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RECONSTRUCTING HOUSEHOLD VESSEL ASSEMBLAGES AND SITE DURATION AT AN EARLY OSTIONOID SITE FROM SOUTH-CENTRAL PUERTO RICO

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The pottery from an Early Ostionoid (ca. A.D. 650) site on the Cerrillos River, north of Ponce, Puerto Rico, was subjected to technological and formal analyses. Forty-eight sample vessels were examined to define nine vessel classes based on size, form, sooting, and use abrasions. Primary intended function was assigned to each vessel class, and the vessel counts were utilized to model the nature and duration of site use. The results suggest that PO-21 was the location of one to three contemporaneous houses, each occupied for less than 20 years. A full range of pot-dependent domestic activity is suggested, and year-round occupations are inferred. The results of the vessel-based analysis are contrasted with general inferences associated with large sherd counts, and implications for modeling settlement are addressed.

In 1986, the Jacksonville District of the US Army Corps of Engineers sponsored data recovery excavations at site PO-21, an Early Ostionoid hamlet in the Cerrillos River valley above Ponce, Puerto Rico (Figure 1). The site yielded a large ceramic data set, allowing for the definition of nine vessel types (Espenshade et al. 1987). The data were reexamined in 1995 (Espenshade 1995), and the present paper represents a further effort to move from sherds to vessels to behavior.

Site PO-21

Site PO-21 was located in an area threatened by a proposed flood control impoundment on the Cerrillos River upstream from Ponce, Puerto Rico. The field investigations included the hand excavation of 153 m^2, the backhoe excavation of 91 linear m of trenches, and detailed geomorphological examination of the trenches (Figure 2). PO-21 was interpreted as a hamlet or small village situated on a small, level shelf immediately above the river. The relatively flat landform measures approximately 110 x 65 m, and prehistoric remains were collected from four contexts:

1. The northwestern midden, an area of approximately 30 x 7 m, with midden deposits up to 32 cm thick;

2. The eastern or upslope midden, approximately 90 x 15 m, with midden deposits up to 30 cm thick;

3. The southeastern midden, covering approximately 20 x 7 m, with deposits up to 38 cm thick;

4. The southeastern, sub-midden living floor, covering approximately 20 x 7 m, with deposits up to 20 cm thick.

As discussed more fully below, the pottery indicates that all areas of the site were approximately contemporaneous. All appear to date to the Early Ostionoid. A calibrated two-sigma radiocarbon result of A.D. 465-870 (uncorrected radiocarbon age of 1360 +/- 90

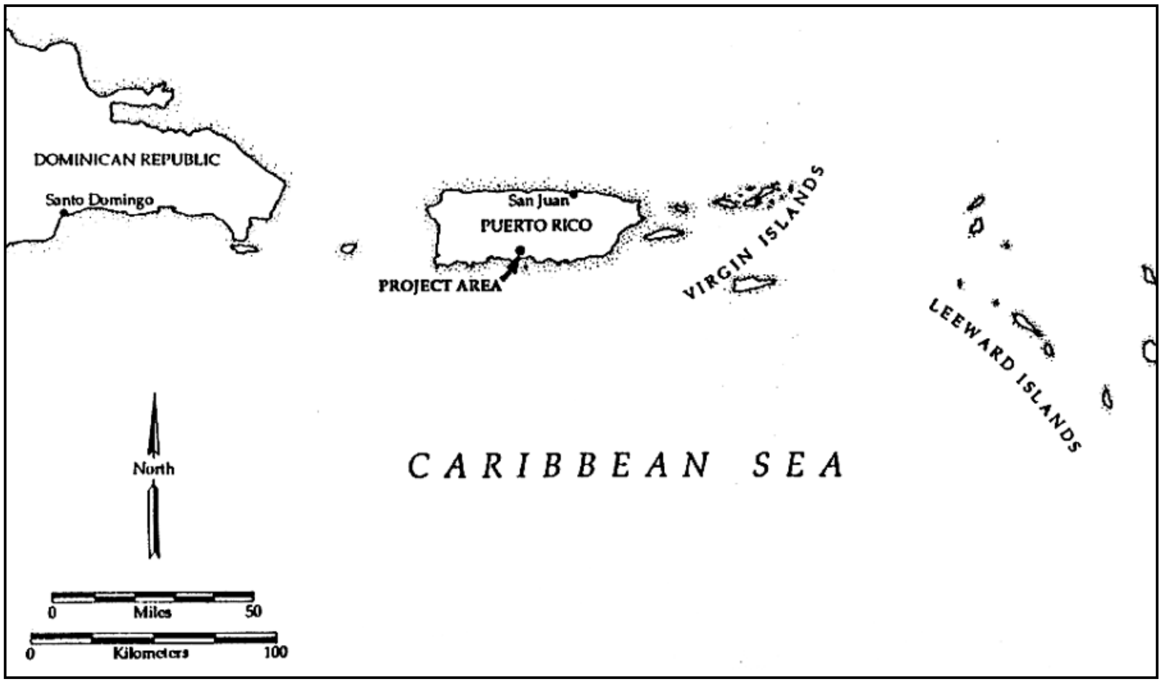

Figure 1. Location of PO-21 Data Recovery Project (from Garrow et al. 1995:Figure 1).

years BP, Beta-18191) was derived from charcoal from Feature 12, a posthole in the southwestern midden. The radiocarbon result supports the Early Ostionoid assignment.

Pottery Assemblage

A total of 11,271 sherds was analyzed. The initial analysis focused on aplastic content and surface decoration of the sherds. The assemblage shares the following traits, regardless of site context:

1. Painted ceramics are extremely rare, representing less than two percent of the assemblage. Painting was popular in the Saladoid and Middle-Late Ostionoid span, and the general lack of painted vessels in this assemblage suggests an Early Ostionoid span.

2. Incised sherds are very infrequent, representing less than one percent of the assemblage. Most of the incising appears to be incidental. Incising was popular in the Saladoid, the Middle-Late Ostionoid, and the Chicoid spans, and the general lack of incised vessels in this assemblage suggests an Early Ostionoid span.

3. Smoothed and semi-burnished sherds dominate the collection, accounting for over 80 percent of the material. Early Ostionoid assemblages are overwhelmingly smoothed, semi-burnished, or burnished.

4. Large (very coarse to granule on the Wentworth scale) limestone/sandstone, small (medium, or coarse on the Wentworth scale) limestone/sandstone, and grog are the major aplastic categories, with virtually no other temper categories represented. The aplastics were identified under 40X magnification on a fresh break. The exact identification of the generic limestone/sandstone material was not pursued, but sandstones are present in upslope bedrock formations.

5. Two-dimensional, modeled lugs are infrequent, representing less than one percent of the collection.

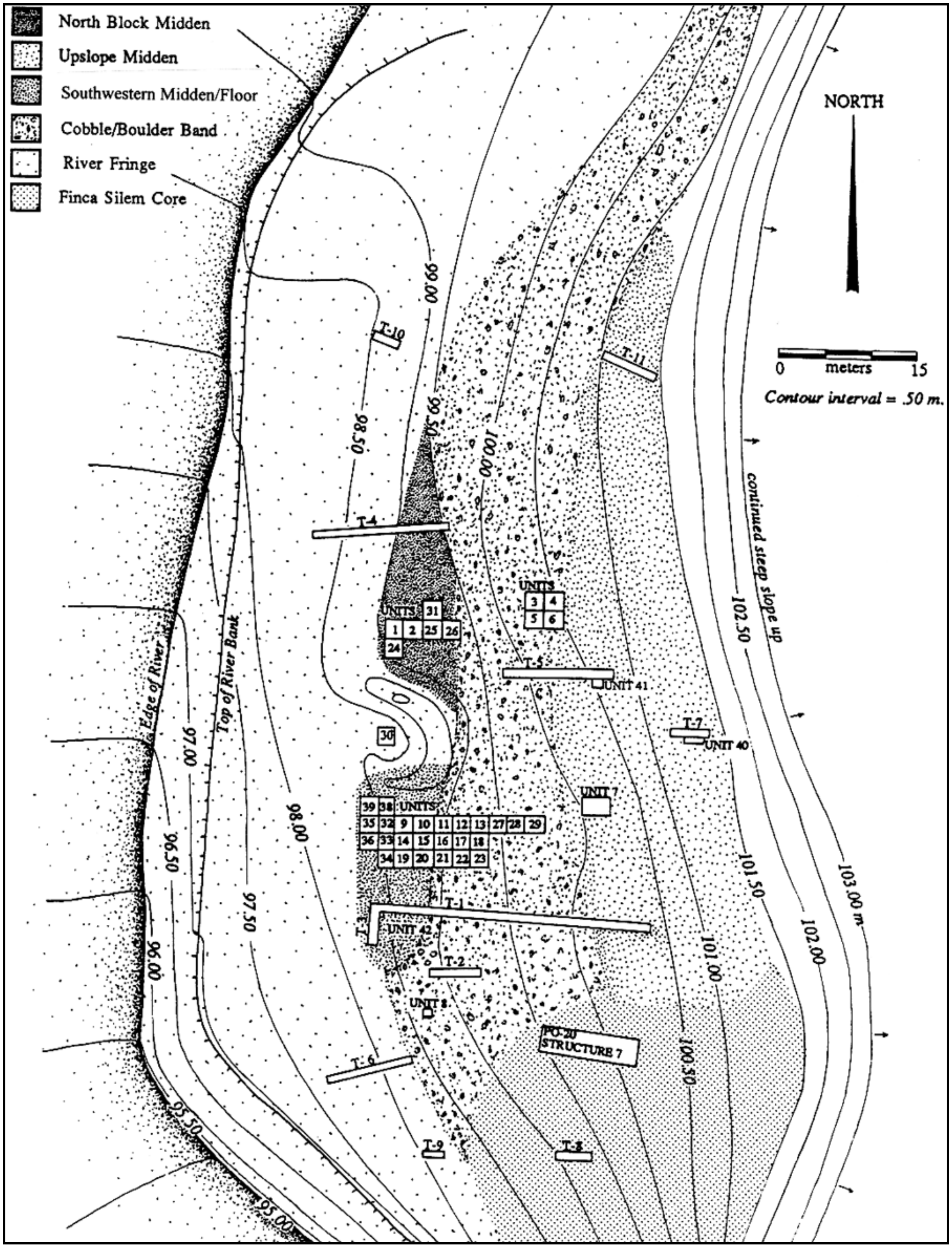

Figure 2. Site Areas (from Espenshade, Foss, and Joseph 1987:Figure 2).

