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SHELLFISH GATHERING AND SHELL MIDDEN ARCHAEOLOGY

by

Gregory A. Waselkov

A Dissertation submitted to the faculty of
The University of North Carolina at Chapel Hill in
partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Anthropology

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Approved by:

Advisor

Reader

Reader

Reader

Reader

ABSTRACT

GREGORY A. WASELKOV. Shellfish Gathering and Shell Midden Archaeology (Under the direction of JOFFRE L. COE).

The development of shell midden archaeology has long been based on an erroneous presupposition; namely, that a single exploitative strategy involving shellfish gathering was adopted in many areas of the world, and it produced a homogeneous class of archaeological sites referred to as shell middens. Some archaeologists have rejected this claim and have explored the possibility that shell middens constitute a heterogeneous class. These are sites of diverse origins associated primarily by reason of superficial visual resemblances and practical considerations arising during their excavation. To pursue this line of inquiry, the extensive literature on shell midden archaeology was reviewed and critiqued, and selected techniques and analytic methods were systematically integrated to form a unified structural and zooarchaeological approach to the archaeology of shell middens. The ethnographic literature was also reviewed and corresponding patterned archaeological correlates of observed behavior were proposed. The origins and subsequent variation of molluscan exploitative strategies and the relationship between shellfish gathering and the origins of agriculture were also discussed.

A deeply stratified shell midden in the lower Potomac River Valley

was excavated in order to test the utility of the structural approach. A detailed consideration of feature characterisitcs and faunal remains led to several specific conclusions regarding the changing role of shellfish gathering in the subsistence-settlement strategies of the region's inhabitants between 2000 B.C. and A.D. 1650. Specifically, the site was repeatedly occupied during the spring by small groups of shellfish gatherers throughout this period, with the goal of obtaining additional protein during the lowest annual period of terrestrial resource availability. Modifications in shellfish roasting procedures and a probable increase in shellfish drying for storage and trade accompanied the intensification of agriculture and the development of chiefdoms. Thus, the role of shellfish gathering changed as overall subsistence-settlement strategy was altered, although this was only discernible upon detailed component analysis.

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INTRODUCTION

"Oysters, come and walk with us!"
The Walrus did beseech.
"A pleasant walk, a pleasant talk,
Along the briny beach;
We cannot do with more than four,
To give a hand to each."

Lewis Carroll
Through the Looking Glass

Many a seduction, it's said, has begun with oysters. Explorers and travellers have long pondered and speculated on the origins of the massive shell accumulations which line the world's coasts. Bleached and decaying molluscan exoskeletons, in the aggregate of their inconceivable numbers, furnished ample food for antiquarian thought and, indeed, were the subject of some of the earliest scientific archaeology. Their nacreous allurement has not waned; rather the attraction has grown more profound with the understanding gained as archaeology passes from adolescent naivety to the slightly insecure self-satisfaction of its early maturity.

In this dissertation, I intent to identify those methodological and theoretical problems toward which shell midden archaeology is most likely to contribute solutions. This is an ideal moment in the discipline's development for such an undertaking. Archaeologists dealing with problems posed by shell middens often seem oblivious of substantial contributions made in previous work; understandably so, because the published literature is so voluminous, with many obscure sources, and has never been adequately synthesized. As a consequence, many archaeologists have busied themselves with "reinventing the wheel," rediscovering useful methods or cogent explanations originally developed years before -- not a healthy state of affairs for a scientific discipline. A general review and critique of archaeological method and theory as it relates to shell midden archaeology seems appropriate. In chapters III and IV, I propose a unified approach to shell midden excavation and analysis which emphasizes the structured nature of shell middens, particularly in terms of feature recognition and interpretation, midden composition, and patterns in zooarchaeological and other artifactual remains. However, this is merely a necessary first step toward development of a general model of human molluscan exploitation which explains its broader role in coastal adaptation and the presence of these sorts of sites. These two endeavors constitute Part 1 of this study. A partial test of these models is offered in Part 2, the analysis of a stratified Chesapeake Bay shell midden which spans a 4,500 year period of sociocultural evolution.

In order to more adequately judge the effectiveness of archaeological methods and the appropriateness of the explanatory models, a wide-ranging search of the ethnographic and ethnohistoric literature on shellfish gathering has also been undertaken. The purpose is to derive general analogies or models of human behavior with characteristic and distinctive implications which may be inferred from the archaeological record. Since the available ethnographic record describes only a portion of all past human behavioral variability, the usefulness of generalizations drawn from analogies lies in their contrast with archaeological patterns to discover anomalies as well as consistencies (Yellen 1977a:4-6; Gould 1980:251). Thus, archaeologists can expand our knowledge of the range of human behavior instead of merely viewing the past in terms of the present.

While shell middens offer exceptional opportunities to study aspects of food gathering (primarily due to visibility and preservation factors, discussed below), they are by no means strictly the remains of hunting and gathering societies. Therefore, ethnographic and ethnohistoric information on shellfish gathering by members of any society, whether dependent on various types of agriculture or not, was reviewed to the extent possible given the varying accessibility and the often incomplete nature of such sources. The results of this survey are organized topically (i.e., procurement methods, division of labor, dietary contribution, seasonality and scheduling, storage and trade, and types of sites) so they may be readily compared with patterns recognized in archaeological deposits.

In such a study, narrowly focused as it is on a single class of resources, the researcher must turn this potential handicap to advantage. While the ethnographic and archaeological cases employed in the following discussions have necessarily been stripped of much of their cultural systemic context, this has also limited the number of variables to a few which are thought to be crucial for understanding changes in subsistence strategy. The extended diachronic analysis of a Chesapeake Bay shell midden as an element of a spatially and temporally extensive adaptive system is meant to compensate for the limitations in the general approach taken in the first half of this dissertation (cf. Butzer 1978).

Finally, before you delve headlong into this somber tome, can you answer this old English riddle?

As I was going across London Bridge,
I met old old Daddy Gray.
I ate his meat and drank his blood
And threw his bones away.

Who was old Daddy Gray?

Part 1

ARCHAEOLOGICAL INTERPRETATIONS OF SHELL MIDDENS

Chapter I

A QUESTION OF ORIGINS

Evolution or Spontaneous Generation?

Molluscan shells have been found in small quantities at some very early archaeological sites -- at 300,000 year old Terra Amata, for instance (Lumley 1972:37). But the oldest known "shell middens," or deposits whose principal visible constituent is shell, are the southwestern Cape of Good Hope rockshelters and open-air sites dating from 70,000 to 60,000 years B.P. (Volman 1978). Elsewhere in the world, there is precious little evidence of shellfish exploitation until the late Pleistocene. Possible exceptions include a Mousterian site at Gibraltar (Garrod et al. 1928) and Haua Fteah in Libya which has been dated 45,400 to 41,000 B.C. (McBurney 1967). Recent excavations in the Cantabrian region of northern Spain have documented a gradual broadening of the resource base to include marine exploitation, particularly shellfish gathering, between 21,000 and 10,500 B.P. (Straus et al. 1981). In Cantabria, as at Gibraltar and Haua Fteah, the earliest use of marine food resources was not intensive.

Judging from extant evidence, shell middens became a world-wide phenomenon during the Holocene (Table 1, Figures 1 and 2). The Cantabrian sites show a dramatic increase in shellfish remains beginning around 9,000 B.P., as do sites along the Mediterranean coast and in Japan (Bailey 1975b (IX):27; Waterbolk 1968:1094; Clark 1977:325).

Table 1. World-wide Distribution of Shell Middens.

Map Number	Location	Selected References
Europe		
1	Scotland	Bishop 1913; Coles 1971; Jardine 1977; Mellars 1978; Mellars and Payne 1971; Tait 1869; Clark 1976:22
2	Ireland	Liversage 1968
3	Wales	Lethbridge 1928
4	Denmark	Bailey 1975b; Brinch Petersen 1973; Troels-Smith 1967
5	Pas-de-Calais	Boone 1976:704
6	Brittany	Pequart et al. 1937; Pequart and Pequart 1954; Boone 1976:704
7	Cantabria	Bailey 1975b; Clark 1971; Clark and Lerner 1980; Straus and Clark 1978; Straus et al. 1980, 1981
8	Portugal	Roche 1960, 1965, 1972
9	Gibraltar	Garrod et al. 1928
10	S France, E Spain	Cohen 1977:94; Lumley 1972; Whitehouse and Whitehouse 1975:49; Boone 1976:703
*11	Pyrenees	Boone 1976:704-705
*12	Provence	Boone 1976:705
13	Italy	Waterbolk 1968:1094; Whitehouse 1968
14	Corfu	Sordinas 1969
15	Devon	Churchill and Wymer 1965
16	Isle of Portland, Dorset	Palmer 1977
Africa		
*17	Algeria, Tunisia, Libya	Lubell et al. 1975; Morel 1974
*18	Libya	McBurney 1967; Hey 1967
19	Mauritania	Elouard 1969
20	Senegal	Linares de Sapir 1971
21	Ivory Coast	Olsson 1973
22	Namibia	Speed 1969:193

*Freshwater or terrestrial molluscan species

Table 1. (cont.)

Map Number	Location	Selected References
23	South Africa	Avery 1974; Buchanan et al. 1978; Deacon 1970; Klein 1975; Maggs and Speed 1967; Parkington 1972, 1976; Robertshaw 1978; Speed 1969; Voigt 1973; Volman 1978
24	Mozambique	Speed 1969:193
Asia		
25	Andaman Islands	Cipriani 1955, 1966
*26	Greater Andaman Island	Cipriani 1966:78
27	W Malaysia	Solheim 1981
28	Sumatra	Solheim 1981
29	Vietnam	Boriskovskii 1970
30	Ryukyu Islands	Pearson 1969
31	Japan	Groot and Sinoto 1952; Morse 1879; Pearson 1977; Yamazaki 1975
32	Korea	Henthorn 1968
33	E Soviet Union	Andreyev 1964; Okladnikov 1965
Oceania		
34	NE Australia	Bailey 1975b, 1977
35	SE Australia	Bailey 1975b, 1977; Campbell 1972; Coutts 1970a; Gillespie and Temple 1977; Lanpert 1971; Statham 1892
*36	SE Australia	Mitchell 1949
37	Tasmania	Gunn 1846; Hiatt 1967-1968; Jones 1971; Taylor 1892
38	New Caledonia	Gifford and Shutler 1956
39	Fiji	Gifford 1949
40	New Zealand	Allo 1970, 1972; Cassels 1972; Coutts 1971a; Shawcross 1967; Terrel 1967
41	Hawaii	Callan 1973
42	Admiralty Islands	Kennedy 1981
43	New Guinea	Allen 1972
44	Tonga	Bailey 1975b: Figure II:1

*Freshwater or terrestrial molluscan species

Table 1. (cont.)

