Curaçao.

Carlson, L. A. (1993). Strings of command: manufacture and utilization of shell beads among the Taíno. Unpublished master's thesis, Department of Anthropology, University of Florida, Gainesville.

Carsten, J. & Hugh-Jones, S. (eds) (1994). *About the house: Levi-Strauss and beyond*. Cambridge: Cambridge University Press.

Cassidy, C. M. (1984). Skeletal evidence for prehistoric subsistence adaptation in the central Ohio Valley. In M. N. Cohen & G. J. Armelagos (eds), *Paleopathology at the origins of agriculture* (pp. 307–45). Orlando, FL: Academic Press.

Chagnon, N. A. (1992). *Yanomamö* (4th edition). Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Chanlatte Baik, L. A. (1976). *Investigaciones arqueológicas en Guayanilla, Puerto Rico: Parte I.* Santo Domingo: Co-Ediciones Museo del Hombre Dominicano y Fundación García Arévalo Inc.

Chanlatte Baik, L. A. & Narganes Storde, Y. M. (1983). *Vieques-Puerto Rico: Asiento de una nueva cultura aborigen antillana* [Vieques-Puerto Rico: seat of a new aboriginal Antillean culture]. Santo Domingo.

Chisholm, B. S. (1986). *Reconstruction of prehistoric diet in British Columbia using stable carbon isotopic analysis.* Unpublished Doctoral dissertation, Simon Fraser University, British Columbia.

Chisholm, B. S., Nelson, D. E. & Schwarcz, H. P. (1982). Stable-carbon isotope ratios as a measure of marine versus terrestrial protein in ancient diets. *Science 216,* 1131–2.

Cody, A. (1991a). Distribution of exotic stone artifacts through the Lesser Antilles: their implications for prehistoric interaction and exchange. Paper presented at the Congress of the International Association for Caribbean Archaeology, Barbados.

Cody, A. (1991b). From the site of Pearls, Grenada: exotic lithics and radiocarbon dates. In E. N. Ayubi & J. B. Haviser (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology* (pp. 589–604). Reports of the Archaeological-Anthropological Institute of The Netherlands Antilles (Curaçao) 9.

Cohen, M. N. (1989). *Health and the rise of civilization.* New Haven: Yale University Press.

Cohen, M. N. & Armelagos, G. (eds) (1984). *Paleopathology at the origins of agriculture*. New York: Academic Press.

Cook, D. C. (1976). *Pathologic states and disease process in Illinois Woodland populations: an epidemiologic approach*. Unpublished Doctoral dissertation, University of Chicago.

Crabtree, D. (1972). An introduction to flintworking. *Occasional Papers of the Idaho State University Museum 28.*

Craig, H. (1957). Isotopic standards for carbon and oxygen and correction factors for mass spectrometric analysis of carbon dioxide. *Geochimica et Cosmochimica, Acta 12,* 133–49.

Crock, J. G. & Bartone, R. N. (1998). Archaeology of Trants, Montserrat. Part 4. Flaked stone and stone bead industries. *Annals of the Carnegie Museum 67*(3): 197–224.

Cruxent, J. M. & Rouse, I. (1958). An archaeological chronology of Venezuela, Vol. 1. *Social Science Monographs, No. 6.* Washington, DC: Pan American Union.

Cruxent, J. M. & Rouse, I. (1961). An archaeological chronology of Venezuela, Vol. 2. *Social Science Monographs, No. 6.* Washington, DC: Pan American Union.

Cummins, J. (1992). *The voyage of Christopher Columbus: Columbus' own journal of discovery newly restored and translated.* New York: St Martin's Press.

Curet, L. A. (1992). House structure and cultural change in the Caribbean: three case studies from Puerto Rico. *Latin American Antiquity 3*(2): 160–74.

Curet, L. A. (1997). Technological changes in prehistoric ceramics from eastern Puerto Rico: An exploratory study. *Journal of Archaeological Science 24*, 497–504.

Curet, A. L. & Oliver, J. R. (1998). Mortuary practices, social development, and ideology in pre-Columbian Puerto Rico. *Latin American Antiquity 9*(3): 217–39.

Cybulski, J. S. (1974). Tooth wear and material culture: Precontact patterns in the Tsimshian area, British Columbia. *Syesis 7*, 31–35.

Dahlberg, A. A. (1963). Dental evolution and culture. *Human Biology 35*: 237–49.

Dansereau, P. (1966). Studies on the vegetation of Puerto Rico I. Description and integration of the plant communities. *Institute of Caribbean Science, Special Publication 1*: 1–45.

Davis, D. D. (1993). Archaic blade production on Antigua, West Indies. *American Antiquity 58:* 688–97.

Davis, D. D. (in press). *Jolly Beach and the Preceramic Occupation of Antigua, West Indies.* Yale University Publications in Anthropology.

deBooy, T. (1919). Archaeology of the Virgin Islands. *Indian notes and monographs 1*(1): 13–100. New York: The Heye Foundation.

deFrance, S. D. (1988). *Zooarchaeological investigations of subsistence strategies at the Maisabel Site, Puerto Rico.* Master of arts research project, Anthropology Department, University of Florida, Gainesville.

deJosselin deJong, J. P. (1924). A natural prototype of certain three-pointed stones. In *Proceedings of the 21st International Congress of Americanists (Part 1*), 29–42. The Hague.

deJosselin deJong, J. P. B. (1947). *Archaeological material from Saba and St Eustatius, Lesser Antilles.* Mededelingen van het Rijksmuseum voor Volkenkinde, Leiden: E. J. Brill.

DeNiro, M. J. (1985). Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to paleodietary reconstruction. *Nature 317*: 806–9.

DeNiro, M. J. (1987). Stable isotopy and archaeology. *American Scientist 75*: 182–91.

DeNiro, M. J. & Epstein, S. (1978). Influence of diet on the distribution of carbon isotopes in animals. *Geochimica et Cosmochimica, Acta 42*: 495–506.

DeNiro, M. J. & Epstein, S. (1981). Influence of diet on the distribution of nitrogen isotopes in animals. *Geochimica et Cosmochimica, Acta 45*: 341–51.

DePangher, M. (1996). *Petrographic report ESY.* Manuscript prepared by Spectrum Petrographics Inc., Winston, OR, on file at Department of Planning and Natural Resources, United States Virgin Islands, St Thomas.

DePangher, M. (1997). *Petrographic report FVK.* Manuscript prepared by Spectrum Petrographics Inc., Winston, OR, on file at Department of Planning and Natural Resources, United States Virgin Islands, St Thomas.

DePaola, P. F., Soparkar, P. M., Tavares, M., Allukian, M. & Peterson, H. (1982). A dental survey of Massachusetts schoolchildren. *Journal of Dental Research 61*: 1356–60.

Doran, G. H. (n.d.). *Osteological analysis of the human skeletal remains from the Aklis Site, St Croix, Virgin Islands.* Manuscript on file at the National Park Service, Southeastern Archaeological Center, Tallahassee.

Drusini, A., Businaro, F. & Calderòn, F. L. (1987). Skeletal biology of the Taíno: a preliminary report. *International Journal of Anthropology 2*: 247–53.

Duff, A. I. (1994). The scope of post-Chacoan community organization in the lower Zuni River region. In T. L. Howell & T. Stone (eds), *Exploring social, political, and economic organization in the Zuni region* (pp. 25–45). Anthropological Research Papers No. 46. Tempe: Arizona State University.

Dunbar, J. B. (1969). Dental caries. In W. Pelton, J. Dunbar, R. McMillan, P. Moller & A. Wolff (eds), *The epidemiology of oral health* (pp. 1–14). Cambridge, MA: Harvard University Press.

Dutour, O., Pálfi, G., Berato, J. & Brun, J-P. (eds) (1994). *L'Origine de la syphilis en Europe: Avant ou après 1493?* [The origin of syphilis in Europe: before or after 1493?]. Paris: Centre Archéologique du Var – Editions Errance.

Edward, J. (1987). *Studies of human bone from the Preceramic Amerindian site at Paloma, Peru, by neutron activation analysis.* Unpublished doctoral dissertation, University of Missouri.

Edward, J. & Benfer, R. A., Jr. (1993). Diagenesis of Paloma bone. In M. K. Sandford (ed.), *Investigations of ancient human tissue* (pp. 183–268). Langhorne: Gordon & Breach Science Publishers.

Eggers, H. F. A. (1879). The Flora of St Croix and the Virgin Islands. *Bulletin of the United States National Museum 13*: 1–133.

Ehrenreich, R., Crumley, C. & Levy, J. (eds) (1995). Heterarchy and the analysis of complex societies. *Archaeological Papers of the American Anthropological Association, No. 6*. Arlington, VA: American Anthropological Association.

Elliott, D. (1990). Field notes, soil profiles, samples lists and maps from investigations at the Magens Bay site, St Thomas. Unpublished raw data. On file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Farnum, J. F. (1996). *Multi-method approaches to diet and health reconstruction and estimations of ages of pregnancies and weaning for Paloma, Peru using Sr, Zn, and non-specific indicators of stress.* Unpublished Master's thesis, University of Missouri.

Farnum, J. F., Glascock, M. D., Sandford, M. K. & Gerritsen, S. (1995). Trace elements in ancient human bone and associated soil using NAA. *Journal of Radioanalytical Nuclear Chemistry 196*: 267–74.

Febles Dueñas, J. (1978). Aguas Gordas: contribución al estudio del material lítico [Aguas Gordas: contribution to the study of lithic material]. *Cuba Arqueológica*, 51–73. Santigao de Cuba: Editorial Oriente.

Febles Dueñas, J. (1988). *Manual para el estudio de la piedra tallada de los aborígenes de Cuba* [Handbook of the study of cut stones of the Cuban aborigines]. La Habana: Editorial Academia.

Febles Dueñas, J. (1991). Herramientos de piedra tallada del conjunto Seboruco, Mayarí, Holguín, Cuba [Tools of cut stone from the Seboruco complex, Mayari, Holguin, Cuba]. In J. Febles Dueñas & A. Rives (eds), *Arqueología de Cuba y de Otras Areas Antillanas* (pp. 380–401). La Habana: Editorial Academia.

Figueredo, A. E. & Winter, J. H. (1986). *Phase II assessment and data recovery at a new site in Estate Judith's Fancy, St Croix*. Cultural Resources Inc., Kingshill, St Croix.

Flower, W. H. (1891). Exhibition of two skulls from a cave in Jamaica. *Journal of the Anthropological Institute of Great Britain and Ireland 20*, 110–12.

Flower, W. H. (1895). On recently discovered remains of the aboriginal inhabitants of Jamaica. *Nature 52*: 607–8.

Gawlik, D., Behne, D., Bratter, P., Gatschke, W. & Gessner, H. (1982). The suitability of the iliac crest biopsy in the element analysis of bone and marrow. *Journal of Clinical Chemistry and Clinical Biochemistry 20*: 499–507.

Genoves, S. (1967). Proportionality of the long bones and their relation to stature among Mesoamericans. *American Journal of Physical Anthropology 26*: 67–78.

Geraghty & Miller Inc. (1993). Technical Memorandum II: results of the field program Tutu service station investigation, St Thomas, US Virgin Islands. Vol. 1. Prepared for Tutu Environmental Investigation Committee, San Juan, Puerto Rico. Copy on file at the Virgin Islands Environmental Protection (EPA) office, St Thomas, USVI.

Gilbert, C., Sealy, J. & Sillen, A. (1994). An investigation of barium, calcium, and strontium as paleodietary indicators in the Southwestern Cape, South Africa. *Journal of Archaeological Science 21*: 173–84.

Goode, G. C., Howard, C. M., Wilson, A. R. & Parsons, V. (1972). Some applications of neutron activation analysis of human bone. *Analytica Chimica Acta 58,* 363–8.