6. There are no three-dimensional lugs in the collection. Three-dimensional lugs generally begin to appear in the Middle-Late Ostionoid span.

7. Loop handles are present, but D-shaped handles are not. D-shaped handles were common in the Saladoid, and loop handles first appear in number in the Ostionoid span.

8. Navicular (or boat-shaped) vessels are present. Navicular vessels first appear in number in the Early Ostionoid span.

Table 1 presents a summary of pottery attributes by site area, with the southwest midden and southwest sub-midden combined. The assemblage is consistent with the expectations for an Early Ostionan Ostionoid manifestation, as defined by Rouse (1952a, 1952b, 1992) and others (e.g., Chanlatte Baik 1986; Goodwin and Walker 1975).

Vessel Form Attributes

One of the recent developments in American archaeology has been an increased emphasis on examining pottery from the vessel (rather than sherd) perspective. It has been argued from the ethnographic and archaeological data that vessel attributes will generally reflect the intended most common function of the pot (Braun 1980; David and Hennig 1972; Deal 1998; Ericson et al. 1972; Foster 1960; Hally 1984, 1986; Henrickson and McDonald 1983; Nelson 1991; Rice 1987, 1996; Smith 1985). These researchers have noted that key vessel form attributes may include volume, rim diameter, height, restriction, presence/absence of handles/lugs, and base size and form. Volume, rim diameter, and height will reflect the capacity of the vessel, which, in turn, may reflect group size and/or permanence of occupation. The capacity attributes will also reflect the ease with which the vessel could be used in transfer (i.e., how heavy a full vessel would have been).

Restriction is a measure of the basic vessel form; it tells whether a vessel mouth is larger or smaller than the maximum vessel diameter. Unrestricted vessels provide high access to contents, and may be expected in cooking (when manipulation during the cooking is necessary), serving (Rice 1987:Table 7.2), and eating vessels (Rice 1987:Table 7.2; Smith 1985:301-302). Restricted vessels provide reduced access to contents, but allow more confident control of the contents when the vessel is moved (Hally 1986:Table 4). Restricted vessels also limit the contamination

Table 1. Assemblage Attributes, PO-21.

Aplastic Category	**NW Midden (%)**	**SW Living Floor and Midden (%)**	**Upslope Midden (%)**
Grog	13.7	11.6	16
Small Limestone/Sandstone	25.7	31.7	4.5
Large Limestone/Sandstone	59.8	55.9	78.5
Other	0.8	0.8	1
Decoration	**NW Midden (%)**	**SW Living Floor and Midden (%)**	**Upslope Midden (%)**
Smoothed	44.1	38.7	46
Semi-burnished	34.8	40.7	35.5
Burnished	12	12.4	7.5
Eroded/Indeterminate	4	2.1	6.5
Rough	3.1	2.9	2.5
Slipped	0.2	0.5	0
Incised	0.3	0.3	0
Painted	1.2	1.8	2
Flat Lugs	0.1	0.3	0
TOTAL SHERD COUNT	3513	7558	200

of contents by dirt, dust, ash, and insects. Slight restriction can be desirable when active boiling is to be pursued (Hally 1986:Table 4; Rice 1987:241). Vessels for liquid transport should be restricted (Rice 1987:24; Smith 1985:305).

In ceramic traditions where handles or lugs occur, their presence is most common for vessels used in transfer (Rice 1987:226, Table 7.2). It is recognized that handles do not occur in all pottery traditions, even though vessels in those traditions do have transfer functions. Handles allow heavy and/or hot vessels to be moved and passed. If the pottery tradition includes appendages, handles or lugs are expected on serving vessels and on active cooking vessels. Pots used for bulk storage or slow cooking of large amounts of material generally do not require handles.

Base size relative to the overall vessel, and base form (flat vs. rounded vs. pointed) will affect the stability of a pot. A broad, flat base will obviously provide a high degree of stability; it will be difficult to accidentally tip such a vessel. A small or pointed base will have minimal stability, unless used in conjunction with pot supports. It should also be noted that a pointed or rounded vessel base will be better suited to use over an open fire than a flat-based vessel, due to the more even heating in the former (Hally 1988:Table 4; Rice 1987:Table 7.2).

Other attributes which can be considered function-related are sooting and interior abrasions. Sooting results from the use of a vessel over an open fire of carbon-rich fuel (Rice 1987; Skibo 1992). Sooting can be removed through washing, clean fuel firing, or post-depositional processes; the presence of soot is generally associated with a cooking vessel.

Interior abrasions represent the scarring of vessels, generally by the use of utensils (Hally 1983; Koyabashi 1994; Skibo 1992; Skibo and Deal 1995). The interior faces of a vessel will often show surface damage such as scratches or pitting. When such marks are found in a latitudinal band, it can generally be assumed that the damage was not post-depositional. Abrasions are expected on certain cooking, serving, and consumption forms, whereas long-term storage vessels should not show abrasions.

PO-21 Vessel Analysis

During the initial analysis of the PO-21 pottery, large sherds with vessel form indicators were pulled from the assemblage. Cross-mending was then attempted, and 48 Analytical Vessels were defined. The Analytical Vessels do not represent a minimum vessel assemblage, but rather represent a general range of the vessel forms in the collection. After the 48 Analytical Vessels were defined, the sherds which could not be linked to an analytical vessel were examined. The sherds not included in the 48 Analytical Vessels did not exhibit any vessel form information not captured by the 48 vessels. Thickness, rim diameter, vessel height, base diameter, surface treatment, presence/absence of handles, sooting, and abrasions were recorded for the 48 Analytical Vessels.

The data from the 48 Analytical Vessels indicate that there are at least ten size/form classes represented at PO-21, including manioc griddles (Figure 3, Table 2). There were between two and eight examples of each vessel form. It is possible that there were additional, uncommon forms that were not captured in the analyzed sample, but the modeling will proceed on the assumption that nine size/form classes were in use prehistorically.

The vessel attributes for each size/form class were reviewed, and a typical vessel was reproduced (coil-built with commercial clay, kiln-fired) for each size/form. These reproductions allowed vessel volume to be estimated, allowed informal experimentation with the performance of the pots in various roles, and served as props for the Espenshade (1995) paper.

In an ideal situation, vessel function could be assigned from performance attributes, use indicators, ethnohistoric accounts of related contact period groups, and ethnographic studies of surviving groups of similar culture type. Hally's (1986) study of Mississippian pottery in northwest Georgia stands as an excellent

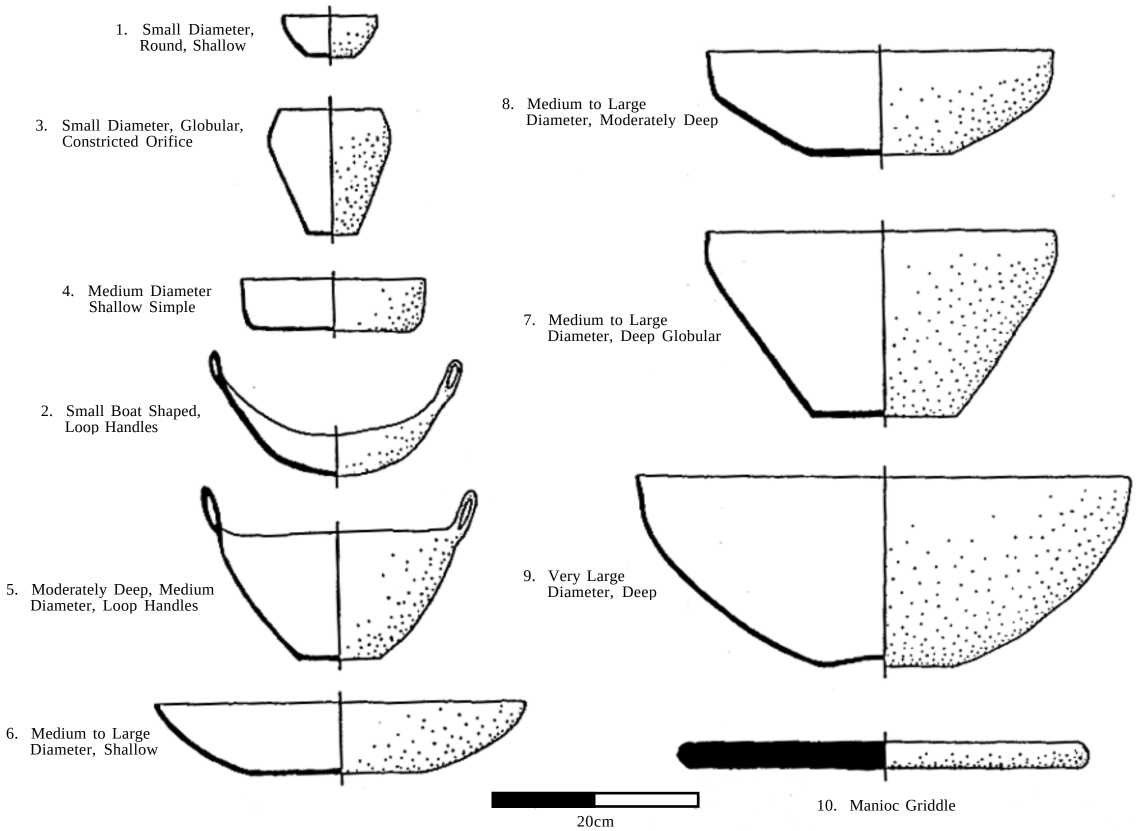

Figure 3. PO-21 Vessel Form Classes (from Espenshade 1995:Figure 4).