Map Number	Location	Selected References
South America		
45	Ecuador	Meggers, Evans and Estrada 1965
46	Peru	Craig and Psuty 1971; Engel 1957
47	Chile	Meggers 1972:26
48	Tierra del Fuego	Bird 1938; Gusinde 1937; Lothrop 1928
49	S Brazil	Andretta and Menezes 1968; Delaney 1963; Fairbridge 1976; Hurt 1974; Rauth 1971; Serrano 1946
*50	Amazon Delta	Serrano 1946:401
51	Colombia	Reichel-Dolmatoff 1972
52	Trinidad	Bullbrook 1953
North America		
53	Aleutian Islands	Dall 1877
54	British Columbia	Ham 1976:61; Hester and Conover 1970; Matson 1976; Sawbridge and Bell 1972; Smith 1909
55	California	Beaton 1973; Botkin 1975; Carter 1941; Cook and Treganza 1950; Gifford 1916; McGeein and Mueller 1955; Meighan 1950, 1959; Nelson 1909, 1910; Shumway et al. 1961; Tartaglia 1976, 1980; Uhle 1907; Warren and Pavesic 1963; Whelan 1967
*56	Central California	Cook and Heizer 1952; Cook and Treganza 1947, 1950; Treganza and Cook 1948
*57	NW Interior Plateau	Morse 1967:246
58	W Mexico	Foster 1975; Long and Wire 1966; Mountjoy 1974; Shenkel 1971, 1974
59	Panama	Borgogno and Linares 1980; Willey and McGimsey 1954
60	Puerto Rico	Fewkes 1904
61	Yucatan	Andrews 1969; Andrews et al. 1974; Eaton and Ball 1978
62	E Mexico	Stark 1974; Voorhies 1976
63	Texas	Dillehay 1975; Gilmore 1974

*Freshwater or terrestrial molluscan species

Table 1. (cont.)

Map Number	Location	Selected References
64	Louisiana	Beyer 1899; Brown 1936; Byrd 1974; Gagliano 1967; Neuman 1972
65	Alabama	Gaines and Cunningham 1878; Holmes and Trickey 1974; Knight 1976; Owen 1922
66	Florida	Bullen and Sleight 1959, 1960; Bullen et al. 1967; Butler 1917; Douglas 1885; Jordan 1963; Sears 1960, 1963
67	Georgia	Crusoe and DePratter 1976; Marrinan 1975; Simpkins 1975; Thomas and Larsen 1979; Waring and Larson 1977
68	South Carolina	Stoltman 1974; Trinkley 1975, 1976, 1980; Trinkley and Ward 1978
69	North Carolina	Loftfield 1970
70	Chesapeake Bay	Holmes 1907; McGuire 1883; McNett and Gardner 1971; Marye 1938; Reynolds 1883a, 1883b; Wright 1973
71	Delaware	Weslager 1939, 1941
72	New Jersey	Rau 1872
73	New York	Brennan 1962a, 1962b, 1963, 1968, 1971, 1974, 1976, 1977; Ceci 1977; Rothschild and Lavin 1977; Salwen 1965, 1968; Smith 1950
74	Rhode Island	Eaton 1898; Fowler 1979
75	Connecticut	Glynn 1953; Powell 1965
76	Martha's Vineyard	Byers 1941; Byers and Johnson 1940; Perlman 1977; Ritchie 1969
77	Massachusetts	Boissevain 1943; Bullen 1949; Johnson and Raup 1947; Moffet 1951, 1959, 1962; Morse 1868
78	Maine and New Brunswick	Allison 1964, 1972; Baird 1881; Berry 1898-1899; Bonnichsen and Sanger 1977; Bradford 1969; Bruce 1965; Byers 1979; Chadbourne 1859; Dow 1971; Fowler 1870; Goldthwaite 1935; Hadlock 1943; Lenik 1977; Loomis and Young 1912; Moorehead 1922; Rice 1971; Rowe 1940; Sanger 1980; Wyman 1868a

*Freshwater or terrestrial molluscan species

Table 1. (cont.)

Map Number	Location	Selected References
79	Nova Scotia	Ambrose 1863; Clark 1963; Clark and Erskine 1961; Erskine 1960; Smith and Wintemberg 1929; Wintemberg 1929
80	Prince Edward Island	Fewkes 1896
81	W Greenland	Rau 1884:34, 218-221
*82	Ohio River	Atwater 1820:226, Blatchley 1912, Morse 1967:158; Rau 1884:239; Winters 1969
*83	Green River	Marquardt and Watson 1977; Webb 1946, 1950a, 1950b; Winters 1974
*84	Tennessee River	Dye 1980; McCollough and Faulkner 1973; Morse 1967; Warren 1975; Webb and DeJarnette 1942, 1948a, 1948b
*85	St. Johns River	Case and Owens 1966; Cumbaa 1976; Moore 1892-1893; Wyman 1868b, 1875
*86	Savannah River	Claflin 1931; Stoltman 1974

*Freshwater or terrestrial molluscan species

Figure 1. Old World Distribution of Shell Middens.

Figure 2. New World Distribution of Shell Middens.

The oldest shell middens in the Hebrides date to 5,850 B.P. and in Denmark to 5,600 B.P. In the Americas, several sites are 9,000 to 7,000 years old (Meggers 1972:27; Brennan 1976), but the great majority date no earlier than 5,000 B.P.

Several writers have accepted these data as accurately reflecting the reluctant adoption of shellfish exploitation late in human prehistory without considering, or simply rejecting as irrelevant, the effects of a post-Pleistocene sea level rise which presumably has submerged numerous continental shelf sites (e.g., Cohen 1977:94; Crusoe and DePratter 1976:2; Osborn 1977b:158). Though others have questioned whether the archaeological record has been severely depleted of Pleistocene and early Holocene coastal sites (Emery and Edwards 1966; Merrill, Emery and Rubin 1965; Powell 1971; Solheim 1981), in those few cases where submerged middens have been sought, they have been found (Goodyear and Warren 1972; R. Ruppe 1980; c.f. Haag 1975:81). The existence of the Pleistocene South African sites certainly suggests that shell middens of comparable age may have existed elsewhere in the world.

On the other hand, a persuasive argument can be made for the late appearance of <u>intensive</u> shellfish exploitation, based on data from the few areas relatively unaffected by eustatic changes. The long Cantabrian sequence indicates that intensive utilization of this resource began only after 10,000 years of very low level exploitation. A similar shift in emphasis is evident in the South African middens near the end of the Pleistocene (Klein 1979). An independent line of supporting evidence is available in the distribution of freshwater and terrestrial molluscan shell middens, most of which are no more than 7,000 years old, and which would not have been as drastically affected as coastal sites by sea level rises (Meggers 1972:27; Cohen 1977:95). However, it should be noted that, at least in eastern North America, terminal Pleistocene/early Holocene riverine sites are very rare, due to erosional destruction and burial by flood deposition (Coe 1964:11; Chapman 1977:2).

Artifacts of Nature or Culture?

Our present knowledge of shell middens, imperfect though it is, is a consequence of a long series of increasingly sophisticated observations and interpretations which parallel the development of scientific archaeology. Once these wide-spread features of the landscape were recognized by natural historians as anomalies deserving of explanation, their first consideration was to solve the problem of shell midden origins. Are they natural accumulations or the result of human activities? Peter Kalm, a Swedish botanist sent to North America by Linnaeus in 1748, considered it probable that both sorts of shell heaps existed.

> ... one sees immense quantities of oysters and mussel shells piled up near the places where it is certain that the Indians formerly built their huts. This circumstance ought to make us cautious in maintaining that in all places on the seashore, or further back in the country where such heaps of shells are to be met with, that the latter have lain ever since the time when these places were overflowed by the sea (Kalm 1966:127).

Across the globe, another botanist, Joseph Banks, had many opportunities to witness shell middens in the process of formation as a member of Captain James Cook's 1768-1771 circumnavigation voyage. While on board the Endeavor, anchored in Mercury Bay off the North Island of New Zealand in 1769, Banks wrote:

> The bay must be a place to which parties of them [the Maori] often resort for the sake of shellfish which are here very plentiful; indeed where ever we went, on hills or in valleys in woods or plains, we continually met with vast heaps of shells often many waggon loads together, some appearing to be very old; where ever these were it is more than probable that Parties of Indians had at some time or other taken up their residence, as our Indians had made such a pile about them (Beaglehole 1962 (I): 427).

Unfortunately, such astute observations had little impact at the time and the general consensus among eighteenth century European savants was that shell deposits were natural formations. Not until the 1830's and 1840's was the question of origins again raised, this time in debate over the possible antiquity of the human species. Geologists in Maine and Maryland first raised the issue and decided in favor of an artificial origin for most shell heaps (Vanuxem 1843; Putnam 1884: 86). To settle this question, a group of Danish scholars, beginning in 1847, undertook some of the earliest problem-oriented scientific excavations. Their conclusions, presented most authoritatively by Japetus Steenstrup in 1851, were that the local kjökkenmødinger, or kitchen middens, were products of human activity (Madsen et al. 1900). Multiple lines of evidence were employed to distinguish natural shell heaps from shell middens. Their excavations demonstrated that shell middens are made up of piles of shells from adult individuals, often including species which live in different habitats. Conversely, naturally occurring shell beds are stratified and sorted according to volume and weight and include individuals of all ages belonging to species of similar habitat. Found throughout middens are artifacts, charcoal, and animal bones left by human occupants (Morlot 1861).

Other archaeologists soon corroborated Steenstrup's findings by excavations in Scotland (Tait 1869), New England (Lyell 1849 (I):252; Chadbourne 1859), Tennessee (Brinton 1872:357) and Florida (Wyman 1875; Moore 1892-1893:117). Although these early workers essentially resolved the problem of shell midden origins, the topic has occasionally been revived through the years (Statham 1892; Gill 1954; Bailey 1977).

So Many Variations on a Theme

The initial archaeological interest in shell middens coincided with, and was at least partly a result of, the momentous controversy over the ultimate origins and antiquity of the human species. With advocates of human evolution proposing a long prehistoric period of development, archaeologists cast about for some evidence to substantiate or refute this claim. Daniel Brinton merely reiterated a view generally held that shell middens might provide an answer when he stated:

> The great size of some of these accumulations may furnish some conception of the length of time required for their gradual accretion, and consequently of the period during which these shores have been inhabited (Brinton 1872:358; see also Wyman 1868a:570).

W.H. Dall (1877:52) was apparently the first to attempt to quantify the rate of midden accumulation for a particular site. He excavated part of a large midden on the island of Amchitka in the Aleutians and determined that it consisted mainly of broken sea urchin tests and spines. Based on observations of modern Aleuts, Dall assumed that each person would consume about 100 four-inch-diameter sea urchins a day, that each community would have consisted of about 20 individuals, and that a community would inhabit a site for about three months of the year, during which time they would consume 184,000 sea urchins. He then experimented with modern sea urchin tests, crushing them to replicate the conditions of midden specimens and estimating the number of tests present per unit volume of midden (i.e., $1000/ft^3$). By calculating the volume of midden at the Amchitka site, determining the number of sea urchins represented in this midden and then dividing that figure by the 184,000 sea urchins consumed every year by the hypothetical community, Dall reached the conclusion that over 2,200 years would have been required for the Amchitka midden to accumulate. Dall's technique was ingenious, but he readily admitted its imprecision and hypothetical basis and disavowed "any intention of proving anything absolutely" (1877:52).