Goodman, A. H. (1989). Dental enamel hypoplasias in prehistoric populations. *Advances in Dental Research 3*: 265–71.

Goodman, A. H. & Capasso, L. L. (eds) (1992). Recent contributions to the study of enamel developmental defects. *Journal of Paleopathology, Monographic Publications No. 2.*

Goodman, A. H. & Rose, J. C. (1990). Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. *Yearbook of Physical Anthropology 33*: 59–110.

Goodman, A. H. & Rose, J. C. (1991). Dental enamel hypoplasias as indicators of nutritional status. In M. A. Kelley & C. S. Larsen (eds), *Advances in dental anthropology* (pp. 279–93). New York, NY: Wiley-Liss.

Goodman, A. H., Lallo, J., Armelagos, G. J. & Rose, J. C. (1984). Health changes in Dickson Mounds, Illinois (AD 950–1300). In M. N. Cohen & G. J. Armelagos (eds), *Paleopathology at the origins of agriculture* (pp. 271–305). Orlando, FL: Academic Press.

Greene, V. (1992). Letter to Elizabeth Righter, 18 May 1992.

Gunn, C. R. (1972). Seed collecting and identification. In T. T. Kozlowski (ed.), *Seed Biology* (Vol. 3, pp. 55–143). New York: Academic Press.

Gustave, S., Hubau, M., Belhache, P., Fabre, J., Ney, C. & Schvoerer, M. (1991). Composition élémentaire d'une série de tessons de céramiques précolombiennes de Vivé et du Diamant (Martinique) [Elementary composition of a series of pre-Columbian ceramic sherds from Vive and Diamant, Martinique]. In A. Cummins & P. King (eds), *Proceedings of the Fourteenth Congress of the International Association for Caribbean Archaeology* (pp. 40–48). Barbados: Barbados Museum and Historical Society.

Hackett, C. J. (1963). On the origin of the human treponematoses. *Bulletin of the World Health Organization 29*: 7–41.

Hackett, C. J. (1983). Problems in the palaeopathology of the human treponematoses. In G. D. Hart (ed.), *Disease in ancient man.* Toronto, Canada: Clarke Irwin.

Haddon, A. C. (1897). Note on the craniology of the aborigines of Jamaica. *Journal of the Institute of Jamaica 2*: 23–24.

Hall, R. K. & Browman, J. E. (1992). Examination of the teeth of twelve children buried in the crypt of the church of St Bride, Fleet Street, London, England, between 1787 and 1840. In A. H. Goodman and L. L. Capasso (eds), *Recent contributions to the study of enamel developmental defects* (pp. 255–66). *Journal of Paleopathology*, Monographic Publications No. 2.

Hamburg, T. D., Knippenburg, S., Nokkert, M. & Brokke, A. J. (1995). A late Saladoid occupation at the Anse des Peres site, St Martin. In Conseil Régional de la Guadeloupe (eds), *Proceedings of the XVIth International Congress for Caribbean Archaeology* (pp 352–73). Guadeloupe.

Hancock, R. G. V., Grynpas, M. D. & Pritzker, K. P. H. (1989). The abuse of bone analyses for archaeological dietary studies. *Archaeometry 31:* 169–79.

Hansen, J. P. H., Meldgaard, J. & Nordqvist, J. (1991). *The Greenland mummies*. Washington, DC: Smithsonian Institution Press.

Harlan, J. R. (1992). *Crops and man* (2nd Edition). Madison, Wisconsin: American Society of Agronomy.

IAWA (1989) List of Microscopic Features for Hardwood Identification. *International Association of Wood Anatomists (IAWA) Bulletin n.s. 10* (3), 219–332. Leiden, The Netherlands.

Harris, M. H. (1991). Material culture I – Pottery. In P. L. Drewett (ed.), *Prehistoric Barbados* (pp. 37–100). London: Institute of Archaeology, University College London, and Barbados Museum & Historical Society.

Hartnady, P. & Rose, J. C. (1991). Abnormal tooth-loss patterns among Archaic-period inhabitants of the lower Pecos region, Texas. In M. A. Kelley & C. S. Larsen (eds), *Advances in dental anthropology* (pp. 267–78). New York, NY: Wiley-Liss.

Hatt, G. (1924). Archaeology of the Virgin Islands. In *Proceedings of the 21st International Congress of Americanists* (Part 1), 29–42. The Hague.

Haviser, J. B. (1988). *An archaeological survey of St Martin/St Maarten.* Reports of the Institute of Archaeology and Anthropology of The Netherlands Antilles No. 7.

Haviser, J. B. (1991). Preliminary results from test excavations at the Hope Estate Site (SM–026), St Martin. In E. N. Ayubi & J. B. Haviser (eds), *Proceedings of the ThirteenthInternational Congress for Caribbean Archaeology* (pp. 647–66). Willemstad: Archaeological-Anthropological Institute of The Netherlands Antilles.

Hayward, M. H. & Cinquino, M. A. (1997a). Archaeological investigations at the Aklis Site Sandy Point National Wildlife Refuge, St Croix, USVI. Final Report, Vol. II. Unpublished draft copy, National Park Service, Atlanta.

Hayward, M. H. & Cinquino, M. A. (1997b). Aklis: A regional perspective. Paper presented at the 17th Congress of the International Association for Caribbean Archaeology, Nassau, Bahamas, 21–25 July 1997, and submitted for publication in the proceedings.

Hayward, M. H., Cinquino, M. A., Schieppati, F. J., Narganes Storde, Y., Newsom, L. A. & Stanley, C. (1997). *Archaeological investigations at the Aklis site, Sandy Point National Wildlife Refuge, St Croix, United States Virgin Islands* (Vols 1–3). Final Report submitted to National Park Service, Southeast Regional Office (Atlanta, Georgia). Buffalo, NY: Panamerican Consultants Inc.

Heck, K. L., Jr. & Weinstein, M. P. (1989). Feeding habits of juvenile reef fishes associated with Panamanian seagrass meadows. *Bulletin of Marine Science 45*(3): 629–36.

Henley, P. (1982). *The Panare: tradition and change on the Amazonian frontier*. New Haven: Yale University Press.

Henneberg, M. & Henneberg, R. J. (1994). Treponematosis in an Ancient Greek colony of Metaponto, Southern Italy, 580–250 BCE. In O. Dutour, G. Pálfi, J. Berato & J-P. Brun (eds), *L'Origine de la syphilis en Europe: Avant ou après 1493?* [The origin of syphilis in Europe: before or after 1493?] (pp. 92–8). Paris: Centre Archéologique du Var – Editions Errance.

Henocq, C. (1995). Baie Rouge: The last Amerindians of Saint Martin. *Bulletin de l'Association Archéologique Hope Estate, 4*: 36–42.

Higgs, E. S. & Vita-Finzi, C. (1972). Prehistoric economies: A territorial approach. In E. S. Higgs (ed.), *Papers in economic prehistory* (pp. 27–36). Cambridge: Cambridge University Press.

Hillson, S. (1986). *Teeth.* Cambridge: Cambridge University Press.

Hoffman, C. (1988). Current research. *American Antiquity 53*(1).

Hofman, C. L. (1993). *In search of the native population of pre-Columbian Saba(400–1450 AD): Part one, pottery styles and their interpretations.* Published Doctoral dissertation, Rijksuniversiteit de Leiden.

Hofman, C. & Hoogland, M. (eds) (2000). Archaeological investigations on St Martin, FWI: the sites of Hope Estate, Norman Estate and Anse des Peres. Leiden: Archaeological Studies, Leiden University.

Hofman, C., Hoogland, M. & Delpuech, A. (2001). Spatial organization at a Troumassoid settlement. The case of Anse à la Gourde, Guadeloupe. Paper presented at the XIXth International Congress for Caribbean Archaeology (Aruba, July 2001).

Hooten, E. A. (1930). *The Indians of Pecos Pueblo: a study of their skeletal remains.* New Haven: Yale University Press.

Hornbeck, H. B. (1835–1839). St Thomas Dansk Americansk Ø Opthaget i 1835–1839. Copenhabn 1846.

Hudson, C. (1976). *The southeastern Indians.* Knoxville, TN: University of Tennessee Press.

Hudson, E. H. (1965). Treponematosis and man's social evolution. *American Anthropology 67*: 885–901.

Hugh-Jones, S. (1978). A closer look at Amazonian Indians. Cambridge: Cambridge University Press.

Hugh-Jones, S. (1985). The Maloca: a world in a house. In E. Carmichael, S. Hugh-Jones, B. Moser & D. Tayler (eds), *The Hidden People of the Amazon* (pp. 77–83). London: British Museum Publications.

Hutchinson, D. L. (1993). Treponematosis in regional and chronological perspective from central gulf coast Florida. *American Journal of Physical Anthropology 92*: 249–81.

Hutchinson, D. L. & Norr, L. (1994). Late prehistoric and early historic diet in Gulf Coast Florida. In C. S. Larsen & G. Milner (eds), *In the wake of contact: Biological responses to conquest* (pp. 9–20). New York: Wiley-Liss.

Hutchinson, D. L. & Larsen, C. S. (1995). Physiological stress in the prehistoric Stillwater Marsh: evidence of enamel defects. In C. S. Larsen & R. L. Kelly (eds), *Bioarchaeology of the Stillwater Marsh: Prehistoric human adaptation in the western Great Basin* (pp. 81–95). Anthropological Papers of the American Museum of Natural History No. 77.

IAWA (1989). IAWA list of microscopic features for hardwood identification. International Association of wood anatomists (IAWA). Bulletin N. S. 10(3): 219–332. Leiden, The Netherlands.

Irish, J. D. & Turner, C. G., II (1987). More lingual surface attrition of the maxillary anterior teeth in American Indians: prehistoric Panamanians. *American Journal of Physical Anthropology 73*: 209–13.

Johansen, O. S., Gulliksen, S. & Nydal, R. (1986). $\delta^{13}C$ and diet: Analysis of Norwegian human skeletons. *Radiocarbon 28*: 754–61.

Johnston, B. J. (1981). Virgin Islands Inventory of Historic Places: St Thomas and St John. Draft. On file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Johnston, B. J. (1982). Virgin Islands Inventory of Historic Places: St Croix. Draft. On file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Joseph, J. W. (1989). *A Phase I cultural resources survey of the St Croix Virgin Grand development site, Estate Judith's Fancy, St Croix, USVI.* Stone Mountain: New South Associates Technical Report 7.

Karasov, W. H. & Diamond, J. M. (1988). Interplay between physiology and ecology in digestion. *Bioscience 38*: 602–11.

Keegan, W. F. (1982). Lucayan cave burials from the Bahamas. *Journal of New World Archaeology 5*(2): 57–65.

Keegan, W. (1992). *The people who discovered Columbus: the prehistory of the Bahamas.* Gainesville: University of Florida Press.

Keegan, W. F. (1997). "No man [or woman] is an island": elements of Taíno social organization. In S. M. Wilson (ed.), *The Indigenous People of the Caribbean* (pp. 109–18). Gainesville: University of Florida Press.

Keegan, W. & DeNiro, M. J. (1988). Stable carbon- and nitrogen-isotope ratios of bone collagen used to study coral-reef and terrestrial components of prehistoric Bahamian diet. *American Antiquity 53*: 320–36.

Keegan, W. F. & Maclachlan M. D. (1989). The evolutions of avuncular chiefdoms: a reconstruction of Taíno kinship and politics. *American Anthropologist 91*(3): 613–30.

Keegan, W. F., Maclachlan, M. D. & Byrne, B. (1998). Social foundations of Taíno caciques. In E. Redmond (ed.), *Chiefdoms and chieftaincy in the Americas.* Gainesville: University of Florida Press.

Keeling, C. D., Mook, W. G. & Tans, P. P. (1979). Recent trends in the $^{13}C/^{12}C$ ratio of atmospheric carbon dioxide. *Nature 277*: 121–3.