Table 2. PO-21, Sample Vessel Data.

Vessel Class	Count	Rim Diameter (cm)	Height (cm)	Base Diameter (cm)	Estimated Volume (liters)
1. Small, shallow	5	6-12	<4	5	0.2
2. Small, boat-shaped, with loop handles	4	25 (l) X 16 (w)	12	NA	0.5
3. Small, restricted	3	8-12	12	5	0.6
4. Medium, shallow	2	18	5	16	0.8
5. Medium, moderately deep, with loop handles	8	20-26	10	8	1.5
6. Medium-large, shallow	4	28-46	7	16	4
7. Medium-large, deep	9	28-42	18	14	8
8. Medium-large, moderately deep	8	28-42	10	12-16	5
9. Very large, deep	5	48-50	18	12-14	15
10. Griddles (buren)	10?	30 ?	NA	NA	NA

Note: Vessel Class numbers match headings in text and labels on Figure 3.

example of utilizing the various data sets to infer vessel functions. However, the Spanish impact to native populations in the Caribbean was so severe that the possible period of ethnohistoric observation was very short. It is estimated that the native Taino population of Puerto Rico dropped from 30,000 in 1508 to just 1,148 in 1515 (Anderson Cordova 1980). For most of those years, the Taino were forced out of their usual culture pattern and placed on work farms or mines. The situation was not conducive to recording details of everyday Taino life, and the ethnohistoric record of the area reflects this. In addition, the actions of the Spanish and other European colonists assured that there would be no surviving population of Taino for later anthropological study. For the present study, the few ethnohistoric accounts of pottery use are included where appropriate, and ethnographic data from mainland groups is used as only vaguely supporting documentation.

The ethnohistoric record is frustrating to one interested in pottery. Martyr D'Anghera (1912:71) mentions "pots of all kinds, jars and large earthen vessels" but offers no further description. Chronicle discussions of cooking in pots are generally focused on either cannibalism (Martyr D'Anghera 1912:72) or the preparation of manioc (Bourne 1904; Vazquez de Espinosa 1968; Fernández de Oviedo y Valdés 1959). The narratives do suggest that many items (including maize, sweet yuca, hutias, and fish) were simply roasted in coals without pots, and many fruits were eaten raw.

1. Small Diameter, Round, Shallow Vessels (n=5)

These vessels had rim diameters of six to twelve cm, and basal diameters of 5 cm (Figure 4). The estimated height is less than four cm; Analytical Vessel 1, for example, consisted of a base plug (a flat, modeled disk used as the first element of a coiled pot) and a single coil as the vessel wall. Volume was low, approximately 0.2 liter. No handles or lugs were observed, and the sample vessels were generally free of interior abrasions. No sooting was noted.

The extreme openness and shallowness of this vessel form negate the possibility that they were utilized for drinking vessels. The lack of abrasion and small size argue against their use

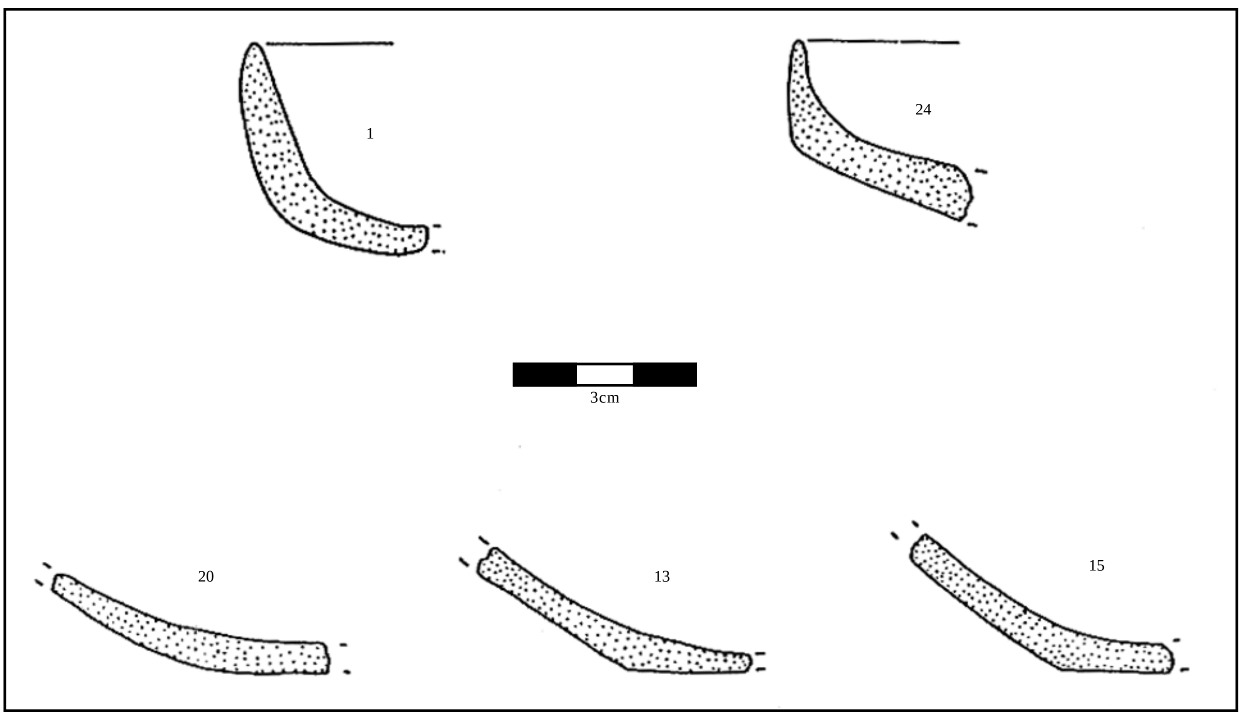

Figure 4. Small Diameter, Shallow Vessels (from Espenshade 1995:Figure 4).

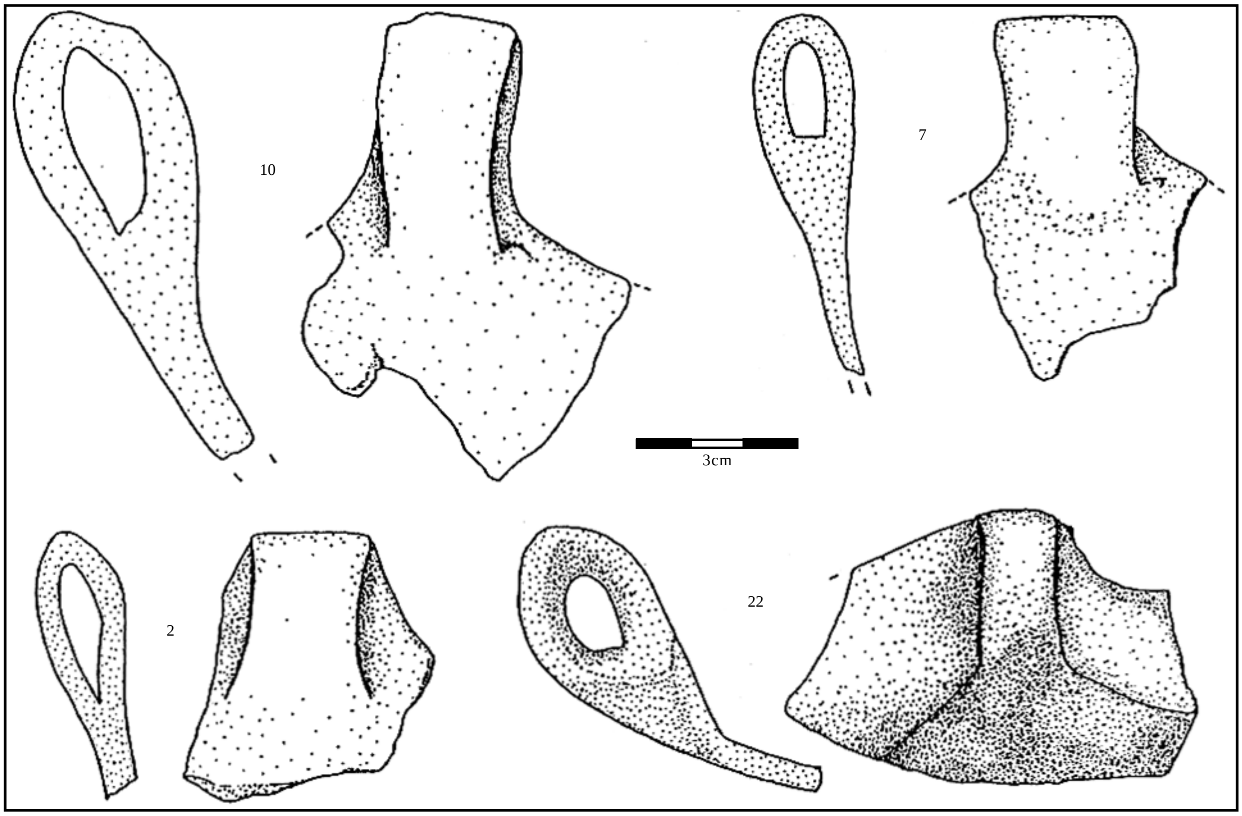

Figure 5. Small Boat-Shaped Vessels with Loop Handles (from Espenshade 1995:Figure 3).

as food preparation vessels. A viable possibility is that these shallow bowls were used for individual servings of dry foodstuffs, or alternatively, they were used for condiments or oils in which to dip bread. This form may parallel the Island Carib form, *balabi*, which served as a dish or plate (Allaire 1984:124).