Dall's calculation was immediately attacked by S.T. Walker, who pointed out that the growth of a shell heap depended on the abundance or scarcity of shellfish, the regularity with which a site was reoccupied, the length of occupation, the number of people living in the vicinity and other variables. In short "there were so many possibilities to be encountered, that the question of age is lost among them" (Walker 1883:680). Despite the cogency of this criticism, calculating rates of accumulation and lengths of occupation became a prescribed ritual of shell midden analysis. Subsequent archaeologists elaborated on the method, refined procedures, but never resolved the essential defect -- the estimates depended on unverifiable assumptions.

Nels Nelson's (1909:345) contribution to the midden accumulation rate problem was to specify a painstaking laboratory analysis of midden samples designed to quantify ash, broken rock, soil and other non-shell midden constituents. Edward Gifford (1916:12-14) based his estimates of occupation duration on weights of midden components, rather than volume. Years later, Sherburne Cook revived Nelson and Gifford's techniques and published a series of articles detailing the analytic procedures and number of samples needed to accurately estimate relative proportions of midden constituents (Cook 1946; Cook and Treganza 1947; Cook and Heizer 1952:281). He also attempted to improve the community size estimate by correlating site surface area with population size (Cook and Treganza 1950:231; see also Lothrop 1928:193-195; Ascher 1959:172-174). The Nelson-Gifford-Cook tradition, usually referred to as the California School of Midden Analysis, has continued up to the present, particularly in New Zealand, with minor variations (e.g., Terrell 1967; Shawcross 1967:121; Davidson 1967; Shenkel 1971:141; Lubell et al. 1976:918).

In 1946, a discovery was made which should have at least stunted the growth of the California School, if not killed it outright. The development of radiocarbon dating allowed archaeologists at last to determine, independently of any cultural assumptions, the total length of site occupation, which was the original purpose of Dall's calculation. But when the relevance of radiocarbon dating was finally realized, the by-now-immortal equation was simply turned on its head and used to estimate the remaining uncontrolled variables: population size, average annual length of occupation, and relative dietary contribution of shellfish (Drover 1972:19; Clark 1975:193-194; Bailey 1975a:54, 1975b (IX):29, 1977:138-139).

Since Walker's original rebuttal of Dall's method one hundred years ago, there has been no shortage of critics (Ambrose 1967; Coutts 1970a:45; Glassow 1967; Gusinde 1937:360; Shawcross 1967:121, 1972:596-597; Tartaglia 1976:53; Yesner 1978:342). These individuals have attributed the extreme unreliability of the method to numerous sources of error which are compounded in the final results. The main sources of error can be grouped in three categories:

1) Cultural Variables -- fluctuations over time in number of site occupants, length and season of occupancy, regularity of visits, dietary importance of shellfish, changes in diet through time and individual differences in diet.

2) Environmental Variables -- effects of local and large-scale environmental changes, and seasonal changes in food resource availability and quality. Reducing error in cultural and environmental variables depends largely on advances in theoretical model development.

3) Archaeological Variables -- differences in preservation of sites and food remains, accounting for food not represented at sites, determining food value from faunal remains, determining contemporaneity of sites or activity areas, and difficulties in sampling heterogeneous archaeological deposits (not homogeneous deposits, as the California School assumed). Reducing error in these variables depends primarily on advances in archaeological method.

In spite of the many shortcomings of age/population estimates, their development and use provoked a vigorous debate and a gradual realization of the problem's complexity. Even though the original goals are no longer paramount in archaeology, the underlying cultural, archaeological and environmental variables remain crucial to our understanding of shellfish exploitative strategies and riverine and marine adaptations.

Chapter II

SHELLFISH GATHERING IN PRACTICE AND THEORY

The Multifarious Mollusc

An underlying premise of this dissertation is that the nature of molluscan exploitation at a particular place is strongly influenced by features of the local molluscan population, especially habitat preferences, relative mobility, and average size of mature individuals of different species. Therefore, a brief discussion of the taxa most often represented in shell middens is interjected here.

Two molluscan classes (Gastropoda and Pelecypoda) have contributed the majority of shells to archaeological middens. Much less significant from this perspective are classes Polyplacophora (which includes chitons), Scaphopoda (dentalium) and Cephalopoda (nautilus). Gastropods occupy both terrestrial and aquatic habitats, and include the genera *Haliotis* (abalones), *Diodora* (limpets), *Patella* (patellas), *Strombus* (conchs), *Busycon* (whelks), *Littorina* (periwinkles) and land and freshwater snails. Most gastropods have a spiral shell, which in the case of limpets and patellas assumes the form of a flattened cone.

The pelecypod exoskeleton consists of two hinged valves which may or may not be symmetrical. Genera include *Mytilus* and *Geukensia* (marine and estuarine mussels), *Mya* and *Mercenaria* (clams), *Ostrea* and *Crassostrea* (oysters), *Cardium* (cockles) and *Unio* (freshwater mussels). Although not from members of the phylum Mollusca, the tests of urchins

(Echinodermata) and the calcareous plates of barnacles (Crustacea) are usually treated as molluscan remains by archaeologists.

All of the most commonly exploited marine molluscan species occupy habitats close to shore, often in the intertidal and shallow subtidal zones. Limpets, patellas, abalones, and many mussels prefer rocky substrates, while others require sand or mud bottoms. Oysters and marine mussels are sessile in their adult stage, whereas other species are mobile to varying degrees. These and other environmental factors necessarily affect the selection of resources and modes of procurement.

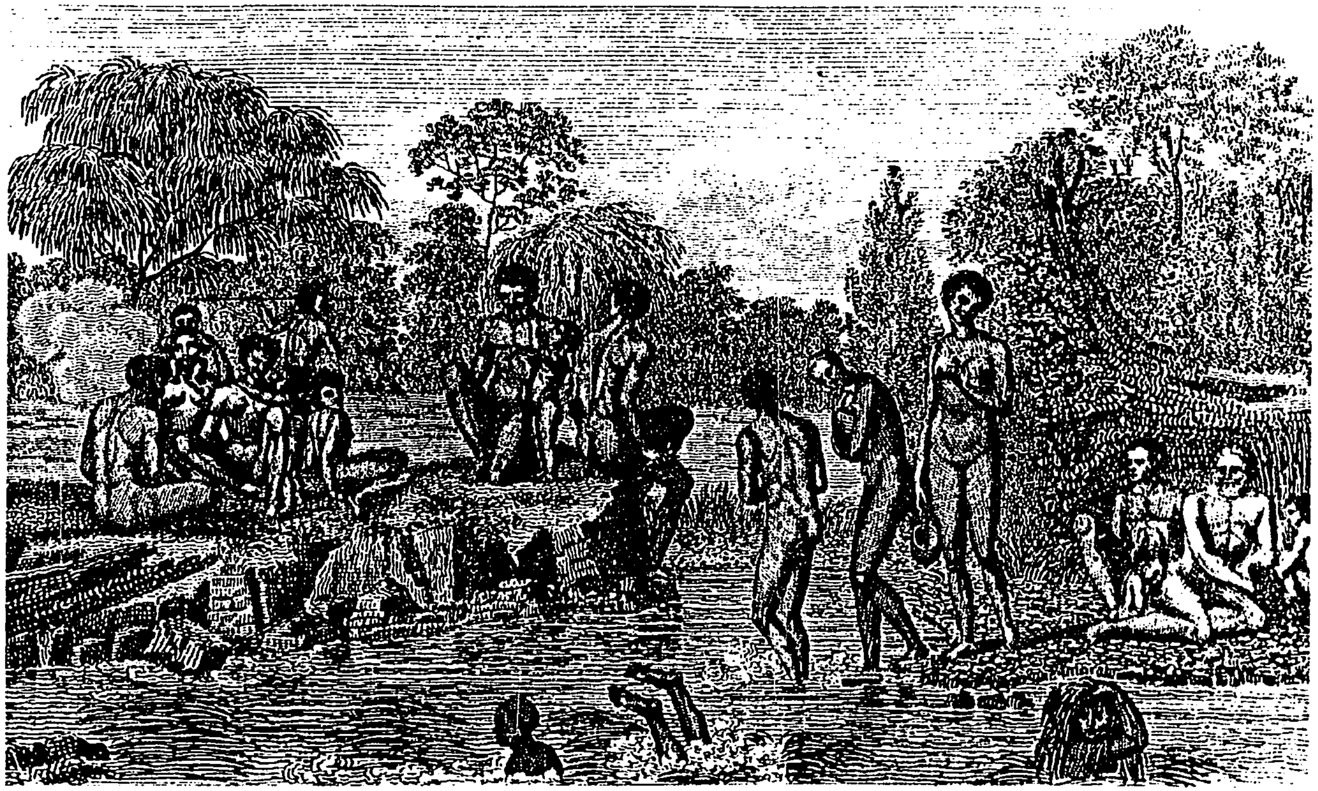
Procurement Methods

The ethnographic and ethnohistoric descriptions used in this chapter were drawn from as wide a range of societies as possible. Unfortunately, there is a great deal of information about shellfish exploitation for some societies and distressingly little on others. The most detailed reports available in English concern the New Zealand Maori; aboriginal groups of northern and southeastern Australia; several South African peoples; the Yahgan, Ona and Alacaluf of Tierra del Fuego; and some California groups, including the Yuki and Yurok. Even in these exceptional cases, it is sometimes difficult to determine whether the writer was describing actual observed activities, drawing normative generalizations, or inferring hypothetical rules of behavior from limited observations, perhaps even from information obtained secondhand (Yellen 1977a:49). Suspect data have been excluded.

Hand collecting of shellfish from rocks exposed during low tide or by wading in shallow water are the procurement methods most frequently mentioned. Bantu-speaking Southern Nguni women of the Transkei remove patellas and abalones from rocks by hand or with the aid of a flat iron bar and then place them in a sack, can or basket (Bigalki 1973:161). Similar levers of wood or bone were used by the Maori and Tasmanians (Best 1924 (II):417; Hiatt 1967-1968:127). In Sonora, Seri women and children gathered oysters from offshore reefs, dislodging shells with a stick or rock (McGee 1898:195; Ascher 1962: 362). Yuki men would swim to outlying rocks and collect mussels in baskets (Gifford 1939:326).

When wading to gather shellfish from sand or mud bottoms, the usual methods seem to have been to sift through the sand with the fingers, as do the Australian Anbara (Meehan 1977a:366; also Beaglehole 1955 (I):312), or to feel in the mud with the toes, lifting the mussels with the toes to a basket held in the mouth (used by both Maori women and southeast Australian Aborigine men and women to collect freshwater mussels; Best 1924 (II):417; Massola 1971:111). Mud flats exposed at low tide could be inspected for siphon holes or lines in the mud which betray the presence of clams and cockles (Goodale 1971:168).

To obtain mussels and sea urchins from deeper waters, the Yahgan and Alacaluf wielded spears and pronged poles up to 4.5 m long from their canoes (Lothrop 1928:Figure 84a; Bird 1946:69). Tasmanian women dove for abalones (see Figure 3). Among the Virginia Powhatan, boys dove for freshwater mussels (Arber 1910 (I):1), as did Alacaluf women for marine mussels to a depth of 9 m (Bird 1946:60). Both men and women from the village of Kawaguchi, Japan, dive for abalones and other shellfish which they market commercially. Women dive for short periods



Savages of Van Diemens Land, Fishing.