Kennedy, B. V. E. (1988). *Variation in* $\delta^{13}C$ *values of Post-Medieval Europeans.* Unpublished doctoral dissertation, University of Calgary.

Khudabux, M. R., Maat, G. J. R. & Versteeg, A. H. (n.d.). *The remains of prehistoric Amerindians of the 'Tingi Holo Ridge' in Suriname: a physical anthropological investigation of the 'Versteeg Collection'* (pp. 135–51).

Kingsley, R. G. (1985). Kin groups and mortuary practices: ethnographic implications for archaeology. Unpublished Doctoral dissertation, Ann Arbor: Michigan State University.

Knight, D. (1997). *Brief history of Estate Charlotte Amalie on St Thomas in the United States Virgin Islands.* Charlotte Amalie: Little Nordside Press.

Koch, P., Behrensmeyer, A. K., Tuross, N. & Fogel, M. L. (1990). Isotopic fidelity during bone weathering and burial. 1989–90 Annual Report of the Director, Geophysical Laboratory, pp. 105–10. Washington DC: Carnegie Institution.

Koch, P., Fogel, M. L. & Tuross, N. (1994). Tracing the diets of fossil animals using stable isotopes. In K. Lajtha & R. H. Michener (eds), *Stable isotopes in ecology and environmental science* (pp 63–92). Oxford: Blackwell Scientific Publications.

Kozlowski, J. K. & Ginter, B. (1973.) *Técnica de la talla y tipología de los instrumentos líticos* [Technique of carving and types of lithic instruments]. La Habana: Museo Antropológico Montané.

Krebs, C. J. (1989). *Ecological methodology.* New York: HarperCollins Publishers Inc.

Krieger, H. W. (1938). Archaeology of the Virgin Islands. *Explorations and Fieldwork of the Smithsonian Institution in 1937*: 95–102. Washington, DC: Smithsonian Institution.

Krogman, W. M. & Iscan, M. Y. (1986). *The human skeleton in forensic medicine* (2nd edition). Springfield, IL: Charles C. Thomas.

Krueger, H. W. (1991). Exchange of carbon and strontium with hydroxyapatite. *Journal of Archaeological Science 18*: 355–61.

Kruskal, J. P. & Wish, M. (1978). *Multidimensional scaling.* Sage University Press series on Quantitative Applications in the Social Sciences, series no. 07–011. Beverly Hills and London: Sage Publications.

Lambert, J. B., Simpson, S. V., Buikstra, J. E. & Hanson, D. (1983). Electron microprobe analysis of elemental distribution in excavated human femurs. *American Journal of Physical Anthropology 62*: 409–23.

Lambert, J. B., Simpson, S. V., Szpunar, C. B. & Buikstra, J. E. (1984). Copper and barium as dietary discriminants: the effects of diagenesis. *Archaeometry 26*: 131–8.

Lambert, J. B., Weydert, J. M., Williams, S. R. & Buikstra, J. E. (1990). Comparison of methods for removal of diagenetic material in buried bone. *Journal of Archaeological Science 17*: 453–68.

Lambert, J. B., Xue, L. & Buikstra, J. E. (1989). Physical removal of contaminative inorganic material from buried human bone. *Journal of Archaeological Science 16*: 427–36.

Lambert, J. B., Xue, L. & Buikstra, J. D. (1991). Inorganic analysis of excavated human bone after surface removal. *Journal of Archaeological Science 18*: 363–83.

Land, L. S., Lundelius, E. L. & Valastro, S. (1980). Isotopic ecology of deer bones. *Palaeogeography, Palaeoclimatology, Palaeoecology 32*: 143–51.

Lanphear, K. M. (1990). Frequency and distribution of enamel hypoplasias in a historic skeletal sample. *American Journal of Physical Anthropology 81*: 35–43.

Larsen, C. S. (1985). Dental modifications and tool use in the western Great Basin. *American Journal of Physical Anthropology 67*: 393–402.

Larsen, C. S. (1995). *The Tutu dental remains: interpretations of prehistoric health and lifeway from St Thomas, US Virgin Islands.* Manuscript on file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Larsen, C. S. (1997). *Bioarchaeology: interpreting behavior from the human skeleton.* Cambridge: Cambridge University Press.

Larsen, C. S. & Hutchinson, D. L. (1992). Dental evidence for physiological disruption: biocultural interpretations from the eastern Spanish Borderlands, USA. In A. H. Goodman & L. L. Capasso (eds), *Recent contributions to the study of enamel developmental defects* (pp. 151–69). Journal of Paleopathology, Monographic Publications No. 2.

Larsen, C. S. & Kelly, R. L. (1995). Bioarchaeology of the Stillwater Marsh: prehistoric human adaptation in the western Great Basin. *Anthropological Papers of the American Museum of Natural History No. 77.*

Larsen, C. S., Schoeninger, M. J., van der Merwe, N. J., Moore, K. M. & Lee-Thorp, J. A. (1992). Carbon and nitrogen stable isotopic signatures of human dietary change in the Georgia Bight. *American Journal of Physical Anthropology 89*: 197–214.

Larsen, C. S., Shavit, R. & Griffin, M. C. (1991). Dental caries evidence for dietary change: an archaeological context. In M. A. Kelley & C. S. Larsen (eds), *Advances in dental anthropology* (pp. 179–202). New York: Wiley-Liss.

Larsen, C. S., Teaford, M. F. & Sandford, M. K. (1995). Teeth as tools at Tutu: extramasticatory behavior in prehistoric St Thomas, US Virgin Islands. Chapter prepared for J. R. Lukacs and G. R. Scott (eds), *Albert Dahlberg memorial volume on dental morphology and evolution.*

Las Casas, Fray B. de (1909). *Apologética historia de las Indias.* Nueva Biblioteca de Autores Espanoles, 13. Madrid.

Las Casas, Fray B. de (1927). *Historia general de las Indias.* 3 vols. Barcelona.

Las Casas, Fray B. de (1929). *Historia de las Indias,* 3 vols, Madrid: M. Aguilar.

Las Casas, Fray B. de (1951). *Historia de las Indias.* Mexico DF: Fondo de Cultura Economica.

Las Casas, Fray B. de (1967). *Apologética historia sumaria.* 2 vols. Mexico City: Universidad Nacional Autonoma de Mexico.

Leavitt, S. W. & Long, A. (1986). Trends of ^{13}C/^{12}C ratios in pinyon pine tree rings of the American Southwest and the global carbon cycle. *Radiocarbon 28*: 376–82.

Lee-Thorp, J. A. (1986). Stable carbon isotope analysis of bone apatite: The implications for dietary and paleoenvironmental reconstruction. *Paleoecology of Africa 17*: 133–5.

Lee-Thorp, J. A. (1989). Stable carbon isotopes in deep time: The diets of fossil fauna and hominids. Unpublished Doctoral dissertation, University of Cape Town.

Lee-Thorp, J. A., Sealy, J. C. & van der Merwe, N. J. (1989). Stable carbon isotope ratio differences between bone collagen and bone apatite, and their relationship to diet. *Journal of Archaeological Science 16*: 585–99.

Lee-Thorp, J. A. & van der Merwe, N. J. (1987). Carbon isotope analysis of fossil bone apatite. *South African Journal of Science 83*: 712–15.

Lee-Thorp, J. A. & van der Merwe, N. J. (1991). Aspects of the chemistry of modern and fossil biological apatites. *Journal of Archaeological Science 18*: 343–54.

Leigh, R. W. (1925). Dental pathology of the Eskimo. *Dental Cosmos 67*: 884–98.

Létolle, R. (1980). Nitrogen–15 in the natural environment. In P. Fritz and J. C. Fontes (Vol. eds), *Handbook of environmental isotope geochemistry, Vol. 1, The terrestrial environment* (pp. 407–33). Amsterdam: Elsevier.

Little, E. L., Jr. & Wadsworth, F. H. (1964). Common trees of Puerto Rico and the Virgin Islands. *USDA Forest Service Agricultural Handbook No. 249.*

Little, E. L., Jr., Woodbury, R. O. & Wadsworth, F. H. (1974). Trees of Puerto Rico and the Virgin Islands (2nd volume). *USDA Forest Service Agricultural Handbook No. 449.*

López, D. & Torres, E. C. (1992). *La colleccion osea arqueológica del museo* [The collection of archaeological bone of the museum]. Turalbo: Museo de Historia, Antropologia y Arte, Universidad de Puerto Rico.

Lovejoy, C. O. (1985). Dental wear in the Libben population: its functional pattern and role in the determination of adult skeletal age at death. *American Journal of Physical Anthropology 68*: 47–56.

Lovell, N., Nelson, D. E. & Schwarcz, H. P. (1986). Carbon isotope ratios in paleodiet: Lack of age or sex effect. *Archaeometry 28*: 51–5.

Lovett, J. C. & Wasser, S. K. (eds) (1993). *Biogeography and ecology of the rain forests of eastern Africa.* Cambridge: Cambridge University Press.

Lukacs, J. R. & Pastor, R. F. (1988). Activity-induced patterns of dental abrasion in prehistoric Pakistan: evidence from Mehrgarh and Harappa. *American Journal of Physical Anthropology 76*: 377–98.

Lundberg, E. R. (1989). Preceramic procurement patterns at Krum Bay, Virgin Island. Unpublished doctoral dissertation. University of Illinois, Urbana.

Lundberg, E. R. & Righter, E. (1997). Ceramic style definition and refinement: Late Saladoid changes in the Vieques Sound area. In J. H. Winter (ed.), *Proceedings of the Seventeenth Congress of the International Association for Caribbean Archaeology* (pp. 234–47). Rockville, New York: Molloy College.

Lundberg, E. R., Righter, E. & Caesar, M. D. (1992). The Late Ceramic Age in the northern Virgin Islands. In D. Watters (Chair), *The Late Ceramic Age in the Northeast Caribbean.* Symposium conducted at the 57th Annual Meeting of the Society for American Archaeology, Pittsburgh.

Lynott, M. J., Bouton, T. W., Price, J. E. & Nelson, D. E. (1986). Stable carbon isotopic evidence for maize agriculture in southeast Missouri and northeast Arkansas. *American Antiquity 51*: 51–65.

Mack, M. E. & Coppa, A. (1992). Frequency and chronological distribution of enamel hypoplasias from the Ra's al-Hamra–5 (RH5) skeletal collection (Oman). In A. H. Goodman & L. L. Capasso (eds), *Recent contributions to the study of enamel developmental defects* (pp. 131–41). *Journal of Paleopathology*, Monographic Publications No. 2.

Mann, R. W., Symes, S. A. & Bass, W. M. (1987). Maxillary suture obliteration: Aging the human skeleton based on intact or fragmentary maxilla. *Journal of Forensic Sciences 32*: 148–57.

Mariotti, A. (1983). Atmospheric nitrogen is a reliable standard for natural ^{15}N abundance measurments. *Nature 303*: 685–7.

Martir de Anglería, P. (1964). *Décadas del Nuevo Mundo* [Decades of the New World]. Porrúa e Hijos, Sucesores, Méxicos, DF.

Mason, J. A. (1941). A large archaeological site at Capa, Utuado, with notes on other Porto Rican sites visited in 1914–41. *Scientific Survey of Porto Rico and the Virgin Islands 18*(2). New York: New York Academy of Sciences.

Mattioni, M. & Nicolas, M. (1972). *Art précolumbien de la Martinique*. Musée Departemental de la Martinique.

Meindl, R. S. & Lovejoy, C. O. (1985). Ectocranial suture closure: A revised method for the determination of skeletal age at death based on the lateral-anterior sutures. *American Journal of Physical Anthropology 68*: 57–66.