2. Small Boat Shaped Vessels With Loop Handles (n=4)

The only boat shaped vessels in the secondary analysis belong to this class. The vessels are approximately 25 cm long, 16 cm wide, and 12 cm high at the top of the handles (Figure 5). All had loop handles which extend above the rim. No sooting or abrasions were noted. These vessels were relatively stable, being short and broad with a flattened base, and offered easy access to the contents. The handles suggest that they were used regularly in transfer. There is an apparent contradiction between the presence of handles and the openness of the vessel. It would not have been well suited to the consumption of runny foods and liquids. The low volume (estimated at 0.5 liters) indicates that these vessels probably did not hold more than a single serving. This form is hypothesized to represent bowls for the individual consumption of food items. This form is similar to the *sappoora* (serving bowl) of Guianan natives in size, shallowness, and lack of restriction (Im Thurn 1967:275).

3. Small Diameter, Globular Vessels with Constricted Orifices (n=3)

Rim diameter ranged from eight to 12 cm for this vessel form, while the single base measured 5 cm in diameter (Figure 6). Height is estimated at approximately 12 cm for this form, resulting in a volume of approximately 0.6 liter. The moderate mouth constriction of this form equates with moderate to high containment, while stability is less than the other small diameter classes. This form lacks

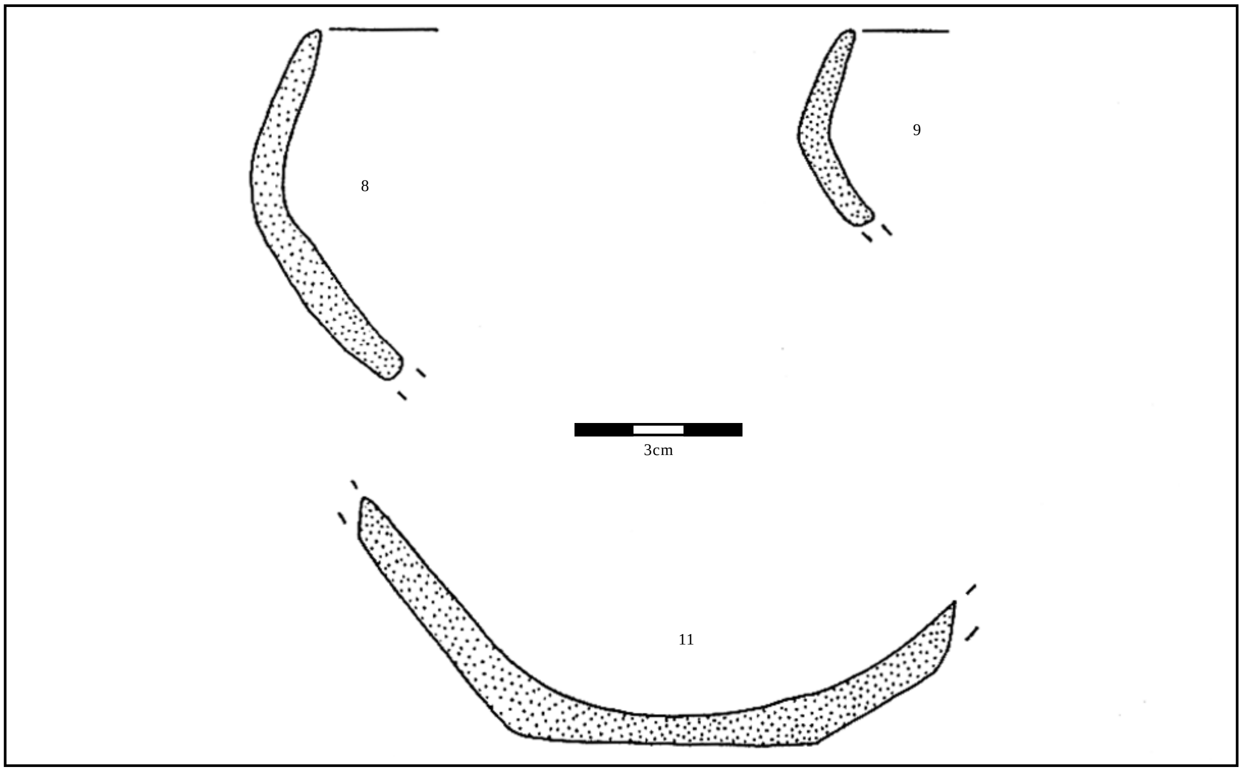

Figure 6. Small, Globular Vessels with Constricted Orifices (from Espenshade 1995:Figure 5).

interior abrasions and sooting. It is suggested that these vessels represent individual receptacles for water and other fluids. Among the Island Carib, small globular vessels were apparently used interchangeably with gourds to hold single-serving ceremonial offerings at feasts (Allaire 1984:124).

4. Medium Diameter, Shallow Simple Bowls (n=2)

The single rim diameter for this class was 18 cm, while the lone base had a diameter of 16 cm (Figure 7). Vessel height is estimated at only five cm, and the volume of the reproduction was 0.8 liters. The basal fragment exhibited heavy interior abrasion, suggesting a possible food preparation function, but sooting was not present. The shallowness and lack of constriction would have provided ready access to the contents, as necessary in food preparation. Broad, shallow, flat-bottomed vessels are more typically associated with braising or roasting than with boiling (Hally 1986:Table 4). The size of these vessels precludes their use for full meal preparation, but specific elements of a meal may have been stirred and cooked in such bowls. This vessel class may also have been used in the roasting of shelled maize or the pressed and washed manioc pulp in the final step to detoxification. Although roasting is mentioned in several of the chronicles, the vessel size and form are not specified (Vazquez de Espinosa 1968; MacNutt 1912; Fernández de Oviedo y Valdés 1959).

5. Moderately Deep, Medium Diameter Bowls with Loop Handles (n=8)

In contrast to the previously discussed class, these bowls probably were over 10 cm in height (Figures 8 and 9). Their rim diameters ranged from 20 to 26 cm; two vessel bases each measured eight cm across. These vessels had relatively high volume (1.5 liters), high accessibility, and low stability. The flat base would not have been well suited for use over

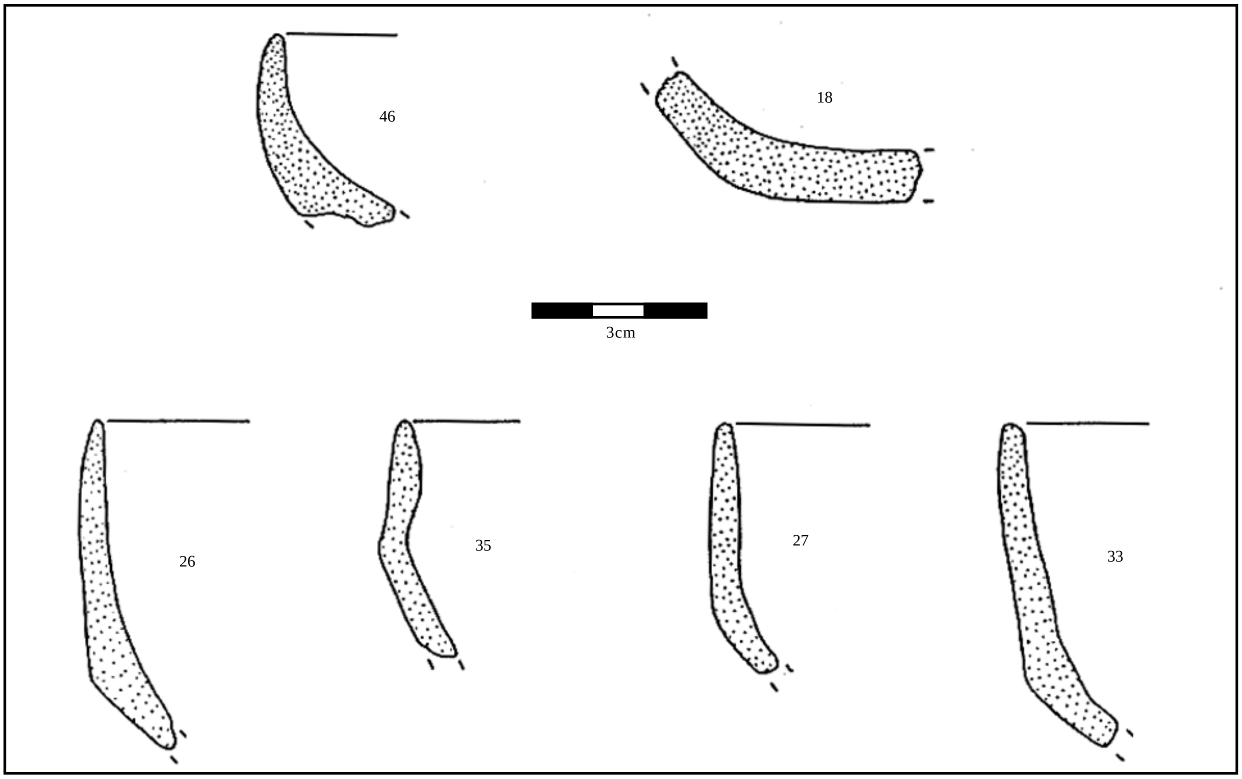

Figure 7. Medium Diameter Shallow Simple Bowls (from Espenshade 1995:Figure 6).