Figure 3. Tasmanian women diving for shellfish at a shell midden on D'Entrecasteaux Channel; engraved from a drawing by M.F. Peron sketched in 1792 (Labillardiere 1799-1800: Atlas Plate IV).

of time (13-39 seconds) 80 to 160 times a day, to depths of 3 to 5 m. The men make longer dives (30-120 seconds) 10 to 33 times a day, to depths of 5 to 20 m. Both sexes use iron spatulas to pry the shellfish from rocks and then put the animals in mesh bags (Irimoto 1977:98-114).

Several societies developed mass harvesting procedures which were probably more task efficient than hand gathering (according to caloric value gained per calories expended). The Maori rountinely took freshwater mussels from lakes by means of long-handled scoops and rakes, the latter consisting of a wooden frame with teeth lashed to the lower beam and a bag net attached to the upper. As their canoes drifted over mussel-bearing shoals, the Maori men dexterously manipulated the rakes, dredging up mussels which were caught in the bag nets. On special occasions, large war canoes replaced the normal fishing vessels and crews competed in ritualized displays, skillfully working the rakes with dramatic thrusts and flourishes which temporarily overshadowed the implements' primary function (Best 1924 (II):419; Buck 1952:235; Firth 1959:171-172).

In form, the Maori hand rakes closely resemble Euramerican clam and oyster dredges used on sail operated and motorized commercial boats. The only other mass capture devices used by traditional societies of which I am aware are hand-held nets and draglines employed by Chinese and Korean women and children in water up to 4 m in depth (Okladnikov 1965:111-113).

The reader probably has noted that women and children were most often involved in shellfish gathering, and when men did participate they tended to concentrate on strenuous methods which required greater physical prowess. Apparent exceptions to this generalization, upon closer scrutiny, still have a basis in the physical differences between the sexes. For example, Alacaluf women divers were better able than the men to withstand frigid water temperatures, presumably due to ample amounts of subcutaneous fat (Bird 1946:60). Conversely, when men gathered shellfish by hand, they collected and carried back to camp significantly larger amounts than did women, although in no society did men participate in these activities as often as women. Betty Meehan has quantified her observations of this sort of pattern during a year-long stay among the Anbara of Arnhem Land, finding that women and girls spent 379 person-days gathering shellfish, compared to 52 for men and boys, though the average weight of molluscs collected by an individual per trip was 8.5 kg and 11.0 kg, respectively. Girls up to the age of 14 yrs averaged only 2.9 kg, while one 45 yr old woman averaged 17 kg and a 30 yr old man 20 kg per trip (Meehan 1977a: 366-367).

As mentioned in the introduction, the purpose of this review of ethnographic and ethnohistoric references is to derive general models of human behavior regarding shellfish gathering, and to specify implications of such behavior recognizable in the archaeological record. One such model has already been suggested -- that women and children are the principal shellfish gatherers, although men make proportionally greater contributions for the time they invest, concentrating on activities requiring greater physical strength or skill. Of course, this is simply a corollary of the generalization that women do most of the resource gathering, as opposed to hunting, in world societies

(Hiatt 1970:2). Unfortunately, there seems to be no independent means to discriminate between those portions of a midden accumulated by men and those by women (Bowdler 1976:255). All such attempts ultimately depend on general analogies which associate the use of certain artifacts with one sex or the other.

Somewhat more progress can be made in determining procurement methods. Shellfish gathered from rocky intertidal or shallow subtidal locations could be transported in baskets or bags, but to collect and transport shellfish from deep waters (or distant shellbeds of any sort) canoes seem to have been needed. Bert Salwen has proposed that molluscs brought to a site in numerous basketloads would be more evenly distributed throughout the midden compared to the spotty distribution of shellfish arriving by the boatload at relatively widely spaced intervals (Salwen 1968:338, 1970:4-5).

Some archaeologists have suggested that mass harvesting, such as with dredges, would collect shellfish of greatly varying size as compared to the presumably selective process of hand gathering (Stark 1974:458-461; May 1979). This simple correlation is complicated by numerous other variables, however. For instance, the size range of individuals taken with a dredge is largely determined by the attached net's mesh size, which could allow most of the smallest molluscs to slip through (Hancock and Simpson 1962:30-31).

Hand gathering is not necessarily a rigorously selective procedure for several reasons. When searching for clams or cockles in sandy or muddy substrates, a collector cannot determine the exact size of an individual until she has it in hand (or foot), at which point it is as easily placed in a basket as discarded. In sticky mud, numbers of small molluscs and other debris can be unintentionally collected along with the desired shellfish. Since oysters must attach to a solid substrate, small oyster spat frequently fasten to adults; consequently, hand gathering of oysters results in the collection of individuals in all stages of growth, plus dead shells, barnacles, pebbles and any other material to which they have attached. A similar range of small objects can be found entangled in the byssus threads of mussels (Stearns 1943:7; Brennan 1974:85; Ham 1976:64; Botkin 1980: 134).

Food Preparation Methods

The tightly closed valves or operculum of a mollusc pose a challenge to prospective predators. Humans have resolved this problem by employing four processes which, when used separately or in combination, allow them to extract the edible portion -- these are roasting (including baking and steaming), boiling, cracking or perforating the shell, and using a shucking knife.

Chitons and bivalves were virtually always opened and cooked in a single operation, by roasting in, over, under or around open fires or in steam ovens (Table 2, Figure 4). Two excellent ethnographic descriptions of bivalve preparation, by the Yahgan and Anbara, respectively, deserve extended quotation.

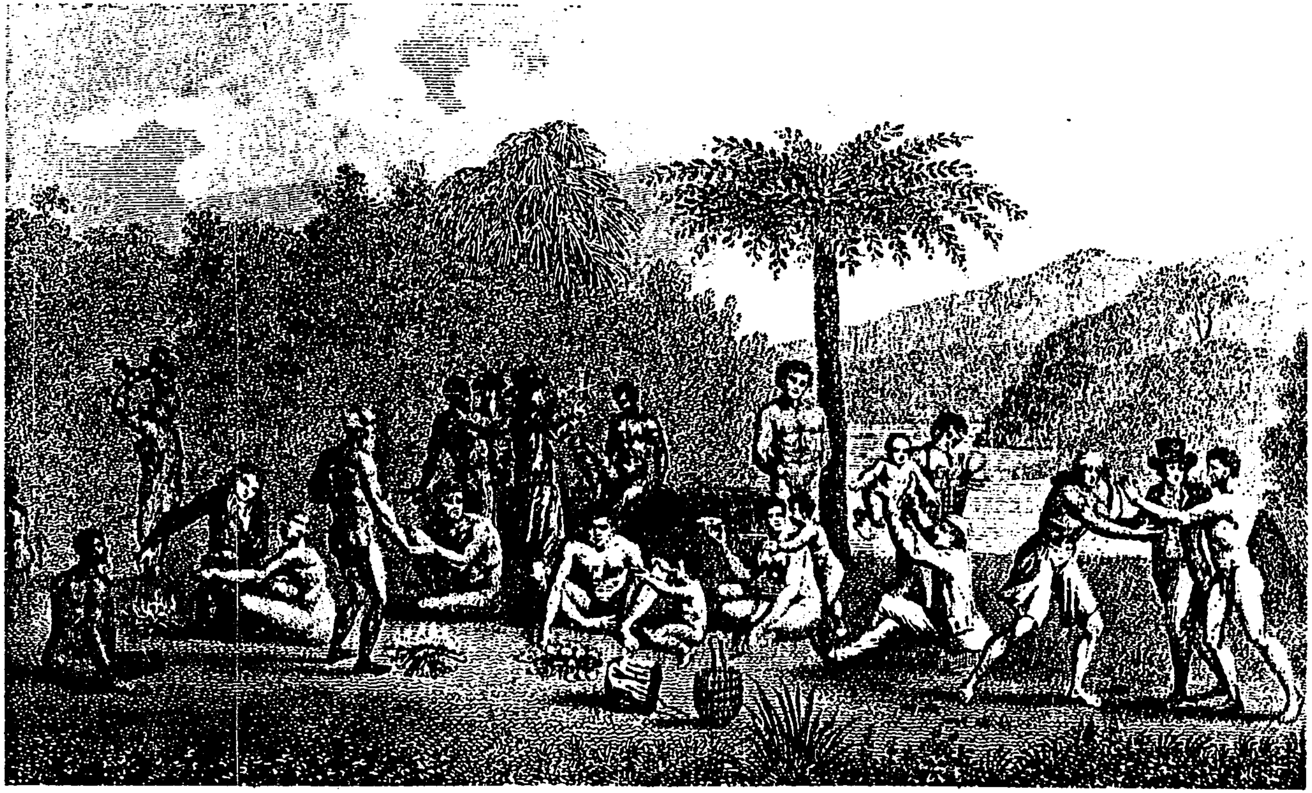
> When the mussels that were shoved onto the embers are done, they burst open by themselves. They are fished out with a little stick and allowed to cool a bit on the ground. Then in one hand, the Indian takes the shell to which the meat adheres, holds it horizontally, breaks off the empty shell with his other hand, and with his fingers tears out the meat which he

Table 2. Roasting Methods Used to Open Chitons and Bivalves - Ethnohistoric (dated) and Ethnographic Observations

Culture	Method	Source
North America		
Maryland Algonquians (1705-1706)	Oysters roasted in fire.	Anonymous 1907:333
Powhatan, Virginia Algonquians (1607)	Oysters roasted in fire.	Quinn 1967:8-9
North Carolina Algonquians (1585, 1701-1711)	Oysters and clams cooked on grill over fire.	Quinn & Quinn 1973:144; Lefler 1967:218
Delaware (pre-1749)	Mussels "broiled."	Kalm 1966:251
American Colonists, Philadelphia (1748)	Oysters roasted on live coals.	Kalm 1966:91
Coast Yuki	Chitons put on fire.	Gifford 1939:327
Tlingit	Clams steamed in a stone-lined oven.	Oberg 1973:67
Nootka (1803)	Clams and mussels steamed over hot stones.	Jewitt 1815:59
Seri	Clams and oysters partially roasted.	McGee 1898:195
South America		
Yahgan	Mussels and chitons placed in the heat of the fire.	Gusinde 1937:331-332

Table 2. (cont.)

Culture	Method	Source
Oceania		
Maori	Shellfish cooked in steam ovens or under open fires.	Best 1924:417
Tasmanians (1770-1777)	Scallops, mussels and oysters roasted around fires.	Beaglehole 1955 (I):306, 309, 325, 1961 (II):55, 786
Australian Aborigines (Botany Bay, 1770)	Oysters broiled over small fires.	Beaglehole 1955 (I):306 (also see Harney 1954:245, and Bailey 1977:137)
Murngin	Oysters and other bivalves put on hot stones and embers.	Warner 1937:144
Tiwi	Cockles arranged in a circle with a large fire built above them or baked in sand ovens with heated shells.	Goodale 1971:170
Anbara	Bivalves cooked under a fire or in steam ovens.	Meehan 1977a:366



Savages of Van Diemen's Land, preparing their Repast.

Figure 4. Tasmanians roasting shellfish; engraving of a 1792 sketch by M.F. Peron (Labillardiere 1799-1800: Atlas Plate V).