Merbs, C. F. (1983). Patterns of activity-induced pathology in a Canadian Inuit population. *Archaeological Survey of Canada Paper No. 119.*

Miles, A. E. W. (1963). The dentition in the assessment of individual age in skeletal material. In D. R. Brothwell (ed.), *Dental anthropology* (pp. 191–209). New York: Pergamon Press.

Miller, G. S. (1918). Mammals and reptiles collected by Theodoor deBooy in the Virgin Islands. *Proceedings of the US National Museum, LIV*, pl. 81. Washington, DC.

Milner, G. R. (1982). Measuring prehistoric levels of health: a study of Mississippian period skeletal remains from the American Bottom, Illinois. Unpublished Doctoral dissertation, Northwestern University, Evanston, IL.

Milner, G. R. (1983). *The East St Louis Stone Quarry Site Cemetery*. Champaign-Urbana, IL: University of Illinois Press.

Milner, G. R. (1984). Dental caries in the permanent dentition of a Mississippian period population from the American Midwest. *Collegium Antropologicum 8*: 77–91.

Milner, G. R. & Larsen, C. S. (1991). Teeth as artifacts of human behavior: Intentional mutilation and accidental modification. In M. A. Kelley & C. S. Larsen (eds), *Advances in dental anthropology* (pp. 357–78). New York: Wiley-Liss.

Minagawa, M. & Wada, E. (1984). Stepwise enrichment of ^{15}N along food chains: further evidence and the relationship between Õ ^{15}N and animal age. *Geochimica et Cosmochimica, Acta 48*: 1135–40.

Molleson, T. (1994). The eloquent bones of Abu Hureyra. *Scientific American 271*: 70–5.

Molnar, S. (1972). Tooth wear and culture: A survey of tooth functions among some prehistoric populations. *Current Anthropology 13*: 511–26.

Molto, J. D., Stewart, J. D. & Reimer, P. J. (1997). Problems in radiocarbon dating human remains from arid coastal areas: an example from the Cape Region of Baja California. *American Antiquity 62*(3): 489–507.

Mooney, H. A., Troughton, J. H. & Berry, J. A. (1977). Carbon isotope ratio measurements of succulent plants in Southern Africa. *Oecologia 30*: 295–305.

Moreau, J-P. (1985). *Un flibustier français dans la mer des Antilles en 1618/1620* [A French privateer in the Antillean sea in 1618/1620]. Clamart: Editions Jean-Pierre Moreau.

Morgan, G. S. & Woods, C. A. (1986). Extinction and the zoogeography of West Indian mammals. *Biological journal of the Linnean Society 28*: 167–203.

Morrison, S. E. (1942). *Admiral of the ocean sea: a life of Christopher Columbus*. Boston, MA: Little Brown & Co.

Morse, B. F. (1990). The pre-Columbian ball and dance court at Salt River, St Croix. *Folk 32*, 45–60.

Morse, B. F. (1991). The classic Tainan ball and dance court at Salt River, St Croix. In E. N. Ayubi & J. R. Haviser (eds), *Proceedings of the Thirteenth International Congress of the International Association for Caribbean Archaeology (Part 2*, pp. 559–75). Willemstad: The Archaeological-Anthropological Institute of The Netherlands Antilles.

Morse, B. F. (1995). The sequence of occupations at the Salt River site, St Croix. In R. E. Alegría & M. Rodríguez (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 471–84). San Juan: Centro de Estudios Avanzados de Puerto Rico y el Caribe.

Murray, K. A. (1989). Bioarchaeology of the post contact Mississippi and Arkansas River valleys: AD 1500–1700. Unpublished Master's thesis, University of Arkansas, Fayetteville.

Murray, M. D. & Schoeninger, M. J. (1988). Diet, status, and complex social structure in Iron Age central Europe: some contributions from bone chemistry. In D. Gibson & M. D. Geselowitz (eds), *Tribe and policy in late prehistoric Europe* (pp. 155–78). New York: Plenum.

Narganes Storde, Y. M. (1995). La lapidaria de la Hueca, Vieques, Puerto Rico [The stone work of La Hueca, Vieques, Puerto Rico]. In R. Alegría & M. Rodríquez (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 141–9). Puerto Rico.

Neff, H. (1994). RQ-mode principal components analysis of ceramic compositional data. *Archaeometry 36*: 115–30.

Nelson, B. K., DeNiro, M. J., Schoeninger, M. J., DePaolo, D. P. & Hare, P. E. (1986). Effects of diagenesis on strontium, carbon, nitrogen and oxygen concentration and isotopic composition of bone. *Geochimica et Cosmochimica, Acta 50*: 1941–49.

Nelson, D. G. A. & Featherstone, J. D. B. (1982). Preparation, analysis and characterization of carbonated apatites. *Calcified Tissue International 34*: 569–81.

Newsom, L. A. (1993). Native West Indian plant use. Unpublished Doctoral dissertation, University of Florida, Gainesville.

Newsom, L. A. & Pearsall, D. M. (1997). Temporal and spatial trends indicated by a survey of archaeobotanical data from the Caribbean islands. In P. Minnis (ed.), *People and plants in ancient North America*. Washington, DC: Smithsonian Institution Press.

Norr, L. (1984). Prehistoric subsistence and health status of coastal peoples of lower Central America. In M. N. Cohen & G. J. Armelagos (eds), *Paleopathology at the origins of agriculture* (pp. 463–90). Orlando: Academic Press.

Norr, L. (1990). Nutritional consequences of prehistoric subsistence strategies in lower Central America. Unpublished Doctoral dissertation, University of Illinois, Urbana-Champaign.

Norr, L. (1992). A reassessment of the relationship between a maize-based diet and porotic hyperostosis in prehistoric central Panama. *American Journal of Physical Anthropology Supplement 14*: 128 (abstract).

Norr, L. (1995). Interpreting dietary maize from bone stable isotopes in the New World tropics: the state of the art. In P. W. Stahl (ed.), *Archaeology in the American Tropics: Current analytical methods and applications* (pp. 198–223), Volume in honor of Donald W. Lathrap. Cambridge: Cambridge University Press.

Norr, L. (1996). Dietary diversity along the northwestern coast of Costa Rica. In F. W. Lange (ed.), *Paths to Central American prehistory* (pp. 253–69), volume in honor of Wolfgang Haberland. Boulder: University of Colorado Press.

Norr, L. & Hutchinson, D. L. (1998, May). *Reconstructing prehistoric subsistence in South Florida.* Paper presented at the annual meeting of the Florida Anthropological Society, Gainesville, FL.

O'Leary, M. (1981). Carbon isotope fractionation in plants. *Phytochemistry 20*: 553–67.

Oliver, J. R. (1990). Ceramic analysis. In Grossman & Associates Inc., *Excavation and analysis results of archaeological investigations at Medianía Alta (L–23) and Vieques (L–22), Loíza, Puerto Rico* (Vol. 1, pp. 42–120). Report submitted by Grossman & Associates Inc., New York, to Puerto Rico Aqueduct and Sewer Authority, San Juan.

Oliver, J. R. (1992). *Results of the archaeological testing and data recovery investigations at the Lower Camp site, Culebra Island National Wildlife Refuge, Puerto Rico.* Report submitted by Garrow & Associates Inc., Atlanta, to US Department of the Interior, National Park Service, Southeast Regional Office, Atlanta.

Oliver, J. R. (1993). Iglesia de Maraguez (po-39): investigations of a local ceremonial center in the Cerrillos river valley, Ponce, Puerto Rico. Report prepared by P. Garrow, C. McNutt, J., G. Weaver & J. Oliver (pp. 14–50). Garrow & Associates Inc., Atlanta, GA.

Oliver, J. R. (1995). The archaeology of Lower Camp Site, Culebra Island: Understanding variability in peripheral zones. In R. E. Alegría & M. Rodríguez (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 485–500). San Juan: Centro de Estudios Avanzados de Puerto Rico y el Caribe.

Oliver, J. R. (1997). Dabajuroid archaeology, settlements and house structures: an overview from mainland western Venezuela. In A. H. Versteeg & S. Rostain (eds), *The Archaeology of Aruba: the Tanki Flip site* (pp. 363–429). Aruba and Amsterdam: Publications of the Archaeological Museum Aruba 8. Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Oliver, J. R. (1998). *El centro ceremonial de Caguana, Puerto Rico: Simbolismo iconográfico, cosmovisión y el poderió cacquil Taíno de Boriguen* [Caguanas ceremonial center, Puerto Rico: iconography, symbolism, cosmic vision and authority of the Taíno chiefs of Puerto Rico]. *B.A.R. International Series 727.* Oxford: Archaeopress.

Oliver, J. & Righter, E. (1998). Placing the Tutu site in the context of Caribbean prehistory. Unpublished manuscript.

Olsen, F. (1974a). *On the trail of the Arawak.* Norman: University of Oklahoma Press.

Olsen, F. (1974b). *Indian Creek: Arawak site on Antigua, West Indies.* Norman: University of Oklahoma Press.

Onwueme, I. C. (1978). *The tropical tuber crops: yams, cassava, sweet potato, and cocoyams.* Chichester: John Wiley & Sons.

Ortiz, E. (1993). *Estudio químico y geológico para identificar fuentes cerámicas precolombinas e impacto en las estratas.* Paper presented at the XVth International Congress for Caribbean Archaeology, San Juan, Puerto Rico.

Ortner, D. & Putschar, W. J. (1981). *Identification of pathological conditions in human skeletal remains.* Washington, DC: Smithsonian Institution Press.

Oviedo y Valdés, G. F. de (1944). *Historia general y natural de las Indias. Islas y Tierra-Firme del Mar Océano.* Paraguay: Editorial Guarania, Asunción.

Oviedo y Valdés, G. F. de (1959). *Historia general y natural de las Indias. In Biblioteca de autores españoles* (Vols. 117–22). Madrid: Ediciones Atlas.

Pané, R. (1974). Relación acera de las Antigüedades de los Indios [Account concerning the antiquities of the Indies]. New version, with notes, maps, and appendices by Jose Juan Arrom, Mexico City, Siglo XXI.

Pantel, A. G. (1977). Progress report and analysis: Barerra Mordán Complex, Azua, Dominican Republic. *Revista Dominicana de Antropología e Historia 5*:161–87.

Pantel, A. G. (1988). *Precolumbian flaked stone assemblages in the West Indies.* Doctoral dissertation, Department of Anthropology, University of Tennessee. Ann Arbor, Michigan: University Dissertation Services.

Pate, F. D., Hutton, J. T. & Norrish, K. (1989). Ionic exchange between soil and bone: toward a predictive model. *Applied Geochemistry 4*: 303–16.

Patterson, D. K., Jr. (1984). A diachronic study of dental paleaeopathology and attritional status of prehistoric Ontario pre-Iroquois and Iroquois populations. *Archaeological Survey of Canada, Paper No. 122.*

Payne, T. M. (1995). Research progress report, Robin Bay Site (12VAm1–27), St Croix, USVI: a site in the Ceramic Age. In R. E. Alegría & M. Rodríguez (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 435–43). San Juan: Centro de Estudios Avanzados de Puerto Rico y el Caribe.

Payne, T. M. & Thomas, R. A. (1988). Archaeological investigations at prehistoric site 12VAm1–7 Reflection Bay, Estate Cane Bay, St Croix, USVI. Newark, Delaware: MAAR Associates Inc.

Pearsall, D. M. (1989a). *Paleoethnobotany. A handbook of procedures.* San Diego: Academic Press.

Pearsall, D. M. (1989b). Plant utilization at the Krum Bay Site, St Thomas, USVI. In E. R. Lundberg, *Preceramic procurement patterns at Krum Bay, Virgin Islands* (pp. 290–361). Unpublished Doctoral dissertation, University of Illinois, Urbana.