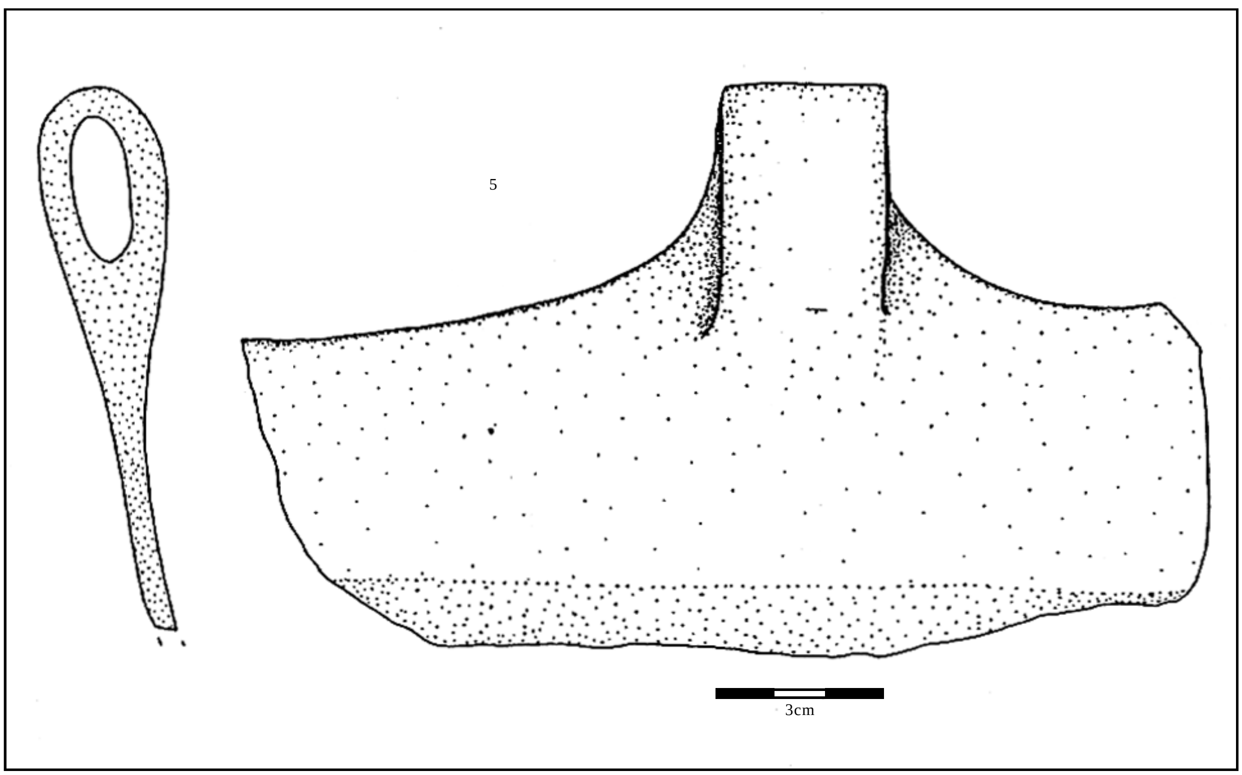

Figure 8. Medium Diameter Bowl with Loop Handles (from Espenshade 1995:Figure 7).

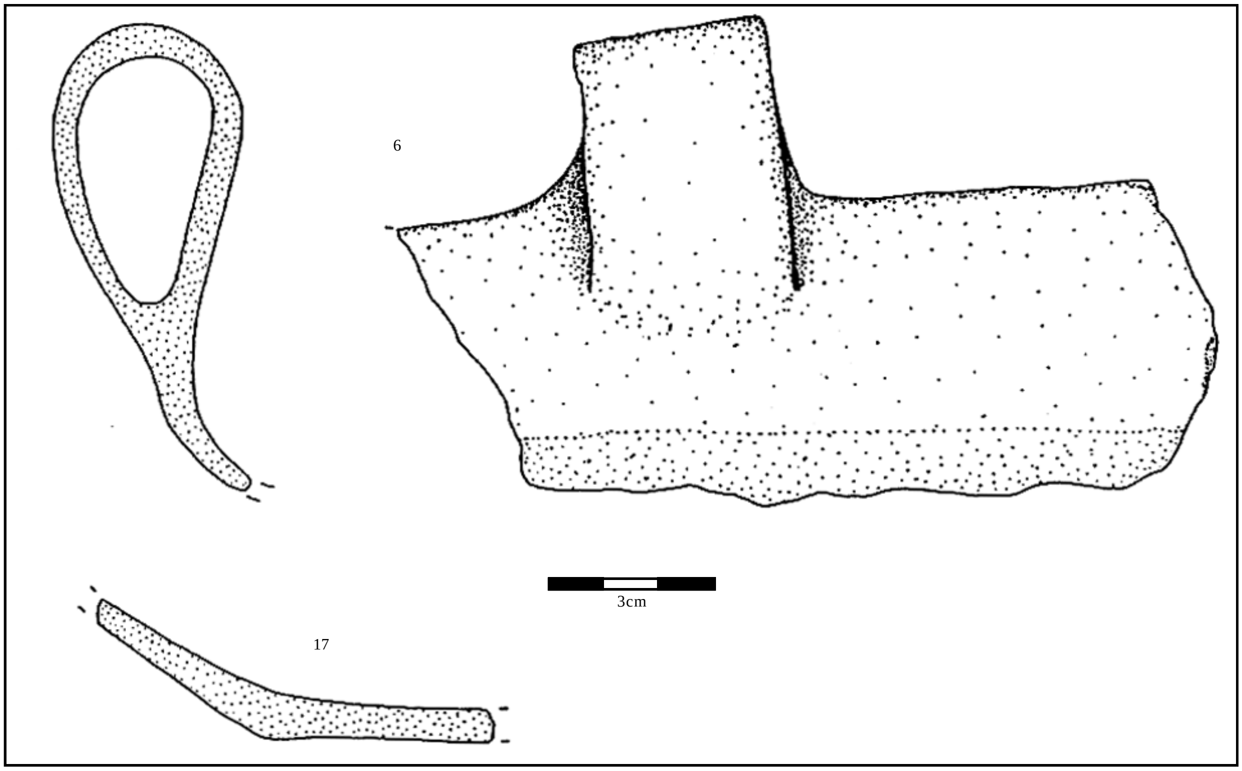

Figure 9. Medium Diameter Bowl with Loop Handles (from Espenshade 1995:Figure 8).

flames, but the form would have been suited for nesting in coals. The handles would have allowed the handling of a hot vessel. Several members of this class exhibit interior abrasions, including two rim/shoulder sherds with heavy abrasion just below the shoulder. These abrasions suggest a food preparation function, with the abrasions derived from stirring of the contents. Sooting is present on at least one of these pots. Vessel size would have been sufficient for full meal cooking, and this form is interpreted as a stew pot or pepper pot.

The pepper pot was apparently ubiquitous in the Caribbean. Unfortunately, none of the chronicles examined for the present project gave a good description of such a pot. The Martyr D'Anghera (1912:72) account of Columbus' second voyage reports that in Guadaloupe birds were boiling in their pots, also geese mixed with bits of human flesh. The same chronicler (Martyr D'Anghera 1912:124) offers an account of preparing iguana in Hispaniola and Puerto Rico:

> First they gut them, then wash and clean them with care, and roll them into a circle, so they look like the coils of a sleeping snake; after which they put them in a pot, just large enough to hold them, pouring over them a little water flavoured with the pepper found in the island. The pot is covered and a fire of odorous wood which gives very little light is kindled underneath it.

Given the size of iguanas, a fairly large pot would be needed for such cooking.

This form is probably similar in size, shape, and function to the *tomalli-acae* and *toma-heim* pepper pots of the Island Carib. An 1671 illustration of a *tomali-acae*, redrawn by Allaire (1984:Figure 2D), shows a medium-sized pot with two handles. Im Thurn (1967:275) illustrates a typical pepper pot of Guiana; it is a medium sized vessel with a slight shoulder constriction.

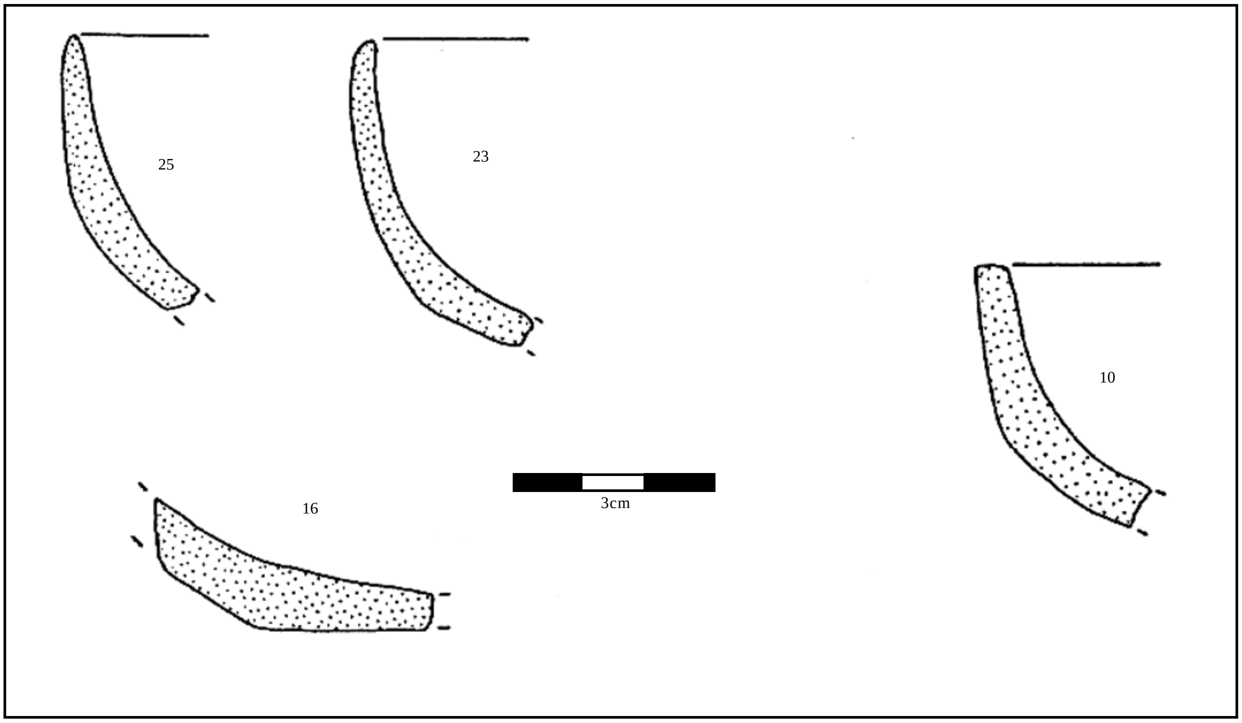

Figure 10. Medium/Large Diameter, Shallow Vessels (from Espenshade 1995:Figure 9).