> immediately pops into his mouth. Finally he holds the flat mussel shell itself to his lips, since the drops accumulated in it are very tasty, and sucks them noisily (Gusinde 1937:331).

> The fresh shellfish were neatly stacked, lips down in clean sand. A small, fast fire was made on top of these -- on the hinges -- and allowed to burn down. The ashes and debris were then swept off the shells with a green branch and the cooked shells placed on a bundle of fresh green grass to cool before they were eaten. On other occasions, when large quantities needed to be prepared for ceremonies, shells were cooked in steam ovens which consisted of very hot dead shells, green branches and bark. In these ovens, thousands of shells could be cooked in a few minutes (Meehan 1977a:366; also see Goodale 1971:170).

The Seri commonly opened clams by cracking the shells with hammerstones without prior cooking (McGee 1898:195). Southern Nguni women boil mussels in iron kettles until the shells open (Bigalke 1973:163). The method used in modern commercial shucking operations is to insert a double-edged knife between the two valves and sever muscle attachments. Korean and Chinese women shucked Mactra sp. in this manner, taking approximately 2 seconds to remove each animal from its shell (Okladnikov 1965:111). This technique apparently depends on the availability of iron or steel for knives. Since hand shucking is more time consuming than roasting, there must be some incentive to avoid cooking the molluscs (i.e., that raw shellfish are thought to taste better). In the United States, oysters and clams used by commercial soup canneries are steamed open (Haven et al. 1978:36).

A variety of methods has been used to remove gastropods from their shells. Tasmanians simply roasted abalones in a fire (Peron 1809:177). However, unlike the relatively exposed abalone, most snails retreat into a spiral shell and seal the aperture with a calcareous or horny operculum. The application of heat, either by roasting (Warner 1937:144) or boiling (Bigalke 1973:163; Hester and Hill 1975; Lubell et al. 1975:97), relaxes the operculum muscles and permits the easy extraction of the gastropod with a thorn or other pointed object. The Yuki and Yahgan roasted snails and then broke open the shell to remove the meat (Gifford 1939:327; Gusinde 1937:331). The final reported extraction technique involves the use of a hammerstone to either break off the upper spirals or perforate the shell in that area, which releases the internal pressure holding closed the operculum (Hamilton 1908:11; Okladnikov 1965:113). Some Diola of southern Senegal still prepare gastropods in this manner, sucking out the snail once the apex of the spire has been removed (Linares de Sapir 1971:41).

If we consider all of these preparation methods from the perspective of effort invested per number of shellfish processed, there is a clear contrast between highly efficient methods of roasting bivalves which can open thousands of shells in a few minutes, versus labor intensive procedures, such as meticulously breaking spires off individual periwinkles. The implications of this dichotomy for exploitative strategies are discussed in Chapter V, but it is appropriate at this point to consider the archaeological correlates of these different methods.

As might be expected, there is no simple correspondence between preparation method and condition of shell midden refuse. Some archaeologists have assumed that roasting would produce a high ratio of burned to unburned shells (Moore 1892-1893:920; Cipriani 1966:74;

Coutts 1970a:59). However, numerous ethnographic descriptions stress the short period of time in or near a fire needed to kill the animal, resulting in few cracked or burned shells (Gifford 1939:327; Coutts 1970a:59; Goodale 1971:170; Bailey 1977:137). Moisture escaping from the heated shellfish, and any water poured over them to create steam would also prevent shell scorching (Avery 1974:110). In situations where dead shells were heated to high temperatures preparatory to their use in steam ovens (such as by the Anbara and Tiwi, cited above), or were exposed to heat from long-burning campfires (Bailey 1977:137), they may have suffered heat-induced fracture or become calcined and brittle. Such effects as these also occur on live shells cooked at high temperatures (Palmer and Williams 1977).

For the archaeologist, a careful examination of cooking pits and other midden features will probably prove to be the most successful approach to this problem. Large roasting pits have been identified at many shell midden sites (e.g., Webb and DeJarnette 1948:21; Terrell 1967:44). At sites in Denmark and New Brunswick, substantial amounts of charred eelgrass (Zostera marina) have been discovered, presumably evidence that the shellfish had been steamed in the succulent plants (Baird 1881:292; Rau 1884:222fn).

Experiments with terrestrial gastropods have shown that boiling has no visible effect on the shells (Hester and Hill 1975; Lubell 1976:917). Of course, when gastropods were consistently crushed or had some particular area broken away by blows from a hammerstone, their archaeological remains are unequivocal evidence for the method employed (Gifford 1916:8, 1939:327; Hoffman 1967:112-113; Linares de Sapir 1971:41; Marrinan 1975). On the other hand, when large numbers of shells of a given gastropod or pelecypod species are found intact (keeping in mind the propensity for thick shells to better withstand post-depositional destructive forces than thin shells), we can confidently infer that some cooking method was used to open the shells which left most of them undamaged.

Storage Methods and Trade

Once the meat was extracted and the shells discarded, additional steps were sometimes taken to preserve the meat from spoilage (Table 3). The Pomo dried mussels in the sun and several peoples (the Powhatan, North Carolina Algonquians, Acolapissas and Pascagoulas) smoked oysters and clams on small grills made of cane. Unfortunately, most references only indicate that shellfish were dried without specifying the process. Dried molluscs either were stored in jars and baskets placed in dry locations or were strung on cords for hanging. Before they were consumed, the dehydrated shellfish were parched or soaked in water for an hour (Gifford 1939:327; Swanton 1946:378).

Smoked and sun dried shellfish were of varying importance to cultures with differential access to coastal resources. People who lived near the sea in temperate zones kept dried shellfish for their own use, so they might be available at any season (Wright and Freund 1953:128; Higham 1976:223). Although the Pomo and Yuki spent half of the year on the California coast, they carried dried mussels on their journeys inland (Gifford 1939:224; Stewart 1943:60). Another pattern was for individuals or small gathering parties to periodically visit coastal portions of larger hunting and gathering territories. The earliest English settlers in North America soon learned the merits of

Table 3. Ethnohistoric (dated) and Ethnographic Observations of Dried Shellfish Preparation and Trade.

Culture	Method	Source
North America		
Wampanoag (1621)	Dried shellfish; basketloads traded to the English.	Heath 1963:65
Munsees (1748)	Dried oysters traded inland.	Kalm 1966:127
Powhatan (1607)	Dried oysters stored in baskets and traded to the English.	Arber 1910:22
Powhatan (1612)	Oysters smoked on cane grills, hung on strings for storage.	Wright & Freund 1953:128
North Carolina Algonquians (1709)	Oysters and clams smoked on cane grills.	Lefler 1967:218
Caicos Islanders	Dried conchs traded to Haiti.	Aschman 1975:46
Acolapissas and Pascagoulas (1753)	Oysters boiled in kettle, then smoked on cane grill, stored in jars or sacks hung in houses.	Swanton 1946:377-378
Chinese in Baja California (late 19th, early 20th centuries)	Dried abalones traded commercially.	Aschman 1975:46
Yuki	Dried chitons	Gifford 1939:327
Pomo (early 19th century)	Mussels dried in the sun, strung on grass fibers, carried to homes in interior valleys.	Stewart 1943:60

Table 3. (cont.)

Culture	Method	Source
South America		
Chiloe, Chile	Dried mussels.	Aschman 1975:46
Oceania		
Maori (late 18th century)	Shellfish threaded on rushes and hung in communal storehouses.	Higham 1976:223
Maori	Mussels and pipis dried and threaded.	Hamilton 1908:11; Best 1924 (II):417
Asia		
Korea and China	*Mactra* sp. dried in spring and summer.	Okladnikov 1965:111

this behavior in certain exigencies.

> ... I must bee enforced for lacke of sustenance, there to disband my company into sundry places to live upon shell fishe, for so the Savages themselves doe, going to Ottorasko, Crotoan, and other places fishing and hunting, while their grownds be in sowing, and their corn growing... (Quinn and Quinn 1973:39; also see Wharton 1957:7).

Because European colonists quickly appropriated coastal lands for their own use, native peoples who once had free access to fish and molluscan resources were forced to readjust their seasonal round to maintain that aspect of their diet. The first oyster licensing law in Virginia, passed in 1622, states that

> ... for the better relief of the poor Indians whom the seating of the English had forced from their wonted convenience of oystering, fishing... that the said Indians upon address made to two of the justices of that county they desire to oyster... they, the said justices, shall grant a license to the said Indians to oyster... (Wharton 1957:30-31).

Indians in New York and New Jersey continued to make such journeys to the Atlantic coast through the eighteenth and early nineteenth centuries, drying oysters and clams for winter consumption as well as for trade to other Indians further inland (Rau 1872:373; Kalm 1966:126-127). Trade in dried shellfish was apparently important even before the native cultures were disrupted by European contact. Two of the earliest exchanges between English colonists at Plymouth and Jamestown and the local inhabitants involved dried shellfish (Arber 1910:xlii; Heath 1963:65).

Archaeologists occasionally find evidence of either regular trade or periodic population movements between coast and adjacent interior regions. Frequent discoveries of marine shell fragments at sites up to 80 kilometers inland in South Carolina (Stoltman 1974:138), northern Yucatan (Andrews 1969:57), the Peruvian Andes (Engel 1973: 272), and South Africa (Deacon 1970:48; Avery 1974:108) imply some means of transmission, whether trade or human population movements. Clearly, any archaeologist working in a coastal area must establish the variety of settlement types occupied during any given period of time, including upcountry as well as littoral sites. While coastal sites of transient bands may appear similar to sites occupied by sedentary peoples who seasonally gathered shellfish (Poiner 1976:196; Voorhies 1976:11), differences in their overall subsistence strategies should be readily apparent when their entire settlement systems are contrasted.

If a basic presupposition of archaeology is, as Shawcross (1972: 590) insists, that the quantity of food remains at prehistoric sites is directly related to the amount of food consumed, then storage and trade raise serious obstacles to the correct interpretation of those remains. There can be no doubt that shellfish were preserved by smoking and drying in many areas of the world. For archaeologists, the implication is that molluscs which were gathered, shucked and dried at one spot could have been consumed months later, possibly many miles away. The shells found at a site necessarily indicate only the amount of food processed there; determining whether the meat was eaten immediately or preserved depends upon a thorough understanding of the subsistence and settlement strategies of the culture.

Seasonality and Scheduling

Early European travelers to distant lands occasionally came upon people who seemed to depend heavily for their subsistence on shellfish gathering. Consider these remarkably similar statements written in three different parts of the world.

> Peter Kalm, New York, 31 October 1748: The Indians who inhabited the coast before the arrival of the Europeans made oysters and other shell fish their chief food... (Kalm 1966:126).
>
> Captain James Cook, Botany Bay, Australia, 6 May 1770: On the Sand and Mud banks are Oysters, Muscles, Cockles &c[a] which I believe are the chief support of the Inhabitants... (Beaglehole 1955:312).
>
> Charles Darwin, Tierra del Fuego, 25 December 1832: The inhabitants living chiefly upon shell-fish, are obliged constantly to change their place of residence... (Darwin 1972:182).