Pearsall, D. M. (1992). The origins of plant cultivation in South America. In C. W Cowan & P. J. Watson (eds), *Origins of agriculture. An international perspective* (pp. 173–205). Washington, DC: Smithsonian Institution Press.

Pearsall, D. M. (1995). "Doing" paleoethnobotany in the tropical lowlands: adaptation and innovation in methodology. In P. Stahl (ed.), *Archaeology in the Lowland American Tropics: Current analytical methods and recent applications* (pp. 113–29). Cambridge: Cambridge University Press.

Pearsall, D. M. (1997). *Analysis of charred botanical remains from the Tutu Archaeological Village Site, US Virgin Islands.* Unpublished report submitted to the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Pearsall, D. M. & Piperno, D. R. (eds) (1993). *Current research in phytolith analysis: applications in archaeology and paleoecology.* Philadelphia: (MASCA Research Papers in Science and Archaeology). MASCA, The University Museum of Archaeology and Anthropology, Philadelphia.

Pedersen, P. O. (1947). Dental investigations of Greenland Eskimos. *Proceedings of the Royal Society of Medicine 40*: 726–32.

Pedersen, P. O. (1952). Some dental aspects of anthropology. *Dental Record* 72: 170–8.

Pedersen, P. O. (1955). Eine besondere form der abnutzung von Eskimozähnen aus Alaska. *Deutsche Zahnärztliche Zeitschrift 10*: 41–6.

Pedersen, P. O. & Jakobsen, J. (1989). Teeth and jaws of the Qilakitsoq mummies. In J. P. H. Hansen & H. C. Gullov (eds), *The Mummies from Qilakitsoq – Eskimos in the 15th Century. Meddelelser om Gronland, Man & Society 12*: 112–30.

Perzigian, A. J., Tench, P. A. & Braun, D. J. (1984). Prehistoric health in the Ohio Valley. In M. N. Cohen & G. J. Armelagos (eds), *Paleopathology at the origins of agriculture* (pp. 347–65). Orlando, FL: Academic Press.

Petersen, J. B. (1996). Archaeology of Trants, Montserrat. Part 3. Chronological and settlement data. *Annals of the Carnegie Museum 65*(4): 27. Pittsburgh: Carnegie Institute. (Reprint)

Petersen, J. B. & Watters, D. R. (1991). Amerindian ceramic remains from Fountain Cavern, Anguilla, West Indies. *Annals of Carnegie Museum 60*(4): 321–57.

Petersen, J. B. & Watters, D. R. (1995). A preliminary analysis of Amerindian ceramics from the Trants site, Montserrat. In R. E. Alegría & M. Rodríguez (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 131–40). San Juan: Centro de Estudios Avanzados de Puerto Rico y el Caribe.

Phenice, T. W. (1969). A newly-developed visual method of sexing the os pubis. *American Journal of Physical Anthropology 30*: 297–301.

Pinchon, P. R. (1967). Quelques aspects de la nature aux Antilles [Several aspects of the nature of the Antilles]. Fort-de France, Martinique.

Piperno, D. R. (1988). *Phytolith analysis: an archaeological and geological perspective.* San Diego: Academic Press.

Piperno, D. R. (1990). Aboriginal agriculture and land usage in the Amazon basin, Ecuador. *Journal of Archaeological Science 17*: 665–77.

Piperno, D. R. (1991). The status of phytolith analysis in the American tropics. *Journal of World Prehistory 5*, 155–91.

Piperno, D. R. (1994). Analysis of pollen and phytoliths from the Tutu Site, US Virgin Islands. Report to the Office of the State Archaeologist, USVI, Charlotte Amalie.

Piperno, D. R. (1995a). Plant microfossils and their application in the New World Tropics. In P. Stahl (ed.), *Archaeology in the Lowland American Tropics: Current analytical methods and applications* (pp. 130–53). Cambridge: Cambridge University Press.

Piperno, D. R. (1995b). *Phytolith and pollen analysis at the Tutu Site, St Thomas, US Virgin Islands.* Manuscript on file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas.

Piperno, D. R. & Pearsall, D. M. (1993a). The status of phytolith analysis. In Pearsall, D. M. and D. R. Piperno (eds), *Current research in phytolith analysis. Applications in archaeology and paleoecology* (pp. 9–18). Philadelphia: MASCA Research Papers in Science and Archaeology, The University Museum of Archaeology and Anthropology.

Piperno, D. R. & Pearsall, D. M. (1993b). Phytoliths from the reproductive structures of maize and Teosinte: implications for the study of maize evolution. *Journal of Archaeological Science 20*: 337–62.

Piperno, D. & Pearsall, D. M. (eds) (1998). *The origins of agriculture in the lowland tropics.* San Diego: Academic Press.

Pons Alegría, M. (1976). Saladoid "incense-burners" from the site of El Convento, Puerto Rico. In R. P. Bullen (ed.), *Proceedings of the Sixth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles* (pp. 272–5). Gainesville: R. P. Bullen.

Powell, M. L. (1988). *Status and health in prehistory: a case study of the Moundville chiefdom.* Washington, DC: Smithsonian Institution Press.

Powell, M. L. (1989). The people of Nodena. In D. F. Morse (ed.), *Nodena: An account of 90 years of archeological investigation in southeast Mississippi County, Arkansas* (pp. 65–95). Arkansas Archeological Survey Research Series No. 30.

Powell, M. L. (1991). Endemic treponematosis and tuberculosis in the prehistoric southeastern United States: biological costs of chronic endemic disease. *Zagreb Paleopathology Symposium*: 173–80.

Powell, M. L. (1994). Treponematosis before 1492 in the south eastern United States of America: Why call it syphilis? In O. Dutour, G. Pálfi, J. Berato & J-P. Brun (eds), *L'Origine de la syphilis en Europe: Avant ou après 1493?* [The origin of syphilis in Europe: before or after 1493?] (pp. 158–63). Paris: Centre Archéologique du Var – Editions Errance.

Ragsdale, B. (1995). Rates and mechanisms of skeletal morphologic change. Workshop presented at the 22nd Annual Meeting of the Paleopathology Association, Oakland, California.

Ragsdale, B. D. & Ortner, D. J. (1992). Descriptive terminology. Workshop presented at the 19th Annual Meeting of the Paleopathology Association, Las Vegas, Nevada.

Rainey, F. G. (1940). Porto Rican archaeology. In E. M. Schlaikjer (ed.), *Scientific survey of Porto Rico and the Virgin Islands* (Vol. 18, Part 1, pp. 1–208). New York: New York Academy of Sciences.

Randall, J. E. (1983). *Caribbean Reef Fishes.* New Jersey: T.F.H. Publ. Inc.

Rapp, G., Jr. & Mulholland, S. (eds) (1992). *Phytolith systematics. Emerging issues.* New York: Plenum Press.

Record, S. J. & Hess, R. W. (1943). *Timbers of the New World.* New Haven: Yale University Press.

Reichs, K. J. (1989). Treponematosis: a possible case for the Late Prehistoric of North Carolina. *American Journal of Physical Anthropology 79*: 289–303.

Reitz, E. J. (1994). The wells of Spanish Florida: Using taphonomy to identify site history. *Journal of Ethnobiology 14*(20): 141–60.

Rhoades, J. D. (1982). Soluble salts. In *Methods of soil analysis, part 2: Chemical and microbiological properties* (pp. 167–79). Agronomy Monograph. No 9. 2nd edition. Madison, WI: ASA-SSSA.

Ricciardi, M. (1991). *Vanishing Amazon.* London: Weidenfeld & Nicolson.

Richier, A. & Bonnissent, D. (1997). Les sépultures du site de Hope Estate à Saint-Martin [The burials of Hope Estate site]. Paper presented at the XVIth International Congress for Caribbean Archaeology. Guadeloupe.

Righter, E. (1990). Letter to Peter Siegel re Saladoid sites on St Croix. On file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Righter, E. (1991a). Importance of the Tutu Archaeological Village. Unpublished manuscript on file at the Department of Planning and Natural Resources, Charlotte Amalie, St Thomas, USVI.

Righter, E. (1991b). *Tutu Archaeological Village Site: a technical proposal for emergency data recovery, analysis, laboratory work, report and exhibit.* Manuscript on file at the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Righter, E. (1992). *Statewide comprehensive historic preservation plan: prehistoric context.* Prepared for the Southeastern Regional Office of the National Park Service, Atlanta.

Righter, E. (1995). *A critical look at prehistoric site distribution in the US Virgin Islands.* Paper presented at the XVIth International Congress for Caribbean Archaeology, Guadeloupe.

Righter, E. (1997). The ceramics, art and material culture of the Early Ceramic Period in the Caribbean Islands. In S. Wilson (ed.), *The Indigenous People of the Caribbean.* Gainesville: University of Florida Press.

Righter, E. (2001). Changing times at the Tutu Archaeological Village site, St Thomas, USVI. Paper presented at the XIXth International Congress for Caribbean Archaeology, Aruba, July 2001.

Righter, E. & Lazelle, J. (1997). Update to the Virgin Islands Inventory of Historic Places. Manuscript on file at the Division for Archaeology and Historic Preservation, Charlotte Amalie.

Righter, E. & Lundberg, E. R. (1991). Preliminary findings at the Tutu Archaeological Village Site, St Thomas, USVI. In A. Cumins & P. King (eds), *Proceedings of the Fourteenth International Congress for Caribbean Archaeology* (pp. 561–76). Barbados.

Righter, E., Sandford, M. K. & Sappelsa, L. (1993). Bioarchaeological investigations at the Tutu Archaeological Village Site, St Thomas, USVI: A preliminary report. In R. E. Alegría & M. Rodríguez López (eds), *Proceedings of the XVth International Congress for Caribbean Archaeology* (pp. 243–55). San Juan.

Rimoli, R. O. (1984). Nuevas citas para mamiferos precolumbinos en la Hispaniola [New sites of pre-Columbian mammals in Hispaniola]. Cuadernos del Cendia, Vol. CCLIX (6): 1–15.

Rivera, V. (1997). Poster session at the Seventeenth Congress of the International Association for Caribbean Archaeology, Nassau, Bahamas.

Rivera, V. & Rodríguez, M. (1991). The Playa Blanca 5 Site: a late prehistoric ceramic site in eastern Puerto Rico (a preliminary report). In E. N. Ayubi & J. B. Haviser (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology* (pp. 541–58). Reports of the Archaeological-Anthropological Institute of the Netherlands Antilles. Curaçao, Netherlands Antilles.

Rivera, L. H., Frederick, W. D., Farris, C., Jensen, E. H., Davis, L., Palmer, C. D., Jackson, L. F. & McKinzie, W. E. (1970). *Soil survey of the Virgin Islands of the United States.* Soil Conservation Service, United States Department of Agriculture, Washington, DC.

Rives, A. & Febles, J. (1990). Aproximación a una metódica interpretativa de los ajuares de silex de las comunidades aborígenes de Cuba [Approach to an expounded method of silex utensils of the aborigines]. *Anuario de Arqueología 1988*, 14–28.

Rivière, P. (1994). Houses, places and people: community and continuity in Guiana. In J. Carsten & S. Hugh-Jones (eds), *About the House: Levi-Strauss and Beyond* (pp. 189–206). Cambridge: Cambridge University Press.

Robins, C. R., Bailey, R. M., Bond, C. E., Brooker, J. R., Lachner, E. A., Lea, R. N. & Scott W. B. (1991). Common and scientific names of fishes from the United States and Canada. *American Fisheries Society Special Publication No. 20.*

Robinson, L. S. (1978). Modified *Oliva* sp. shells from the Virgin Islands: a morphological study. In L. Allaire & F. M. Mayer (eds), *Proceedings of the Tenth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles* (pp.169–87), Martinique.