6. Medium to Large Diameter, Shallow Vessels (n=4)

Diameters of 28 and 46 cm for the rims, and 16 cm for the base stand in marked contrast to an estimated height of only seven cm (Figure 10). Volume is estimated at 4.0 liters. No interior abrasions were noted. The vessel form would have been extremely stable, with very high accessibility. This vessel form would be well suited for drying or parching, but no abrasions were present. Such vessel forms may have served as pans for the catching and water washing of grated manioc pulp and/or juice.

Chronicles from several islands suggest that there was a relatively consistent means of preparing manioc/cassava. The Fernández de Oviedo y Valdés (1959:16-17; parentheses added) account provides good detail:

> ...the Indians grate it (raw manioc) and then press it in a strainer, which is a sort of sack about ten palms or more in length and as big as a man's leg. The Indians make this bag from palms which are woven together as if they were rushes. By twisting the strainer as one does to remove the milk from crushed almonds, the juice is extracted from the yuca. The juice is a powerful and deadly poison, and one swallow of it will produce sudden death. The residue after the liquid is removed, which is something like moist bran, is cooked in the fire in a very hot flat clay vessel of the size they want the loaf to be. . . The liquid which is extracted from the yuca is boiled several times and left in the open for several days. Then it becomes sweet and is used as honey or other syrup to mix with other foods.

This technique was observed in Cuba (Bourne 1904), Puerto Rico (Vasquez de Espinosa 1968:47), and generally throughout the Greater Antilles (Martyr D'Anghera 1912). Vasquez de Espinosa (1968:39-40) reports that the manioc syrup was also transformed into beer. A similar technique was recorded for the Mainland Carib of Guiana (Im Thurn 1967).

The manioc processing probably would have required at least three types of vessels. First, there would be the need for a large, open vessel (or wooden trough) to catch the pulp as it is grated over a stone-toothed tool. Secondly, a flat vessel, undoubtedly the manioc griddle, was used for cooking the loaf. Lastly, there would be need for a large, deep pot for boiling the manioc extract to render syrup. There may have been an additional large, deep pot for storage of the syrup, and a small, globular pot to transfer the syrup from storage to a pepper pot.

7. Medium to Large Diameter, Deep Globular Vessels (n=9)

This class of vessels had rim diameters of 28 to 42 cm; the single base diameter was 14 cm (Figures 11 and 12). Vessel height was estimated as approximately 18 cm, with straight to slightly incurving walls at the rim. Volume probably averaged 8.0 liters. Constriction was very low (i.e., access was high), while stability was moderate. None of the nine specimens exhibited interior abrasion or sooting. The lack of abrasions and the volume of the vessel suggest that it may represent a stationary storage jar for water or manioc syrup. The ethnohistoric accounts and mainland ethnographic data indicate that large stores of manioc syrup were maintained, and that the syrup served as the basis for most dishes (Vazquez de Espinosa 1968; Fernández de Oviedo y Valdés 1959; Im Thurn 1967). Among the Island Carib, a similar form, the *chamacou*, was used "usually for keeping manioc beer" (Allaire 1984:125). The *casiri* (manioc beer) jar among the natives of Guiana was the largest vessel in their assemblage, and there were typically 1-2 per household (Im Thurn 1967:274).

8. Medium to Large Diameter, Moderately Deep Vessels (n=8)

This vessel class is similar to that just described in terms of rim diameter (28 to 42 cm)

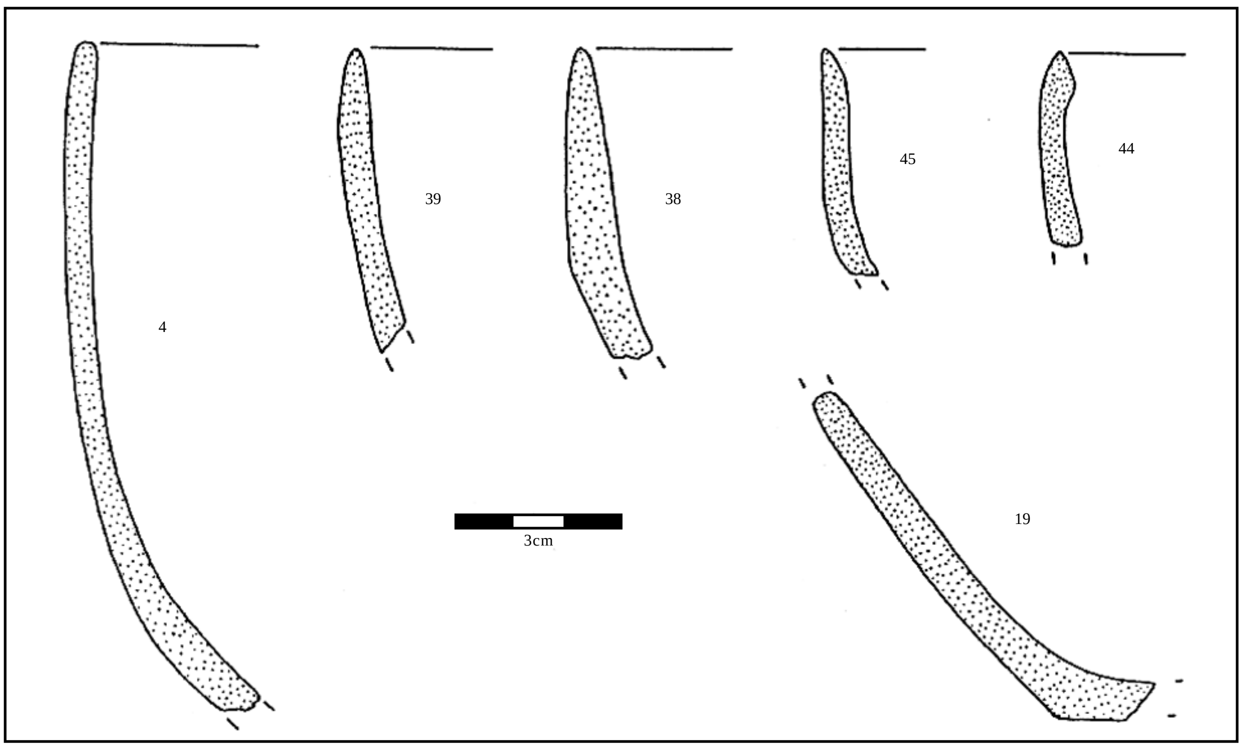

Figure 11. Medium/Large Diameter, Deep Globular Vessels (from Espenshade 1995:Figure 10).

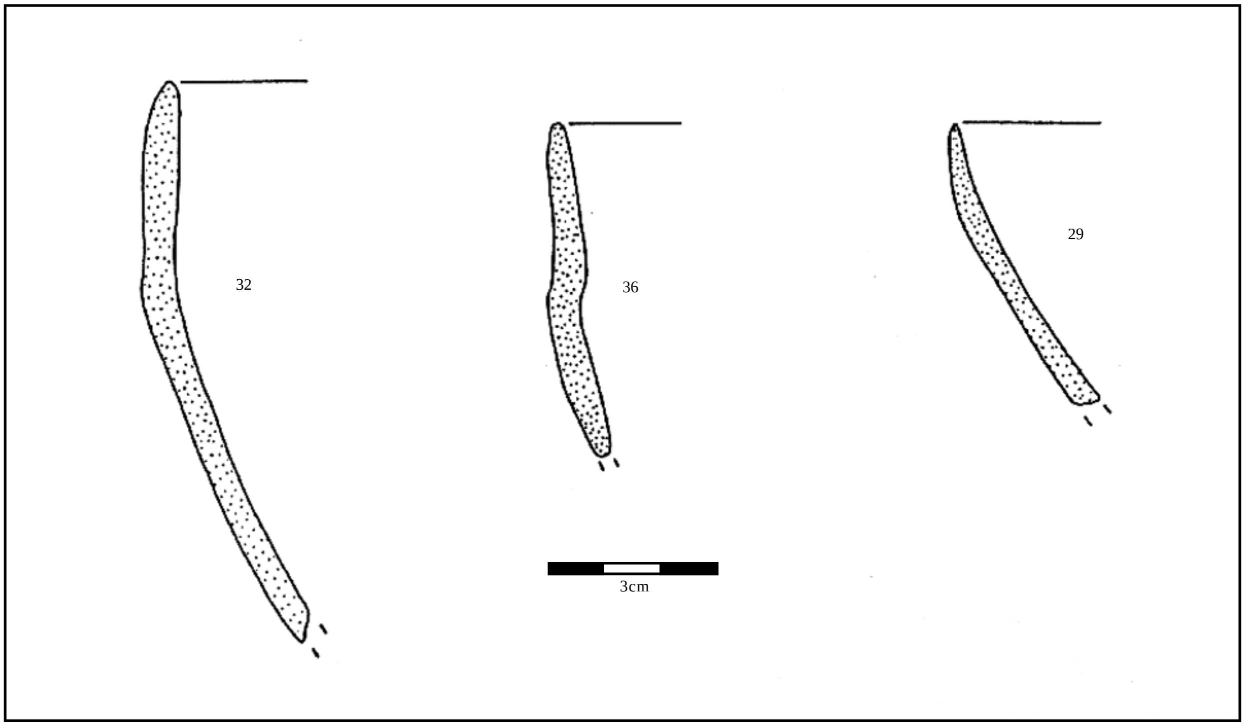

Figure 12. Medium/Large Diameter, Deep Globular Vessels (from Espenshade 1995:Figure 11).

and base diameter (12 to 16 cm). The key difference is that the latter class is only 10 cm tall (Figure 13). No interior abrasions were observed. This vessel form would have provided high stability and high access. The probable use of this vessel class is unknown, but it may have served as a catch basin during manioc processing, its wide mouth well suited to catching the drip of manioc juice from a manioc press.