These initial conjectures were based on limited observations of native cultures during brief visits. Kalm, Cook and Darwin were also influenced to some extent by the sheer immensity of the shell heaps upon which the native Americans and Australians camped. It is now clear that no modern society has relied primarily on molluscan resources for subsistence (Murdock 1967:170-233). Of the three observers just quoted, Darwin came closest to the truth; the Yahgan and Ona gathered mussels year round, and depended upon them in certain seasons for a large portion of their diet (Gusinde 1937:360; Stuart 1977:263-266). But even in such extreme cases, additional foods were obtained by gathering, hunting and fishing. In other ethnohistorically and ethnographically known cultures (Table 4), shellfish were seasonally important dietary <u>supplements</u>, not staples (for reasons discussed at length in Chapter V).

A number of writers have maintained that shellfish were primarily a starvation food. Sieur de Champlain said of the Canadian Algonquins:

Table 4. Ethnohistoric (dated) and Ethnographic Observations of Seasonal Marine Shellfish Gathering.

Culture	Season: Spring	Summer	Fall	Winter	Comments	Source
North America						
Quebec Algonquins (1613)				—		Champlain 1613:192
Munsees (17th century)	—					Ceci 1977:68
Maryland Algonquians (1705-1706)				—		Anonymous 1907:334
Powhatan (1607-1615)	—	—		—	Mainly in late spring, early summer.	Arber 1910:68, 363; Hamor 1957:43; Quinn 1967:8-9; Wharton 1957:10; Wright & Freund 1953:80
Karankawa (c. 1529)			—			Cabeza de Vaca 1961:62
Aleuts (1760-1764)				—		Jochelson 1933:11
Tlingit	—		—	—	Most in March.	Oberg 1973:67
Nootka				—	Some throughout the year.	Drucker 1951:37-39
Yuki	—	—				Gifford 1949:224
Chumash (1770, 1776)	—			—		Tartaglia 1976:59
South America						
Ona	—	—		—	Some in the fall, too.	Stuart 1977:263-266

Table 4. (cont.)

Culture	Season: Spring	Summer	Fall	Winter	Comments	Source
Oceania						
Anbara	—	—	—	—	Most in January.	Meehan 1977b:523
Australian Aborigines (Botany Bay, 1770)			—	—		Beaglehole 1955 (I): 309, 312, 325
Tasmanians (1773, 1777)		—	—			Beaglehole 1961:150, 733; 1967 (III):54
Africa						
San (17th century)	—			—		Parkington 1972: 241-242
San (19th century)		—				Deacon 1970:48
Southern Nguni		—			Several days each month.	Bigalke 1973:160

> These people suffer so much that sometimes they are compelled to live on certain shellfish and eat their dogs and the skins with which they cover themselves against the cold (Champlain 1613:192; also see Jochelson 1933, for a similar reference to the Aleut).

Others have reported that shellfish gathering was principally resorted to either when the day's hunt was unsuccessful (Bennett 1955:374; Cipriani 1955:250-251; Goodale 1971:168), or during seasonal food shortages when herd animals had dispersed or migrated, few nuts and seeds were ripe, or field crops had not yet matured (Arber 1910:363; Parkington 1976:131).

These three alternative exploitative strategies have radically different adaptive and archaeological implications. If shellfish were gathered only during times of direst famine, then large shell midden accumulations indicative of repeated brushes with starvation would not be expected since such a precarious and maladaptive subsistence base could not successfully maintain a population for long. Occasional starvation-induced dependence on molluscan resources, separated by years or even decades of abstinence, must undoubtedly produce anomalous features in the archaeological record easily distinguished from those produced by regularly recurring seasonal exploitation.

If seasonal emphasis on shellfish gathering was the favored strategy, what were the environmental or cultural determinants of seasonal exploitation? One important environmental factor was seasonal change in molluscan physiology. For instance, most shellfish species have higher meat weight to shell weight ratios just prior to and following spawning. In addition, spawning shellfish are often said to be less palatable than at other times of the year. Such seasonal alterations as these may partially explain the folk adage which warns against eating oysters in the summer:

> The Oyster is an headless fish, yet passing toothsome,... It is unseasonable and unwholesome in all monethes, that have not the letter R. in their name, because it is then venerious (Buttes 1599).

English visitors to the North American colonies noted that Indians and lower class colonists living on the coast seemed blithely unaware of this prohibition (Anonymous 1907:338; Kalm 1966:126), the original intent of which was probably to alert people to the danger of eating raw shellfish which were liable to spoil when transported inland during warm weather (Waring and Larson 1977:267).

In some areas of the world's oceans, there can be a genuine risk involved in eating shellfish during summer months, due to "red tide" planktonic blooms of toxic dinoflagellates, particularly <u>Gonyaulax catenella</u> (Drucker 1951:39; Bullen and Sleight 1959:29; Parkington 1972:232, 1976:127). The Pomo kept watch on hot summer nights for the bioluminescent blooms and, upon sighting them, called a halt to shell-fishing for several days (Kroeber and Barrett 1960:111). Filter-feeding molluscs ingest the temporarily abundant plankton and concentrate the toxins in certain body tissues, which may remain poisonous to humans for four to five months. However, certain species, such as scallops, quickly inactivate the toxins in their adductor muscles, so that part of the animal can be ingested without danger of paralytic poisoning (Shimizu and Yoshioka 1981). In spite of the potential danger, dinoflagellate blooms occur relatively rarely, and by taking the proper precautions, coastal peoples were seldom deterred from exploiting marine molluscan resources.

Many molluscs can move about their littoral habitat by adjusting their depth in mud or shifting from one substrate to another. Such activity can occur in response to changes in water salinity, water temperature, tidal variation and the approach of a predator. Cooler winter water temperatures in temperate zones commonly cause mobile species to descend to deeper waters or burrow further into soft substrates. Neither this change in accessibility nor frigid water temperatures appear to have seriously impeded winter and spring exploitation (Table 4), although they probably affected species selection.

Since shellfish are available throughout the year in most locales, seasonal emphases in exploitation must result from seasonal changes in peoples' perceptions and expectations of the environment. In other words, decisions regarding the scheduling of shellfish gathering depend not merely on shellfish availability but rather on a continuous reassessment of all potential food resources, constant reappraisal of their present and future relative food values and ease of procurement, and changing estimates of group needs.

One simple example of scheduling, though not necessarily of a seasonal nature, is the general tendency for shellfish gathering to take precedence over other subsistence activities during low ebb tides (Drucker 1951:37; Bigalke 1973:160; Voigt 1975:97; Meehan 1977a:366). As Darwin observed of the Fuegians, "whenever it is low water, winter or summer, night or day, they must rise to pick shell-fish from the rocks..." (1972:184). Once a decision to gather shellfish was made, the task was most efficiently carried out at low tide. But what other factors are considered before reaching a scheduling decision such as this one?

Data on the Anbara of northern Arnhem Land, reported by Betty Meehan (1975, 1977a, 1977b), are the most comprehensive for any group of shellfish gatherers and examplify some principal scheduling considerations. Meehan lived with the Anbara for nearly one year, during which time shellfish gathering was the most frequent foraging activity, occurring on 58% of the days. Shellfish were never more than a supplement to the diet, contributing 6% to 17% of total Anbara caloric intake. While average protein intake (from all sources) per person per day remained nearly constant throughout the year, caloric intake varied markedly from 1,620 kcal during the monsoon season to 2,500 kcal in the Early Dry Season. The single most instructive correlation in the Anbara data is the inverse relationship between average protein intake (.14 kg to .19 kg/person/day) and average molluscan protein contribution (26.2% to 8.2% of total protein intake/person/day). Daily protein intake was held at a fairly steady rate by intensifying shellfish exploitation when protein from other sources is unavailable. Meehan's data also show that the average caloric contribution from shellfish varies independently of average total caloric intake, suggesting that caloric stress was not the main concern in shellfish scheduling decisions among the Anbara.

The following year Meehan was told by the Anbara that unusually heavy rains had lowered estuarine water salinity and killed most of the shellfish. They adapted to their altered environment by catching more fish than they had the previous year (Meehan 1977a:369).

Archaeologists should anticipate that long term, as well as seasonal, fluctuations are responsible for variation in the archaeological record.

Many variables influence scheduling decisions, particularly the relative protein/carbohydrate/fat content, edible proportion, kcal/weight, spatial distribution, mobility, size, and requisite preparation time of each potential resource. There is little ethnohistoric or ethnographic information on their effects on shellfish scheduling, so they are discussed in the following chapter on zooarchaeological interpretations of shell middens. To recapitulate this section, most modern shellfish gatherers have relegated that activity to particular seasons of their yearly subsistence cycles. In the few cases where molluscs were exploited all year long, they were seasonally more important in the diet and different species varied in relative importance according to scheduling considerations.

Spatial Considerations of Shellfish Gathering

Molluscs, from the viewpoint of a human predator, are small packages of meat sealed in heavy inedible shells. In terms of energy efficiency, this fact sets definite limits on the distance live molluscs can be transported with simple technologies, beyond which, energy expended in transport will exceed that gained from the food. So it is no surprise to discover that modern traditional shellfish gatherers choose to locate their camps near collecting spots or process shellfish at the shore and carry only the meat back to camp (Cipriani 1955:250-251; Bigalke 1973; Meehan 1977a). Southern Nguni women of the Transkei travel 3 to 5 km to shellbeds and return carrying the live shellfish in baskets or cans balanced on their heads. Those individuals living 8 to 10 km from the sea use donkeys to carry the load (Bigalke 1973:161). The Australian Anbara shift their base camp in the course of a year. When it is located about 1 km from shellbeds, molluscs are commonly brought back to the base camp, shell and all. At other times of the year, the base camp is 3 to 3.5 km from shellbeds so shellfish are normally first prepared at "dinner-time camps" and "processing sites" and the shells are discarded at those places (Meehan 1977a:364; Gould 1980:223).

Thus, transitory shellfish preparation sites, and to a lesser extent, base camps of shellfish gatherers, are predicted to be located near the collection point. The specific location may be chosen for any number of reasons. A compact resource, such as an oyster reef or a large mussel bed at a shoal, or a limited number of access points from shore may circumscribe the choice of suitable nearby campsite locations (Figure 5A, C). On the other hand, a dispersed resource (such as an extensive rocky shoreline with limpets and patellas) or a centrally located compact resource can be profitably exploited from numerous points (Figure 5B, D). In the first case, the few preferred camp sites are liable to be frequently reoccupied as long as shellfish are gathered. As for the latter, campsite selection is arbitrary, in relation to the molluscan resource, so sites will seldom be reoccupied, other factors remaining constant.