Robinson, L. S, Lundberg, E. R. & Walker, J. B. (1985). *Archaeological data recovery at El Bronce, Puerto Rico, Final Report, Phase 2.* Archeological Services Inc., Ft. Myers, Florida. Submitted to US Army Corps of Engineers, Jacksonville District, Jacksonville.

Rodríguez, M. (1991a). *Early trade networks in the Caribbean.* In A. Cummins & P. King (eds), *Proceedings of the Fourteenth International Congress for Caribbean Archaeology* (pp. 306–14). Barbados.

Rodríguez, M. (1991b). Arqueólogia de Punta Candelero, Puerto Rico. In E. N. Ayubi & J. Haviser (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology* (pp. 605–27). Willemstad, Curaçao: Archaeological-Anthropological Institute of The Netherlands Antilles.

Rodríguez, M. (1995). Algunas practicas funerarias en Punta Candelero, Puerto Rico [Some burial customs of Punta Candelero, Puerto Rico]. XVI Congreso de Arqueologia del Caribe, Guadeloupe, FWI.

Rodríguez López, M. & Rivera, V. (1983). Sitio "El Destino", Vieques, Puerto Rico: Informe preliminar. In L. Allaire & F. M. Mayer (eds), *Proceedings of the Ninth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles* (pp. 163–72). Montréal: Centre de Recherches Caraïbes, Université de Montréal.

Rodríguez, M. & Rivera, V. (1991). Puerto Rico and the Caribbean pre-Saladoid "crosshatch connection." In L. S. Robinson (ed.), *Proceedings of the Twelfth International Congress for Caribbean Archaeology* (pp. 45–51). Martinique: International Association for Caribbean Archaeology.

Roe, P. G. & Siegel, P. E. (1982). The life history of a Shipibo compound: ethnoarchaeology in the Peruvian montana. *Archaeology and Anthropology 5*(2): 95–118.

Roosevelt, A. C. (1980). *Parmana: prehistoric maize and manioc subsistence in the Amazon and Orinoco.* New York: Academic Press.

Roosevelt, A. C. (1989a). Resource management in Amazonia before the conquest: Beyond ethnographic projection. In W. Balee and D. Posey (eds), *Resource management in Amazonia: Indigenous and folk strategies* (pp. 30–62). Advances in Economic Botany, Vol. 7. New York: New York Botanical Garden.

Roosevelt, A. C. (1989b). Discussion of early ceramic population lifeways and adaptive strategies in the Caribbean. In P. E. Siegel (ed.), *BAR International Series 506* (pp. 193–245). Oxford: British Archaeological Reports.

Roosevelt, A. C. (1991). *Moundbuilders of the Amazon: Geophysical Archaeology on Marajo Island, Brazil.* San Diego: Academic Press.

Roosevelt, A. C. (1993). The rise and fall of the Amazon chiefdoms. In A. C. Taylor & P. Descola (eds), *La remontée de l'Amazone: anthropologie et histoire des sociétés amazonienne,* (pp. 255–84). L'Homme 33(126–8). Special Issue. Paris.

Roosevelt, A. C. (ed.) (1994). *Amazonian Indians from prehistory to the present: anthropological perspectives.* Tucson: University of Arizona Press.

Roosevelt, A. C. (1997). The excavations at Corozal, Venezuela: stratigraphy and ceramic seriation. *Yale University Publications in Anthropology No. 83.* New Haven.

Roosevelt, A. C. (1999). The maritime-highland-forest dynamic and the origins of complex society. In F. Salomon & S. Schwartz (eds), *History of the native peoples of the Americas: South America* (pp. 264–349). Cambridge: Cambridge University Press.

Roosevelt, A. C. (in press). Amazonia, A dynamic human habitat. In D. Lentz (ed.), *Pre-columbian New World ecosystems.* New York: Columbia University Press.

Rose, J. J. (1983). A replication technique for scanning electron microscopy: Applications for anthropologists. *American Journal of Physical Anthropology 62*: 255–61.

Rostain, S. & Versteeg, A. H. (1997). Special features, spatial patterns and symbolism at Tanki Flip. In A. H. Versteet & S. Rostain (eds)*, The archaeology of Aruba: the Tanki Flip Site*. Aruba and Amsterdam: Publications of the Archaeological Museum Aruba 8, Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Rouse, I. (1937). [Unpublished archaeological research field notes]. Unpublished raw data. New Haven: Yale University Peabody Museum of Natural History.

Rouse, I. (1939). Prehistory in Haiti. *Yale University Publications in Anthropology No. 21*. New Haven: Yale University Press.

Rouse, I. (1952). Porto Rican prehistory: Introduction: excavations in the west and north. *Scientific Survey of Porto Rico and the Virgin Island, New York Academy of Sciences 18*(3–4): 307–577.

Rouse, I. (1954). On the use of the concept of Area Co-tradition. *American Antiquity 19*: 221–25.

Rouse, I. (1960). The classification of artifacts in archaeology. *American Antiquity 25*(3): 313–23.

Rouse, I. (1962). Field notes on Cuevas excavation, 1962 season. Unpublished raw data. New Haven: Yale University Peabody Museum.

Rouse, I. (1965). The place of "peoples" in prehistoric research. *Journal of the Royal Anthropological Institute, 95*(1): 1–15.

Rouse, I. (1972). *Introduction to prehistory: A systematic approach*. New York: McGraw-Hill.

Rouse, I. (1974). The Indian Creek excavations. In R. P. Bullen (ed.), *Proceedings of the Fifth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles* (pp. 166–76). *Gainesville, Florida.*

Rouse, I. (1982). Ceramic and religious development in the Greater Antilles. *Journal of New World Archeology 5*(2): 45–55.

Rouse, I. (1986). *Migrations in prehistory*. New Haven: Yale University Press.

Rouse, I. (1992). *The Taínos: rise and decline of the people who greeted Columbus*. New Haven: Yale University Press.

Rouse, I. & Alegría, R. E. (1990). Excavations at Maria de La Cruz Cave and Hacienda Grande Village Site, Loiza, Puerto Rico. *Yale University Publications in Anthropology 80*. New Haven: Yale University Press.

Rouse, I. & Faber Morse, B. (1995). *The Mill Reef period: A local development of the island of Antigua*. Paper presented at the XVIth International Congress for Caribbean Archaeology, held on Basse-Terre, Guadeloupe, 24–28 July 1995, and submitted for publication in the proceedings.

Rouse, I. & Faber Morse, B. (1999). Excavations at the Indian Creek Site, Antigua. *Yale University Publications in Anthropology*, New Haven: Yale University Press.

Sale, P. F. (ed.) (1991). *The ecology of fishes on coral reefs*. San Diego: Academic Press.

Sandford, M. K. (1992). A reconsideration of trace element analysis in prehistoric bone. In S. Saunders & M. A. Katzenberg (eds), *The skeletal biology of past peoples: advances in research methods* (pp. 79–103). New York: Wiley-Liss.

Sandford, M. K. (ed.) (1993a). *Investigations of ancient human tissue: chemical analyses in anthropology*. Langhorne, PA: Gordon & Breach Science Publishers.

Sandford, M. K. (1993b). Understanding the biogenic-diagenetic continuum: interpreting elemental concentrations of ancient bone. In M. K. Sandford (ed.), *Investigations of ancient human tissue* (pp. 3–57). Langhorne: Gordon & Breach Science Publishers.

Sandford, M. K. (1994). Possible pre-Columbian treponematoses from coastal populations in the Caribbean and North Carolina. *American Journal Physical Antrhopology Supplement 18*: 176.

Sandford, M. K. & Kissling, G. E. (1994). Multivariate analyses of elemental hair concentrations from a Medieval Nubian population. *American Journal of Physical Anthropology 95*: 41–52.

Sandford, M. K., Bogdan, G. & Kissling, G. E. (1997). *A view to the past: an investigation of the bioarchaeology and paleopathology at the Tutu site, St Thomas, USVI.* Manuscript prepared by the University of North Carolina at Greensboro and submitted to the Division for Archaeology and Historic Preservation, Charlotte Amalie, St Thomas, USVI.

Sandford, M. K., Bogdan, G. Weaver, D. S. & Sappelsa, L. (1994). Possible treponematoses from the pre-Columbian Caribbean and coastal North Carolina. In O. Dutour, G. Palfi, J. Berato and J-P. Brun (eds), *L'Origine de La Syphilis en Europe: Avant ou Après 1493?* (pp. 164–68). France: Centre Archaeologique du Var, Toulon.

Sandford, M. K., Sappelsa, L., Weaver, D. S., Larsen, C. S., Russell, K. S. & Righter, E. (1992). *Paleopathology of human skeletal material from the Tutu Site, St Thomas: A preliminary report.* Paper presented at the annual meeting of the Paleopathology Association, Las Vegas, NV.

Sandford, M. K., Van Gerven, D. P. & Meglen, R. R. (1983). Elemental hair analysis: New evidence on the etiology of cribra orbitalia in Sudanese Nubia. *Human Biology* 55: 831–44.

Sappelsa. L. (1993). *Paleopathology of a precolumbian human skeletal sample from Tutu, St Thomas, United States Virgin Islands*. Unpublished master's thesis, Department of Anthropology, Wake Forest University, Winston-Salem, NC.

Saul, J. M. & Saul, F. P. (1997). The Preclassic skeletons from Cuello. In S. L. Whittington & D. M. Reed (eds), *Bones of the Maya: Studies of ancient skeletons* (pp. 28–50). Washington, DC: Smithsonian Institution Press.

Schinkel, K. (1991). *The archaeology of St Eustatius: the Golden Rock Site.* Publication of the Foundation for Scientific Research in the Caribbean Region, No. 130, The Netherlands.

Schinkel, K. (1992). The features of the Golden Rock site, St Eustatius, NA. In A. Versteeg & K. Schinkel (eds), *The archaeology of St Eustatius; the Golden Rock site.* St Eustatius: Publication of the St Eustatius Historical Foundation, No 2.

Schmidt-Nielsen, K. (1984). *Scaling.* Cambridge: Cambridge University Press.

Schoeninger, M. J. (1985). Trophic level effects on $^{15}N/^{14}N$ and $^{13}C/^{12}C$ ratios in bone collagen and strontium levels in bone mineral. *Journal of Human Evolution 14*: 515–25.

Schoeninger, M. J. & DeNiro, M. J. (1982). Carbon isotope ratios of apatite from fossil bone cannot be used to reconstruct diets of animals. *Nature 297*: 577–8.

Schoeninger, M. J. & DeNiro, M. J. (1983). Reply to: Carbon isotope ratios of bone apatite and animal diet reconstruction. *Nature 301*: 177–8.

Schoeninger, M. J. & DeNiro, M. J. (1984). Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica, Acta 48*: 625–39.

Schoeninger, M. J. & Peebles, C. S. (1981). Effect of mollusc eating on human bone strontium levels. *Journal of Archaeological Science 8*: 391–7.

Schoeninger, M. J., DeNiro, M. J. & Tauber, H. (1983). Stable nitrogen isotope ratios of bone collagen reflect marine and terrestrial components of prehistoric human diet. *Science 220*: 1381–3.

Schulz, P. D. (1977). Task activity and anterior tooth grooving in prehistoric California Indians. *American Journal of Physical Anthropology 46*: 87–91.

Schulz, P. D. & McHenry, H. M. (1975). Age distribution of enamel hypoplasias in prehistoric California Indians. *Journal of Dental Research 54*: 913–20.

Schwarcz, H. P., Melbye, J., Katzenberg, M. A. & Knyf, M. (1985). Stable isotopes in human skeletons of southern Ontario: Reconstructing paleodiet. *Journal of Archaeological Science 12*: 187–206.

Schwartz, A. and Henderson, R. W. (1991). *Amphibians and reptiles of the West Indies.* Gainesville: University of Florida Press.