9. Very Large Diameter, Deep Bowls (n=5)

This class was the best represented in terms of size of vessel fragments and information content. Rim diameters varied from 48 to 50 cm, while the two bases measured 12 and 14 cm (Figure 14). The height is estimated at 18 cm; the volume of the reproduction is 15.0 liters. Several of the vessels in this class had interior abrasions on their walls. Sooting was noted. The large vessel size, high accessibility, moderate stability, and interior abrasions suggest that this class of vessels served in full meal preparation and cooking. The size of the vessel suggests that the vessel was used for minimally a family unit, and that the vessel was not often moved. This vessel class may represent large pepper pots.

10. Manioc Griddles (n=10?)

A total of 74 manioc griddle fragments over 2 by 2 cm were collected from PO-21. The represented griddles shared three traits: large aplastic size; greater thickness than seen in other vessel classes; and one rough face and one uneven face. The aplastic found in the griddles are significantly larger than seen in the other vessel classes; many had pebble-sized inclusions (4 to 64 mm) on the Wentworth scale. The relationship of aplastic size to thermal shock resistance is not clear (Steponaitis 1983:37-38). The addition of large aplastics has been suggested as a means to reduce risk of thermal shock (Steponaitis 1983:37-45; Blandino 1984:26-27), possibly by limiting the spread of stress cracks. Other researchers, however, argue that smaller mineral aplastics

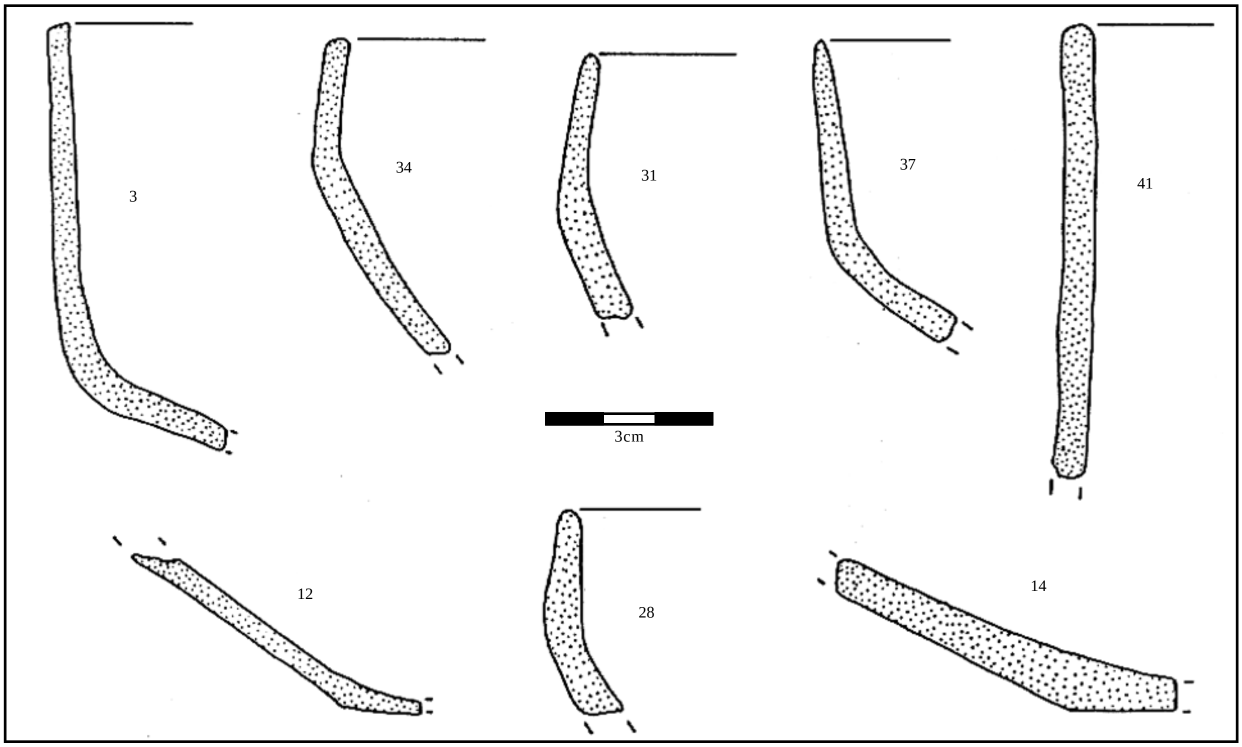

Figure 13. Medium/Large Diameter, Moderately Deep, Extreme Shoulder Vessels (from Espenshade 1995: Figure 12).

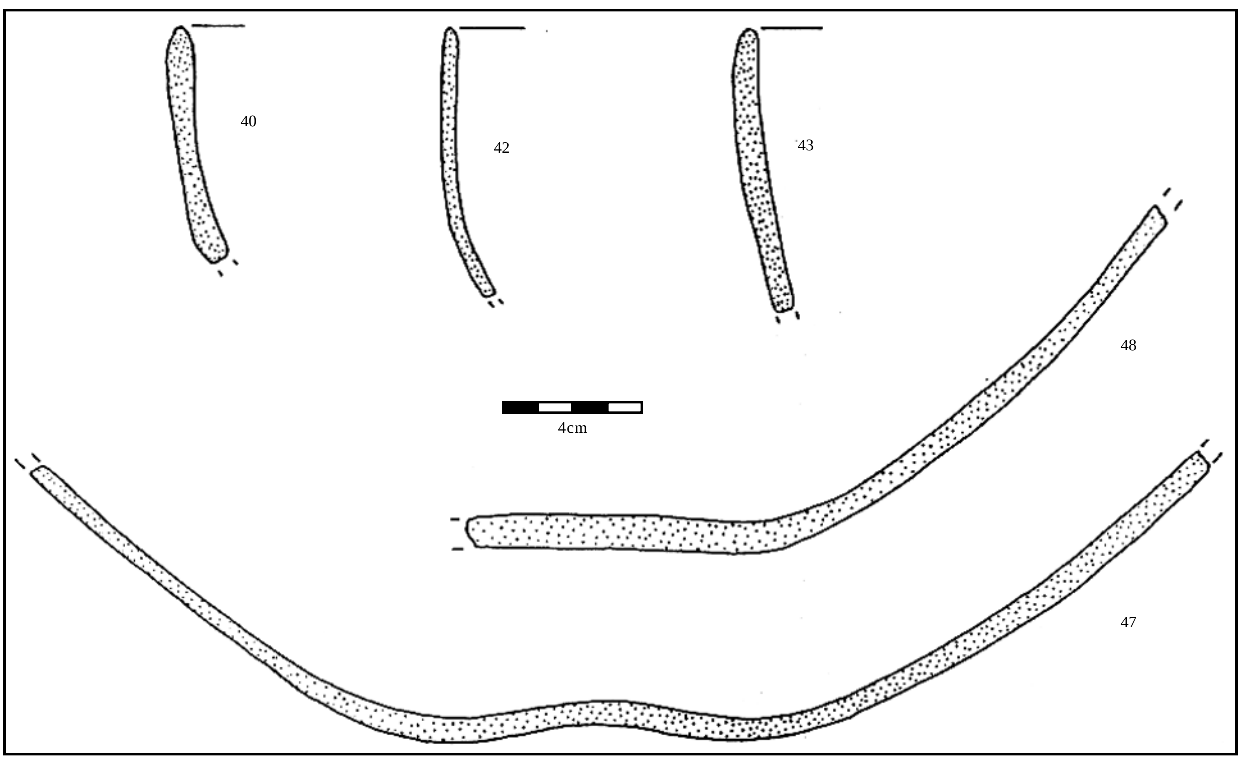

Figure 14. Very Large Diameter, Deep Bowl with Weak Shoulders (from Espenshade 1995:Figure 13).

are desirable in limiting damage by thermal shock (Bronitsky 1986; Bronitsky and Hamer 1986). The repeated, intense heating of the griddles over an open fire represented a high potential for thermal shock.

If not related to thermal shock resistance, the large aplastics in the manioc griddles may have been necessary in the forming process. Large aplastics can help limit warping and cracks during drying (Rye 1981). The thick, large griddles would have been prone to drying difficulties, and the large aplastics may have been added to help remedy this potential problem.

The thickness was also a functional consideration. Even the largest vessels had maximum thicknesses of less than 1 cm, but the griddles were consistently greater than 2 cm thick. Thick ceramic vessels will hold heat longer than thin vessels made of the same paste.

The opposing smooth and rough faces of the griddle were also functional. The smooth face would have served as the upper, cooking surface. By smoothing this face, the potter facilitated the removal of the griddle bread, reducing problems of sticking. The lower, rough face was subjected to the fire. Studies (e.g., Herron 1986) have shown that rough or textured surfaces absorb and disperse heat more evenly than a smooth surface, and that the former holds heat longer. It appears that the potter(s) at PO-21 intentionally engineered the paste to suit the specialized form and function of the griddles.

Summary of Vessel Form Analysis

The interpretation of 48 Analytical Vessels from PO-21 has revealed that there was a broad range of size/form classes associated with a variety of inferred functions. The diversity of vessel forms suggests that the site served as the locus of diverse subsistence processing, storage, and consumption activities. The assemblage is not consistent with a resource-specific station; instead, it is suggestive of permanent residential site use. The presence of structural features, manioc-processing artifacts, and dense midden likewise support a permanent residential occupation.