In some areas of the world, shell mounds have developed when the site inhabitants confined midden accumulations to a restricted compass for some perceived benefit derived from an elevated living space. At sites located in floodplains or mangrove forests and occupied during

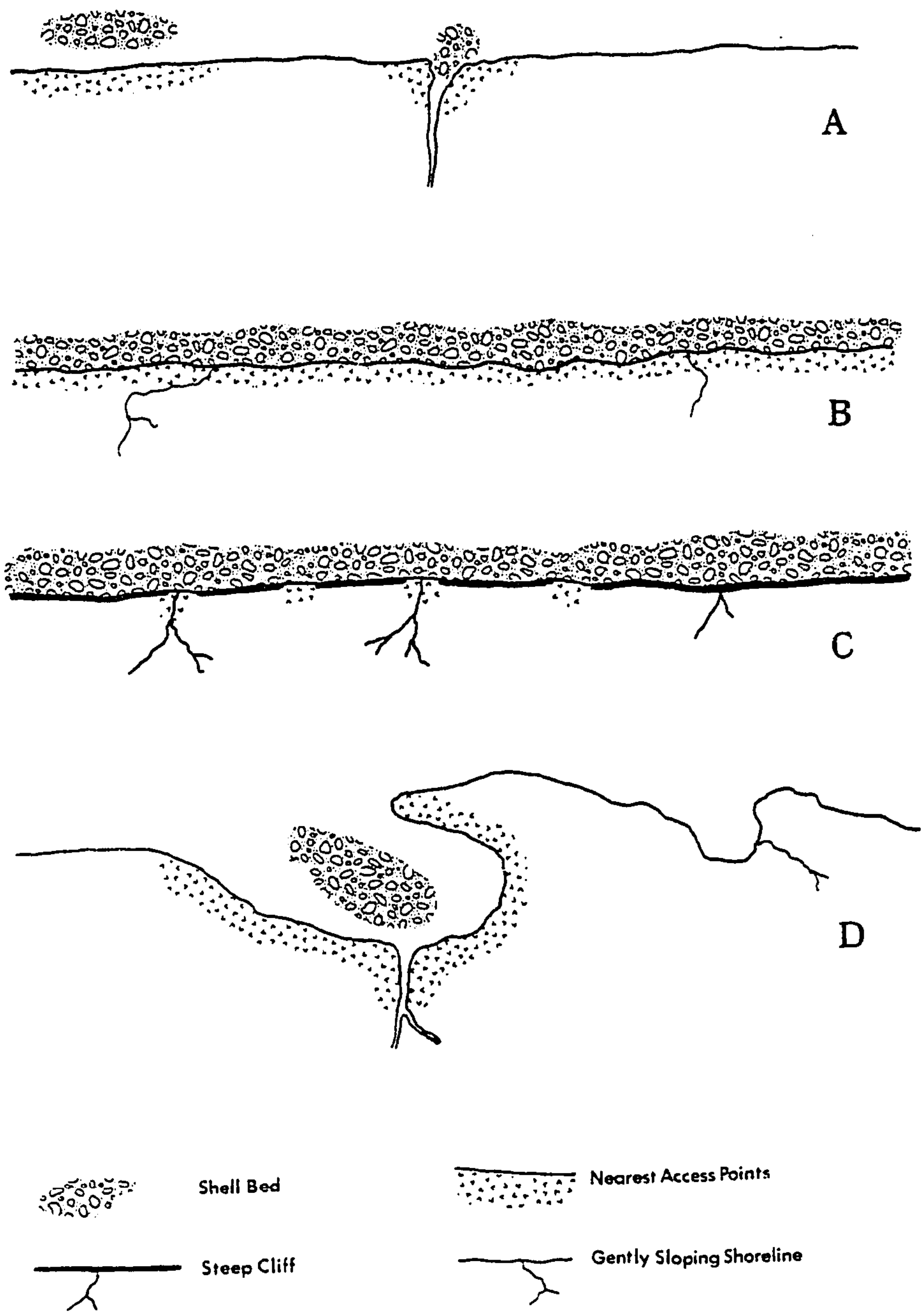


Figure 5. Environmental Constraints on Shellfish Preparation Sites: A) a linearly distributed compact resource, B) a linearly distributed dispersed resource, C) a shoreline with a limited number of resource access points, D) a centrally located compact resource.

rainy seasons, the incentive was evidently to secure well-drained habitation areas. Naturally occurring high spots would first attract settlement (abandoned and decayed termite mounds are utilized in Arnhem Land; Peterson 1973, 1976:272). A consequence of occupation would be the deposition of shells and other debris resulting in a slight, barely perceptible increase in site elevation, thereby initiating a positive feedback process of repeated occupations and incremental growth of the mound.

Tall mounds, up to 20 m in height and usually in the form of truncated cones, can result from environmental constraints on habitable terrain. Lower, longer mounds develop in somewhat less confining situations, such as along river levees and shoreline bluffs near linearly distributed molluscan resources. Elevation above the surrounding land surface may be a factor in midden location, but the primary determinant is access to water, and hence to aquatic resources. For this reason, low, elongated shell mounds are almost invariably oriented parallel to contiguous riverbanks and shorelines. Their inhabitants returned again and again to the same general area until in time the debris from these innumerable visits completely covered the ground, creating an apparently continuous, undulating midden actually consisting of many small, individual overlapping shell heaps (Nelson 1909:325; Byers and Johnson 1939:192, 1940:83; Brennan 1962:11; Shenkel 1971:100; Winters 1974:xix; Bailey 1977:139; Marquardt and Watson 1977:8; Stein 1980:iii).

These small, discrete shell heaps are equivalent to the piles of discarded shells deposited adjacent to living areas, described by several writers (Beaglehole 1962 (I):427; Linares de Sapir 1971:45; Peterson 1973:187; also see Boissevain 1943:8). Later occupants might then fix their living area on an old refuse heap and deposit their refuse over a former living area (Darwin 1972:182-183; Cipriani 1966: 68). After several years' captivity among the Karankawa in the early sixteenth century, Cabeza de Vaca related that those people had "cabins of mats and erect them on heaps of oyster shells, upon which they sleep naked" (Rau 1884:216).

In such "accretion middens," the sequence of deposition is extremely complex and notoriously difficult to decipher. Demonstrating the contemporaneity of horizontally adjacent but distinct deposits is usually a moot question (Brennan 1968:20; Coutts 1970a:47; Avery 1974: 105; but see Dillon and Clark 1980 for a potential solution to this problem). Not all middens are so disordered, however. Shell rings are known only from archaeological contexts, but test excavations suggest that they are accretion middens in which the deposits were deliberately arranged in the form of rings 70 to 80 m in diameter. Habitations, shellfish preparation areas and shell disposal heaps were limited to the ring, but storage pits have been found in the cleared interiors (Reichel-Dolmatoff 1972:2; Trinkley 1975:32-33, 1980; Waring and Larson 1977:273). This unusual type of site has not been adequately studied, nor has the function of the ring-plan been explained.

Archaeologists frequently bemoan the paucity of detectable structural remains in shell middens (e.g., Haag 1942:212; Bullen and Sleight 1960:40; Davis 1972:18), when the evidence they seek is often in the nature of the midden itself. Both the Yahgan of Tierra del

Fuego and the Tasmanians are known to have built simple shelters in concave depressions on the surface of shell middens. These depressions were reoccupied during successive visits, sometimes for many years. Fires for cooking and warmth were tended inside the huts and the refuse, primarily the quickly accumulating shells, was tossed outside the huts (Gusinde 1937:360-361, 599; Jones 1971:278). In this manner the depressions were maintained and served as partial shelter from the wind. This sort of hut depression has been recognized by archaeologists at a number of sites (Holmes 1907:120-122, 1912:542; Lothrop 1928:179; Jones 1971:278; Bonnichsen and Sanger 1977:112). In cases where the sites had not yet been leveled by plowing, surface depressions measured 3 to 9 m in diameter and one meter deep, and contained an inordinate amount of charcoal and humus in comparison with intervening midden consisting mainly of shells.

In other regions, more substantial structures were erected in round or square pits dug into the midden, with walls built of sod or upright wooden posts. Such subterranean house foundations have been discovered in Japan, the Soviet Far East, and on the northwestern coast of North America (Groot and Sinoto 1952:10-11; Okladnikov 1965:87; Dall 1877:46; Rau 1884:251; Hester and Conover 1970:138; also see Moore 1899). Besides the usual inter-house accretion midden, extensive refuse dumps are occasionally located along the shore-side of sites (Hester and Conover 1970; Bonnichsen and Sanger 1977). Since hut depressions and subterranean house foundations are found only in regions of temperate climate, they may have been occupied principally during cold seasons.

Finally, although not as common as accretion middens, "blanket middens" are distinguished by their homogeneity, with internally undifferentiated strata covering extensive areas of a site (Uhle 1907:14; Craig and Psuty 1971:130; Knapp 1973:115; Bailey 1975a:50; Voorhies 1976:41). Ethnohistoric and ethnographic sources do not explicitly describe the formation of blanket middens, but historically documented instances of large quantities of molluscs being dried for trade might indicate a process which produced this sort of feature. Blanket middens appear to be the result of a single activity, the disposal of vast amounts of shells either at dumps near permanently occupied villages or at sites devoted exclusively to shellfish procurement for trade.

Chapter III

ARCHAEOLOGICAL DISSECTION AND INTERPRETATION OF SHELL MIDDEN ANATOMY

Introduction

From the preceding review of ethnohistoric and ethnographic references to shellfish gathering, a number of general principles have been inferred concerning human molluscan exploitation as adaptive behavior. In order to expand upon these principles and test derived hypotheses, we must now focus attention on the archaeological evidence.

The gradual realization that the deceptive visual similarity of shell middens obscures a considerable diversity in shellfish gathering strategies has led to a reexamination of midden formation processes and their archaeological signatures, although progress toward this goal has been excruciatingly slow. Fifteen years ago, Ambrose (1967) pointed out that the implicit assumption underlying the California School's quantitative approach to shell midden analysis (i.e., site structural homogeneity) was indefensible. He warned that refuse deposits "... are likely to be extremely complex in both a structural and compositional sense. They cannot be presumed to be homogeneous..." (Ambrose 1967: 177; also see Meighan 1969:416; Coutts 1971b:155; Shenkel 1971:3). Archaeologists have still to develop a unified approach to this problem, but the major sources of shell midden internal differentiation can now be identified as variations in 1) midden formation processes, 2) intra-site activity areas, and 3) taphonomic aspects of midden decomposition.

Midden Formation Processes

The single most important effect of large-scale molluscan consumption and shell disposal is the rapid rate of midden accumulation which consequently results. One outspoken theorist has described the archaeological record, in general, as follows:

> Rates of deposition are much slower than the rapid sequencing of events which characterizes the daily lives of living peoples; even under the best of circumstances, the archaeological record represents a massive palimpsest of derivatives from many separate episodes (Binford 1981:197).

While this statement accurately assesses the nature of many archaeological features, accretional shell middens are specifically comprised of individual disposal heaps. Furthermore, within each heap there is often internally consistent artifactual and biological evidence that the debris derives from a single meal or similarly short-term occupational event. One might argue that numerous "separate episodes" of individual shellfish consumption are represented, but there is an undeniable difference in scale between a single shell heap which has accumulated in no more than a few days and the palimpsest of activities normally represented in archaeological features. This fact has two implications of great significance to the archaeologist.

First, the rapid accumulation of shells, which are relatively impervious to weathering and other destructive forces, means that small sites which might frequently be overlooked by archaeologists are more easily detectable because of an increased number and volume of preserved remains (Bowdler 1976:249; Yellen 1977a:78). Such sites are particularly unusual since most of the smallest sites discovered by archaeologists are hunting camps, kill sites, or single house farmsteads, while small sites of short-term gathering and collecting activities, aside from shell middens, have extremely low archaeological visibility.