Sciulli, P. W. (1978). Developmental abnormalities of the permanent dentition in prehistoric Ohio Valley Amerindians. *American Journal of Physical Anthropology 48*: 193–8.

Sealy, J. (1986). *Stable carbon isotopes and prehistoric diets in the South-Western Cape Province, South Africa.* (International Series No. 293) London: British Archaeological Reports.

Sealy, J. (1989). *The use of chemical techniques for reconstructing prehistoric diets: a case study in the South-Western Cape* (69–76). Goodwin Series No. 6. Cape Town: South African Archaeological Society.

Sealy, J. & van der Merwe, N. J. (1985). Isotope assessment of Holocene human diets in the Southwestern Cape, South Africa. *Nature 315*: 138–40.

Sealy, J., van der Merwe, N. J., Lee-Thorp, J. A. & Lanham, J. L. (1987). Nitrogen isotope ecology in southern Africa: implications for environmental and dietary tracing. *Geochimica et Cosmochimica, Acta 51*: 2707–17.

Serrand, N. (1997). Tanki Flip shell artefacts with a relatively high level of modification. In A. H. Versteet & S. Rostain (eds), *The archaeology of Aruba: the Tanki Flip Site* (pp.189–218). Aruba and Amsterdam: Publications of the Archaeological Museum Aruba 8, Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Shepard, A. O. (1956). *Ceramics for the archaeologist.* Washington, DC: Carnegie Institution of Washington.

Siegel, P. E. (1989). Site structure, demography, and social change in the early Ceramic Age of the Caribbean. In P. E. Siegel (ed.), BAR International Series 506 (pp. 193–245). Oxford: British Archaeological Reports.

Siegel, P. E. (1991). Political evolution in the Caribbean. In J. B. Haviser & E. N. Ayubi (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology* (pp. 232–51). Willemstad: Archaeological-Anthropological Institute of the Netherlands Antilles.

Siegel, P. E. (1992). *Ideology, power, and social complexity in prehistoric Puerto Rico.* Unpublished doctoral dissertation, Department of Anthropology, State University of New York, Binghampton, NY Microfilms, Ann Arbor.

Siegel, P. E. (1995). The archaeology of community organization in the tropical lowlands: a case study from Puerto Rico. In P. W. Stahl (ed.), *Archaeology in the lowland American tropics* (pp. 42–65). Cambridge: Cambridge University Press.

Siegel, P. E. (1996). Ideology and culture change in prehistoric Puerto Rico: a view from the community. *Journal of Field Archaeology 23*(3): 313–33).

Sillen, A. (1986). Biogenetic and diagenetic Sr/Ca in Plio-Pleistocene fossils of the Omo Shungara Formation. *Paleobiology 12*: 311–23.

Sillen, A. (1989). Diagenesis of the inorganic phase of cortical bone. In T. D. Price (ed.), *The chemistry of prehistoric human bone* (pp. 211–29). Cambridge: Cambridge University Press.

Simon, A. W., Komorowski, J. C. & Burton, J. H. (1992). Patterns of production and distribution of Salado wares as a measure of social complexity. In C. L. Redman, G. E. Rice & K. E. Pedrick (eds), *Developing perspectives on the Tonto Basin prehistory* (pp. 61–76). Tempe: Arizona State University.

Sleight, F. W. (1962). Archaeological reconnaissance of the Island of St John, US Virgin Islands. *William L. Bryant Foundation, American Studies Report No.3.* E. O. Painter Printing Company, Deland, Florida.

Smith, B. H. (1984). Patterns of molar wear in hunter–gatherers and agriculturalists. *American Journal of Physical Anthropology 63*: 39–56.

Smith, B. N. (1972). Natural abundance of the stable isotopes of carbon in biological systems. *BioScience 22*: 226–31.

Smith, B. N. & Epstein, S. (1971). Two categories of $^{13}C/^{12}C$ ratios for higher plants. *Plant Physiology 47*: 380–4.

Smith, B. N., Oliver, J. & McMillan, C. (1976). Influence of carbon source, oxygen concentration, light intensity, and temperature on $^{13}C/^{12}C$ ratios in plants. *Botanical Gazette 137*: 99–104.

Smith, B. N., Otto, C. B., Martin, G. E. & Boutton, T. W. (1979). Photosynthetic strategies of plants. In J. R. Goodin & D. K. Northington (eds), *Arid land plant resources* (pp. 474–81). Lubbock: Texas Technical University Press.

Spencer, C. E. (1987). Rethinking the chiefdom. In R. D. Drennan & C. A. Uribe (eds), *Chiefdoms in the Americas* (pp. 369–90). Lanham: University Press of America.

Steadman, D. W. (1995). Prehistoric extinctions of Pacific Island birds: Biodiversity meets zooarchaeology. *Science 267*: 1123–31.

Steele, D. G. & Bramblett, C. A. (1988). *The anatomy and biology of the human skeleton.* College Station, TX: Texas A & M University Press.

Steinbock, R. T. (1976). *Paleopathological diagnosis and interpretation.* Illinois: Charles Thomas.

Stirland, A. (1994). Evidence for pre-Columbian treponematosis in medieval Europe. In O. Dutour, G. Pálfi, J. Berato & J-P. Brun (eds), *L'Origine de la syphilis en Europe: Avant ou après 1493?* [The origin of syphilis in Europe: before or after 1493?] (pp. 109–115). Paris: Centre Archéologique du Var – Editions Errance.

Stokes, A. V. (1998). A biogeographic survey of prehistoric human diet in the West Indies using stable isotopes. Unpublished Doctoral dissertation, University of Florida. Ann Arbor, Microfilms International.

Stoltman, J. B. (1989). A quantitative approach to the petrographic analysis of ceramic thin sections. *American Antiquity 54*(1): 147–60.

Stoltman, J. B., Burton, J. H. & Haas, J. (1992). Chemical and petrographic characterizations of ceramic pastes: Two perspectives on a single data set. In H. Neff (ed.), *Chemical characterization of ceramic pastes in archaeology* (pp. 85–92). Madison, WI: Prehistory Press.

Stuart-Macadam, P. (1985). Porotic hyperostosis: representative of a childhood condition. *American Journal of Physical Anthropology 66*: 391–98.

Sullivan, C. H. & Krueger, H. W. (1981). Carbon isotope analysis in separate chemical phases in modern and fossil bone. *Nature 292*: 333–5.

Sullivan, C. H. & Krueger, H. W. (1983). Carbon isotope ratios of bone apatite and animal diet reconstruction. *Nature 301*: 177.

Sutherland, W. J. (1990). Evolution and fisheries. *Nature 344*: 814–15.

Swanton, J. R. (1946). Indians of the Southeastern United States. *Bureau of American Ethnology, Bulletin No. 132.*

Szarek, S. R. & Ting, I. P. (1977). The occurrence of Crassulacean Acid Metabolism among plants. *Photosynthetica 11*: 330–42.

Tacoma, J. (1991). Precolumbian human skeletal remains from Curaçao, Aruba and Bonaire. In E. N. Ayubi and J. B. Haviser (eds), *Proceedings of the Thirteenth International Congress for Caribbean Archaeology* (pp. 302–12). Reports of the Archaeological-Anthropological Institute of The Netherlands Antilles, No. 9. Curaçao, Netherlands Antilles.

Tauber, H. (1981). $\delta^{13}C$ Evidence for dietary habits of prehistoric man in Denmark. *Nature 292*: 332–3.

Teaford, M. F. (1991). Dental microwear: What can it tell us about diet and dental function? In M. A. Kelley & C. S. Larsen (eds), *Advances in dental anthropology* (pp. 341–56). New York: Wiley-Liss.

Teaford, M. F. & Oyen, O. J. (1989). Live primates and dental replication: New problems and new techniques. *American Journal of Physical Anthropology 80*: 73–81.

Tieszen, L. L. (1991). Natural variations in the carbon isotope values of plants: implications for archaeology, ecology and paleoecology. *Journal of Archaeological Science 18*: 227–48.

Timm, R. M., Salazar, R. M. & Peterson, A. T. (1997). Historical distribution of the extinct tropical seal, *Monachus tropicalis* (Carnivora Phocidae). *Conservation Biology 11(2)*: 549–51.

Todd, T. W. (1920). Age changes in the pubic bone VIII: roentgenographic differentiation. *American Journal of Physical Anthropology 14*: 255–71.

Trippel, E. A. (1995). Age at maturity as a stress indicator in fisheries. *BioScience 45*(11): 759–71.

Tronolone, C. A., Cinquino, M. A. & Vandrei, C. E. (1984). *Cultural resource reconnaissance survey for the Vieques Naval Reservation, Part I: Summary report.* Report submitted by Ecology and Environment Inc., to Department of the Navy, Atlantic Division, Norfolk, VA.

Troughton, J. H., Wells, P. V. & Mooney, H. A. (1974). Photosynthetic mechanisms and paleoecology from carbon isotope ratios in ancient specimens of C_4 and CAM plants. *Science 185*: 610–12.

Turgeon, D. D., Quinn, Jr., J. F., Bogan, A. E., Coan, E. V., Hochberg, F. G., Lyons, W. G., Mikkelsen, P. M., Neves, R. J., Roper, C. F. E., Rosenberg, G., Roth, B., Scheltema, A., Thompson, F. G., Vecchione, M. & Williams, J. D. (1988). Common and scientific names of aquatic invertebrates of the United States and Canada: mollusks. *American Fisheries Society, Special Publication No. 16*.

Turner, C. G., II (1972). Comment. *Current Anthropology 13*: 520–1.

Turner, C. G., II (1979). Dental anthropological indications of agriculture among the Jomon people of central Japan. *American Journal of Physical Anthropology 51*: 619–36.

Turner, C. G., II & Machado, L. dM. C. (1983). A new dental wear pattern and evidence for high carbohydrate consumption in a Brazilian Archaic skeletal population. *American Journal of Physical Anthropology 61*: 125–30.

Tuross, N., Fogel, M. L. & Hare, P. E. (1988). Variability in the preservation of the isotopic composition of collagen from fossil bone. *Geochimica et Cosmochimica, Acta 52*: 929–35.

Ubelaker, D. H. (1977). Human skeletal remains from Botany Bay, St Thomas. *Government of the Virgin Islands of the United States Office of the Territorial Archaeologist Bulletin 29*,1–3.

Ubelaker, D. H. (1982). The development of American paleopathology. In *A History of American Physical Anthropology: 1930–1980* (pp. 337–56).

Ubelaker, D. H. (1989). *Human skeletal remains: excavation, analysis, interpretation, 2nd Edition.* Taraxacum, Washington, DC.

Ubelaker, D. H. & Angel, J. L. (1976). Analysis of the Hull Bay skeletons, St Thomas. *Journal of the Virgin Islands Archaeological Society 3*: 7–15.

Ubelaker, D. H., Murray, K. A. & C. E. Watson (1988). Biological analysis of human remains from Cane Bay, St Croix, United States Virgin Islands. In T. Payne & R. Thomas (eds), *Archaeological Investigations at Prehistoric Site 12VAm1–7, Reflection Bay, Estate Canebay, St Croix, USVI.*

US Coast & Geodetic Survey (1918). Map of St Thomas, US Virgin Islands. Register No. 3771. US National Archives, Washington, DC.