Vessel Assemblage and Occupation Duration

Since the early 1990s, there has been renewed interest in ceramic ethno-archaeology (e.g., Arnold 1991; Deal 1998; Koyabashi 1994; Longacre and Skibo 1994; Longacre et al. 1991; Rice 1996; Schiffer and Skibo 1997; Skibo 1992; Skibo and Deal 1995). The development most germane to the present data set is the consideration of ceramic use-life in reconstructing site occupation duration (e.g., Pauketat 1989; Shott 1996). It is possible to model occupation span scenarios based on the vessel assemblage at a given site. The modeling requires building premise on premise, but nonetheless can provide interesting insight into past behavior.

The first premise is that the total number of vessels deposited on the site can be extrapolated from the sample vessels. In the current analysis, 48 sample vessels were identified from excavations that represented approximately 10 percent of the site midden and living floor (by area). It is not practical to simply multiply the 48 vessels times 10, since portions of many vessels are spread throughout the midden. The rate of representation would equal the percentage of site excavated only if each vessel was limited to a single point in space. However, single PO-21 vessels were dispersed over several units, as generalized midden. For the sake of modeling, it is assumed that 25 percent of the vessel assemblage is represented in the 48 Analytical Vessels. There is no statistical model to validate this estimate. Working from the 25 percent assumption, it follows that there were 192 vessels broken at PO-21.

The next premise is that an average lifespan can be assigned to these vessels. A review of various texts on pottery analysis and ethnohistoric use of pottery reveals a wide range of use-life spans for low-fired pottery (Arnold 1991; Deal 1998; DeBoer and Lathrap 1979; Foster 1960; Nelson 1991; Pauketat 1989; Rice 1987; Shott 1996). In two Central Maya communities, cooking jars last on average 0.58 to 3.72 years, and griddles generally last less than a year (Deal 1998:Table 4.11). In another

Mesoamerican example, Foster (1960) reported average use lives of 1.0 years for daily cooking jars, 6.3 years for liquid storage jars, 0.5 years for griddles, and 0.5 years for eating bowls. For Shipibo-Conibo pottery of eastern Peru, DeBoer and Lathrap (1979:Table 4.5) report generally short use lives (0.24-1.38 years) for all vessel forms. Arnold's (1991) study of pottery in Los Tuxtlas, Veracruz, Mexico, revealed low use lives for all six of the major vessel forms: *comal* (0.2 years); *tecualon* (0.7 years); *cazuela* (1.3 years); *frijol olla* (1.3 years); *maiz olla* (1.7 years); and *tostador* (1.5 years). Most of the ethnographic studies are based on fully sedentary groups with substantial residential structures.

It is recognized here that use-life will also vary with primary function and vessel size (David and Hennig 1972; Foster 1960). None of the vessel forms from PO-21 were apparently used in long-term storage, the function associated with generally long use lives. Instead, most of the PO-21 forms were used in a cooking and/or transfer mode, with moderate to high risk of breakage.

Vessel size will also affect use-life, with larger vessels generally having better survival rates than their small counterparts (Shott 1996). Relative to the ethnographic examples, all of the PO-21 forms can be considered medium or small. Combined with function, size supports an average use-life estimate on the low end of ethnographically established range. A use-life of one year or less was selected as the estimate in the current model on the basis of several ethnographic studies (Arnold 1991; Deal 1998; DeBoer and Lathrap 1979; Foster 1960).

Another assumption is that the number of vessels in use at one time in each household can be reasonably estimated. A household is defined as a nuclear family or its equivalent. The distribution of midden refuse and the admittedly tenuous interpretation of post features suggests that the site had small houses, rather than longhouses or other multi-nuclear forms (but see Siegel 1989:204 for a brief critique of the PO-21 house data). A review of ethnographic summaries suggests that 5-10 vessels is a typical to low count of pots per household for semi-sedentary to sedentary groups (Arnold 1991:Table 27; David and Hennig 1972; Deal 1998; DeBoer and Lathrap 1979; Nelson 1991; Rice 1987:Table 9.4). In the case of PO-21, the sample vessel assemblage of 48 vessels included multiple examples of all nine non-griddle vessel types. The recovery of two to nine examples of each vessel type suggests that none is idiosyncratic or atypical. Taken with the ethnographic data, it is argued here that a typical household use assemblage at PO-21 included at least nine vessels, at least one of each type.

If these assumptions are all accepted as reasonable, it is straightforward to produce models of the duration of pottery use at the site, using Pauketat's (1989:291) formula:

Time = (Total Number of Vessels X Use Lifespan) / Average Household Pot Assemblage

Table 3 presents the outcome of the model based on 192 total vessels and a 1-year mean lifespan. If the average pot life was one year, then a single household that was occupied year-round would take 21 years to accumulate the inferred vessel assemblage.

The derived Single Household Years (21) can be interpreted many ways based on the length of each domestic episode and the number of concurrent structures. The number of structures will be addressed first. The site has at least three distinct midden areas, and each

Table 3. Duration of Pottery Use Modeled from Vessel Counts.

Value	Average Lifespan 1 year
Total Vessels	192 pots
Cumulative Duration of Pottery Use (Vessels X Life Span)	192 years
Single Household Years [(Vessels X Life Span)/9 vessels per household]	21 years

Notes: Total vessels defined as 48 sample vessels X 4, assuming sample vessels account for 25 percent of total site vessels. Single Household Years follows the Pauketat (1989:291) formula.

yielded post features from the prehistoric occupation. The southwestern portion of the site had at least two sequential structures, one overlying the other. The detailed technological and stylistic/formal analysis indicated a very high degree of consistency between the various areas of the site (Espenshade et al. 1987), but time control is not sufficient to say if all multiple loci were occupied concurrently or if the different loci simply represent minor shifts within the site. For this modeling, three scenarios are considered: one structure occupied at a given time; three concurrent structures; and six concurrent structures.

For this analysis, year-round occupation is assumed. It is clear that manioc processing occurred on site on the basis of griddle fragments, structures were present, dense midden accumulated, and the soils of the site vicinity would have been conducive to manioc gardening (and possibly maize, if it was present in this period). Unfortunately, no faunal remains or ethnobotanical foodstuffs were recovered from any of the flotation samples. There is a wide variety of vessel forms, suggesting diverse domestic activities, rather than short-term, functionally limited activities. The model can then be run for year-round occupations by one, three, or six structures, using the formula:

Span of Site Use = Single Household Years / Number of Contemporaneous Houses

The modeling indicates the occupation of the site by one household for 21 years could account for the inferred assemblage. If there were three or six structures at a time, the span of site use is reduced to 7 and 3.5 years respectively. Given the presence of four household midden areas, it is likely that at least four houses were present, as either sequential or partly contemporaneous occupations (the lower house in the southwestern area could not have been occupied at the same time as the upper house). The range in site use for the one year lifespan model (3.5-21 years) is consistent with ethnographic data on settlement duration in the moist tropics (e.g., Wagley 1977; Im Thurn 1967). Structure decay, midden accumulation, insect and parasite infestations, and possibly depletion of shallow, clayey soils (this last has not been adequately examined for volcanic soils) all can force movement of settlements every five to 10 years. A single household occupation might reasonably stretch beyond this range, since the single structure could be rebuilt elsewhere within the site, and midden would not accumulate as quickly as with multiple structures. The fit between the modeled spans and the ethnographic data suggests that the various premises are generally reasonable for the one-year lifespan model.

Discussion and Conclusion

The results of the final modeling directly reflect possible past behaviors, again assuming that the various premises are valid. It is possible through such modeling to move beyond 11,271 sherds or 48 sample vessels. The modeling of site use duration is based on stacked premises. For PO-21, the numbers derived for one-year lifespan and 1-6 concurrent households are consistent with ethnographic data sets and the site contexts. In terms of behavior, the modeling suggests that one to six residential units concurrently occupied PO-21 for a relatively short duration (3.5-21 years). These results fit well with the strong technological and stylistic consistency of pottery from all areas of the site.

If the results are accepted as reasonable approximations of prehistoric behavior at this particular site, they also have implications for overall settlement modeling. On face value (thick midden, 11,271 sherds), PO-21 might be (indeed was) considered an intensively occupied site for this portion of the Cerrillos Valley. However, if this supposedly heavily occupied site represents one to a few structures inhabited for 3.5 to 21 years, our perception of the overall settlement pattern requires adjustment. By the model presented here (acknowledging all the assumptions upon which it is based), one to three families could easily account for all the known Early Ostionoid sites in the Cerrillos Valley (for settlement studies, see Espenshade et al. 1978; Garrow et al. 1995; Garrow and McNutt 1990; McNutt and Garrow 1990;

Oakley and Solís Magaña 1990; Pantel 1978; Robinson et al. 1985; Solís Magaña 1985, 1989; Weaver 1989). Changes in the base assumptions would clearly alter the outcome of this exercise, but it is unlikely that the model would ever result in a conclusion of high population density. At best, the valley was very lightly settled in this period. This conclusion, in turn, has implications for the interpretation of boundary area phenomena (Chanlatte Baik 1986; Chanlatte Baik and Narganes Storde 1990; Oliver 1995; Rouse 1952a, 1952b, 1982, 1992; Siegel 1989) and the presence of apparent ballcourts in the upper Cerrillos Valley in the Ostionoid span (Garrow and McNutt 1990; Garrow et al. 1995 ; McNutt and Garrow 1990; Weaver 1989). These implications cannot be fully developed here, but it is clear that vessel use duration modeling may advance settlement system reconstructions for this valley and other areas of the Caribbean. If the various premises used in the modeling approximate reality, this conclusion may require a reconsideration of the intensity (or lack thereof) of Ostionoid settlement in the Cerrillos Valley.

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