Valdes, P. T. & Rivero de la Calle, M. (1972). Paleopatológia de los aborigenes de Cuba [Paleopathology of the aborigines of Cuba]. *Serie Espeleológica y Carsológica 32*: 3–27.

van der Klift, H. M. (1992). Faunal remains of Golden Rock. In A. H. Versteeg & K. Schinkel (eds), *The archaeology of St Eustatius: the Golden Rock Site* (pp. 74–84). Publication of the St Eustatius Historical Foundation, No 2.

van der Merwe, N. J. (1982). Carbon isotopes, photosynthesis, and archaeology. *American Scientist 70*: 596–606.

van der Merwe, N. J. & Vogel, J. C. (1978). ^{13}C Content of human and collagen as a measure of prehistoric diet in Woodland North America. *Nature 276*: 815–16.

van der Merwe, N., Roosevelt, A. C. & Vogel, J. C. (1981). Isotopic evidence for subsistence change at Parmana, Venezuela. *Nature 292*(5823): 536–8.

van der Schalie, H. (1948). *The land and fresh-water mollusks of Puerto Rico.* Misc. Publ. Mus. Zool. Univ. Michigan No. 70.

van der Steen, E. J. (1992). Shell artefacts of Golden Rock. In A. H. Versteeg & K. Schinkel (eds), *The archaeology of St Eustatius: the Golden Rock Site* (pp. 93–119). Publication of the St Eustatius Historical Foundation, No. 2.

Van Doren, M. (ed.) (1928). *Travels of William Bartram.* New York: Dover.

Verano, J. W. & DeNiro, M. J. (1993). Locals or foreigners? Morphological, biometric, and isotopic approaches to the question of group affinity in human skeletal remains recovered from unusual archaeological contexts. In M. K. Sandford (ed.), *Investigations of ancient human tissues: chemical analysis in anthropology* (pp. 361–86). Langhorne, PA: Gordon and Breach.

Versteeg, A. H. (1991). Saladoid houses and the functional areas around them: the Golden Rock site in St Eustatius (Netherlands Antilles). In L. Robinson (ed.), *Proceedings of the Twelfth International Coongress for Caribbean Archaeology* (pp. 35–44). Cayenne.

Versteeg, A. H. (1992). Golden Rock Pottery. In A. H. Versteeg & K. Schinkel (eds), *The archaeology of St Eustatius: the Golden Rock site* (pp. 36–73). St Eustatius: St Eustatius Historical Foundation; Amsterdam: Foundation for Scientific Research in the Caribbean Region.

Versteeg, A. H. (1997). Tanki Flip Hearths and Kilns. In A. H. Versteeg & S. Rostain (eds), *The archaeology of Aruba: the Tanki Flip Site.* Aruba and Amsterdam: Publications of the Archaeological Museum Aruba 8, Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Versteeg, A. H. & Effert, F. R. (1987). *Golden Rock: the first Indian village on St Eustatius*. Publication of the St Eustatius Historical Foundation, No. 1, The Netherlands.

Versteeg, A. & Rostain, S. (eds) (1997). *The Archaeology of Aruba: the Tanki Flip Site*. Aruba & Amsterdam: Publication of the Archaeological Museum Aruba 8, Publications of the Foundation for Scientific Research in the Caribbean Region 141.

Versteeg, A. & Schinkel, K. (eds). (1992). *The archaeology of St Eustatius: the Golden Rock site*. St Eustatius: Publication of the St Eustatius Historical Foundation, No 2.

Vescelius, G. S. (1952). *The cultural chronology of St Croix*. Unpublished Senior Thesis, Yale University, New Haven.

Vescelius, G. S. (1979). *Archeoecology of the Virgin Islands, 1: Changing patterns of resource utilization.* Unpublished paper presented at the Eighth International Congress for the Study of the Pre-Columbian Cultures of the Lesser Antilles, held on St Kitts, 30 July–4 August 1979.

Vescelius, G. S. & Robinson, L. S. (1979). Exotic items in archaeological collections from St Croix: prehistoric imports and their implications. Paper presented at the Eighth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles, St Kitts.

Vogel, J. C. & van der Merwe, N. J. (1977). Isotopic evidence for early maize cultivation in New York State. *American Antiquity 42*: 238–42.

Wada, E., Kadonaga T. & Matsuo, S. (1975). ^{15}N abundance in nitrogen of naturally occurring substances and global assessment of denitrification from isotopic viewpoint. *Geochemical Journal 9*: 139–48.

Walcott, T. G. (1988). Ecology. In W. W. Burggren & B. R. McMahon (eds), *Biology of land crabs* (pp. 55–96). Cambridge: Cambridge University Press.

Walker, J. B. (1980). *Analysis and replication of lithic artifacts from the Sugar Factory Pier Site, St Kitts, West Indies*. Unpublished Master's thesis, Department of Anthropology, Washington State University.

Walker, J. B. (1985a). A preliminary report on the lithic and osteological remains from the 1980, 1981 and 1982 field seasons at Hacienda Grande (12 PS07–5). In L. Allaire (ed.), *Proceedings of the Tenth International Congress for the Study of Pre-Columbian Cultures of the Lesser Antilles* (pp. 181–225). Montreal: Centre de Recherches Caraïbes, University of Montreal.

Walker, J. B. (1985b). Analysis of the lithic artifacts from El Bronce archaeological site, Puerto Rico, Appendix G. In L. S. Robinson, E. R. Lundberg & J. B. Walker, *Archaeological data recovery at El Bronce, Puerto Rico, Final Report, Phase 2* (pp. G1-G34). Archaeological Services Inc., Ft. Myers, Florida. Submitted to US Army Corps of Engineers, Jacksonville District, Jacksonville.

Walker, J. B. (1992). Letter report to Ms. Ana Vergara, Forest Service, Caribbean National Forest. 28 August 1992.

Walker, P. L. (1986). *Sex differences in the diet and dental health of prehistoric and modern hunter–gatherers*. Paper presented at the European meeting of the Paleopathology Association, Madrid.

Walker, P. L. & DeNiro M. J. (1986). Stable nitrogen and carbon isotope ratios in bone collagen as indices of prehistoric dietary dependence on marine and terrestrial resources in southern California. *American Journal of Physical Anthropology 71*: 51–61.

Walker, P. L. & Erlandson, J. M. (1986). Dental evidence for prehistoric dietary change on the northern Channel Islands, California. *American Antiquity 51*: 375–83.

Walker, P. L. & Hewlett, B. S. (1990). Dental health diet and social status among central African foragers and farmers. *American Anthropologist 92*: 383–98.

Walker, P. L., Sugiyama, L. & Chacon, R. (1995). *Variation in the dental health of South American Indian horticulturalists*. Paper presented to the American Association of Physical Anthropologists, Oakland, California.

Washburn, S. L. (1953). The strategy of physical anthropology. In A. L. Kroeber (ed.), *Anthropology Today.* Chicago: University of Chicago Press.

Watters, D. R. (1994). Archaeology of Trants, Monserrat. Part 1. Field methods and artifact density distribution. *Annals of the Carnegie Museum 63*(4): 265–95.

Watters, D. R. (1997). Maritime trade in the prehistoric eastern Caribbean. In S. M. Wilson (ed.), *The indigenous people of the Caribbean* (pp. 88–100). Gainesville: University of Florida Press.

Watters, D. R. & Scaglione, R. (1994). Beads and pendants from Trants, Monserrat: implications for the pre-historic lapidary industry of the Caribbean. *Annals of the Carnegie Museum 63*: 215–37.

Webb, P. A. O. & Suchey, J. M. (1985). Epiphyseal union of the anterior iliac crest and medial clavicle in a modern multiracial sample of American males and females. *American Journal of Physical Anthropology 68*: 457–66.

Wells, C. (1980). The human bones. In *Excavations at North Elmham Park. East Anglican Archaeological Report 9*: 247–374.

Weydert, J. M. (1990). *Elemental analysis of bone for ancient diet reconstruction.* Unpublished Doctoral dissertation, Northwestern University.

White, C. & Schwarcz, H. P. (1986). Ancient Maya diet as inferred from isotopic and elemental analysis of human bone. *Journal of Archaeological Science 16*: 451–74.

White, D. E. & Burton, J. H. (1992). Pinto Polychrome: A clue to the origin of the Salado polychromes. In R. C. Lange & S. Germick (eds), *Proceedings of the 2nd Salado Conference, Globe, AZ 1992* (pp. 216–22). Phoenix: Arizona Archaeological Society.

White, T. D. (1991). *Human Osteology*. San Diego: Academic Press.

Whitney, W. F. (1883). On the existence of syphilis in America before the discovery by Columbus. *Boston Medical and Surgical Journal 108*: 365–66.

Wild, K. S. (1999). Investigations of a "Caney" at Cinnamon Bay, St John and social ideology in the Virgin Islands as reflected in pre-Columbian ceramics. In L'Association Internationale d'Archéologie de la Caraïbe (eds), *Proceedings of the XVIIIth International Congress for Caribbean Archaeology* (pp. 304–10). Grenada.

Willey, G. R. & Sabloff, J. A. (1974). *A history of American archaeology*. San Francisco, CA: W. H. Freeman.

Williams, A. B., Abele, L. G., Felder, D. L., Hobbs, Jr., H. H., Manning, R. B., McLaughlin, P. A. & Farfante, I. P. (1989). Common and scientific names of aquatic invertebrates of the United States and Canada: decapod crustaceans. *American Fisheries Society Special Publication No. 17*.

Wilson, S. M.(ed.) (1997). The Taíno social and political order. In F. Bercht, E. Brodsky, J. A. Farmer and D. Taylor (eds), *Taíno pre-Columbian art and culture from the Caribbean* (pp. 46–55). New York: El Museo del Barrio and Monacelli Press.

Wing, E. S. (1989). Human exploitation of animal resources in the Caribbean. In C. A. Woods (ed.), *Biogeography of the West Indies* (pp. 137–52). Gainesville: Sandhill Crane Press.

Wing, E. S. (1991). Dog remains from the Sorcé Site on Vieques Island, Puerto Rico. In J. R. Purdue, W. E. Klippel & B. W. Styles (eds), *Beamers, bobwhites, and blue-points* (pp. 379–86). Illinois State Museum Scientific Papers, Vol. 23, and University of Tennessee, Report No. 52.

Wing, E. S. (1993). The realm between wild and domestic. In A. Clason, S. Payne & H. P. Uerpmann (eds), *Skeletons in her cupboard* (pp. 243–50). Oxford: Oxbow Books.

Wing, E. S. (1995). *Crabs in Caribbean prehistory*. Paper presented at the XVIth International Congress for Caribbean Archaeology, July 1995, Guadeloupe.

Wing, E. & Brown, A. (1979). *Paleonutrition: method and theory in prehistoric foodways.* New York: Academic Press.

Wing, E. & Reitz, E. (1982). Prehistoric fishing economies of the Caribbean. *Journal of New World Archaeology 5* (2), 13–32.

Wing, E. S. & Wing, S. R. (1995). Prehistoric ceramic age adaptation to varying diversity of animal resources along the West Indian archipelago. *Journal of Ethnobiology 15*(1): 119–48.

Wing, E. S., deFrance, S. & Kozuch, L. (1995). *Faunal remains from the Tutu Archaeological Village, St Thomas, USVI.* Manuscript on file at the Division for Archeology and Historic Preservation, Charlotte Amalie, St Thomas.

Winter, J. & Gilstrap, M. (1991). Preliminary results of ceramic analysis and the movements of populations into the Bahamas. In L. S. Robinson (ed.), *Proceedings of the Twelfth International Congress for Caribbean Archaeology* (pp. 371–86). Martinique: Association Internationale d'Archéologie de la Caraïbe.

Wolcott, T. G. (1988). Ecology. In W. W. Burggren & B. R. McMahon (eds), *Biology of the land crabs* (pp. 55–96). Cambridge: University of Cambridge Press.

Wright, L. E. & Schwarcz H. P. (1996). Infrared evidence for diagenesis of bone apatite at Dos Pilas, Guatemala: Paleodietary implications. *Journal of Archaeological Science 23*: 933–44.

Zedeño, M. N. (1995). The role of population movement and technology transfer in the manufacture of prehistoric Southwestern ceramics. In B. J. Mills & P. L. Crown (eds), *Ceramic production in the American Southwest* (pp. 115–40). Tucson: University of Arizona Press.

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