A second implication of rapid midden accumulation is the resultant bulk of the deposits, which tends to maintain a vertical separation of stratigraphic units. The thickness of these units is much exaggerated in comparison to non-shell middens with strata representing consolidated debris amassed over a long period of time (Hughes and Lampert 1977:136; Sanger 1981:41). In some cases, this physical separation may enhance stratigraphic integrity by lessening the mixing of cultural material which normally occurs by natural and cultural processes.

Of course, anyone attempting to estimate rates of shell midden deposition must contend with the frequently wide horizontal dispersal of refuse dumps. Because shell heaps can be of considerable bulk, the surface of an occupied accretional shell midden can be quite uneven. Thus, the midden deposited on that uneven surface by the next inhabitants will probably vary considerably in vertical as well as horizontal extent, since preexisting depressions will tend to become filled. This characteristic of accretion middens is at least partly responsible for the difficulties archaeologists experience in attempting to excavate occupation layers identifiable in shell middens (Brennan 1977; Marquardt and Watson 1977:8; Gould 1980:220; Sanger 1981:41).

Reoccupation, or successional use, of particular sites is a critical factor in the formation of many large shell middens. If there was no feature of the prehistoric landscape to focus settlement, then no great midden depth was likely to develop. If, however, shellbeds were accessible from only a few sites, or if the initial deposit of midden itself made a site more suitable for occupation than the surrounding terrain, then reoccupation of that site might continue for many generations. For example, along portions of the South African coast, deep shell middens are clustered near rocky outcrops where shellfish are exposed daily by the tides, whereas thin middens, or continuous scatters of shells line sandy beaches (Parkington 1976:132). At the Carlston Annis shell midden on the Green River in Kentucky, contour mapping of the pre-occupational land surface by means of auger testing failed to reveal any topographic feature which would have originally prompted this settlement choice (Stein 1980:iii). Perhaps a nearby mussel shoal existed at the time of occupation; or the floodplain location of the site could have emphasized any elevational advantage conferred by reoccupying a slightly higher, drier, abandoned midden. In Chapter V, the possibility that old shells were a preferred matrix for mollusc roasting pits, and thus their presence influenced subsequent site selection decisions, is explored.

Shell middens from several areas of the world reportedly have very little stratification, either due to bioturbation (e.g., earthworms at the Carlston Annis site; Stein 1980), or because apparently little but shell was being deposited at sites interpreted as commercial shellfish preparation and exporting centers (Shenkel 1971:137-138). This last type of midden formation process is poorly understood, but it probably is most significant at sites which supplied state-level societies with dried molluscs.

Intra-Site Activity Areas

This brief discussion of shell midden formation processes has so far emphasized shell refuse dumping, but of course other activities occurred at any mollusc collecting and preparation camp. In fact these other activities may have consumed more time, provided more food, or been of considerably greater social importance than shellfish gathering, though they contributed only a fraction of the archaeological residues. Detailed analysis will generally lead to the identification of variable midden types and features which reflect the broader range of activities which occurred at a site (Glassow 1967:357; Yellen 1977a:81). Since so many shell midden features result from quite short-term accumulations of debris and brief site occupations, the artifact assemblages from different features are liable to be quite varied, simply because a narrower range of specific activities are likely to have occurred in a brief period, than during the longer expanses of time represented in middens at other sorts of sites (Binford 1978:483; Gould 1980:197). The effect, in general village middens, is to consolidate the by-products of numerous tasks and produce a composite view of activities performed in the village. In some shell middens, the rapid accumulation of shells serves to physically separate debris derived from different activities. Willey and McGimsey have developed a "Contentration Index," based on the number of items per unit volume of features or strata to quantify these differences in rates of deposition (1954:43-48; Gifford 1949).

It is postulated that a greater proportion of the total tool assemblage will be employed and consequently lost or discarded, at habitation base camps or permanently occupied villages than at briefly occupied, special purpose camps. This generalization has been applied to shell midden components in attempts to distinguish temporary occupations (Rau 1884:250; Goldthwait 1935:8; Long and Wire 1966:43; Terrel 1967:63-64; Hester and Conover 1970:138; Coutts 1971a:196; Shenkel 1971:138; Campbell 1972:286; Voorhies 1976:12) from multi-functional habitation sites (Baird 1881:292; Haag 1942:212; Stark 1974:377-378; Dillehay 1975:84-85). A predictable corollary of this functional division of sites is the absence of evidence of permanent structures at temporarily occupied sites, while semi-subterranean house depressions are frequently present in (Rau 1884:251; Nelson 1909:345; Lothrop 1928:183-184; and perhaps Holmes 1907:120-122) or contiguous with other types of shell midden (Snow 1972:216; Bonnichsen and Sanger 1977:112; Sanger 1981:38).

Even in situations where permanent structures did not exist, habitation areas can often be identified by the comminuted nature of the shells found in particular sections of a site. Numerous archaeologists have remarked on the frequent occurrence of primary refuse heaps, consisting largely of unbroken shells, adjacent to thin lenses of triturated shell gravel which is almost invariably attributed to the trampling of pedestrian traffic (Moore 1892-1893:914-915; Loomis and Young 1912:19-20; Gifford 1916:11; Boissevain 1943:8; Hadlock 1943:342; Treganza and Cook 1948:297; Maggs and Speed 1967:86; Coutts 1970a:41; Dillehay 1975:85-86; Voorhies 1976:41; Klein 1980:234). This seems to be a reasonable inference. However, the physical nature of the shell debris depends not only on the intensity of occupation (i.e., the size of the group and duration of their stay), but also on differences in shell fragility between species, the possible intentional breakage of shells during meat extraction, and numerous post-depositional factors. The presence of fires on the midden surface may also contribute to the broken condition of underlying shells (Gusinde 1937: 347; Palmer and Williams 1977:25).

Shell middens would seem to have a great unexplored potential for other sorts of activity analyses. For instance, dense concentrations of fish bones, primarily those from the branchial region of the skeleton, have been interpreted as indicators of fish gutting and cleaning areas in a Scottish shell midden (Mellars 1978:386-388). In a Tennessee shell midden, clusters of tools customarily ascribed to men's tasks were found to be consistently distributed differently than "women's tools," which at least suggests the existence of distinguishable activity areas or refuse disposal patterns (Morse 1967:304).

Post-depositional Changes in Midden Content and Structure

The matrix of a shell midden is subject to several disruptive processes between the time it is formed until it is finally destroyed by excavation. These processes may work gradually or catastrophically, affecting an entire midden or limited to certain constituents. Although this aspect of shell midden analysis generally receives little consideration, the vagaries of midden decomposition directly determine the nature of archaeological data.

As anyone who has composted leaves for a garden knows, organic refuse decays and compresses in a relatively short time, losing most of its original mass and volume. In the majority of archaeological contexts, the only organic remains to resist this decay process are shell, bones (and other calcified vertebrate hard parts such as teeth and scales), and charred plant remains. If the refuse consists primarily of shells, as it evidently did at many shell middens, then the decay-resistant shells consolidate only slightly as other organic material is decomposed, essentially maintaining the form and volume of the original refuse heap. This continuity in microstructure is frequently apparent in the uniform shell orientations visible in many middens. Shell "attitudes" or "angles or repose" usually coincide within a heap, with shells lying parallel to the surface of the pile, suggesting that they had been tossed there individually. Where shells have been dumped en masse into a pit or onto a secondary refuse heap, they form a characteristically irregular deposit (Bishop 1913:76-77; Goldthwait 1935:5; William Marquardt, personal communication, 1978).

This same poorly consolidated midden matrix may contain many open spaces, interstices between shells, through which small objects can fall, eventually settling at some level far beneath their points of origin and possibly in specious cultural contexts. The extent of this downward migration can be highly variable, even within a single midden (Webb and DeJarnette 1942:101-102; Cahen and Moeyersons 1977:814; Sanger 1981:41). The problem can be particularly irksome because debitage, small faunal remains, plant remains and other small objects are seldom attributable to a particular cultural occupation except on the basis of physical association with artifacts of known date. Some idea of the extent of the problem can at least be estimated by the filtration of potsherds and other reliable temporal and cultural indicators.

In habitation areas, as opposed to refuse disposal areas, "treadage and scuffage" by site occupants can depress small objects (up to about 3 cm in diameter), introducing them into older deposits, and uncover large objects, subjecting them anew to weathering and other destructive processes (Stockton 1973:116). This size-dependent sorting is relatively well documented and has several predictable consequences. Small objects will have greater chances for burial, and hence preservation, although they may be incorporated into the upper level of an older zone. Large objects, if they survive repeated exposure on the ground surface, are likely to be found in more recent contexts than they belong (Gifford and Behrensmeyer 1977:245-259; Hughes and Lampert 1977:135; Gifford 1980:102). On the other hand, rapid deposition of material in shell refuse heaps of large volume may protect many objects from transport by scuffage and treadage, while also limiting exposure of and damage to bones from weathering and carnivore gnawing (Toots 1965).

Site abandonment and reoccupation can seriously disrupt the stratigraphic integrity of previously deposited strata. If the surfaces of old refuse heaps become habitation areas (Brennan 1968:20; Will 1976: 78), later artifacts will almost certainly be introduced into the refuse heaps by the processes just discussed. This problem is especially vexing, since refuse heaps often contain few culturally diagnostic artifacts, since they normally result from rapid accumulations of debris from a single task: shellfish collection and preparation. Later site occupants may also dig into older strata to make storage pits, semi-subterranean structures, roasting pits and other features. Tall shell heaps may be intentionally levelled off or they may slump of their own accord (Gilmore 1974:24; Davidson 1976). In some areas of the world, domiciliary or temple mounds were constructed using old shell middens from earlier occupations (Moore 1892-1893:915; Nelson 1909:325-326; Fairbridge 1976:358; Sanger 1981:40). All such activities seem to have been motivated by a desire to create interpretive difficulties for archaeologists.

Even though molluscan shell is a remarkably resistant material, shells can be destroyed by mechanical and chemical means. Aside from intentional shell breakage incurred during meat extraction, mechanical damage can occur accidentally by human trampling, as mentioned above, and during archaeological excavation unless precautions are taken. Shells tend to fracture along naturally occurring lines of structural weakness peculiar to each species, either shattering through the shell or exfoliating along lamellar growth planes. Abrasion can also damage shells by obliterating surface features (Gifford 1916:7; Coutts 1969b: 136; Driscoll 1970:898; Hill 1979:743; Hall 1980:280; Gifford 1981: 371-374).

Chemical alteration can take the form of either acid deterioration or calcination. Shell weight loss is a well documented effect of acid leaching in shell middens (e.g., Shenkel 1971:146; Bunyan 1976; Tartaglia 1976:167). This leaching acts principally on shell surfaces, but it can dissolve a considerable amount of calcium carbonate before affecting a shell's external appearance (Stuiver and Borns 1975:102). In regions of the world with heavy rainfalls, the lowest levels of shell middens commonly contain badly deteriorated shells, or none whatsoever -- the shells having completely decomposed with time (Linares de Sapir 1971:34-35; Warren 1975:219; Hughes and Lampert

1977:136; see Coutts 1969a:82-84, 1972b, for somewhat similar results produced by wind erosion). The apparent causes of this leaching are carbonic acids from plant roots and humic acids from decaying organic materials deposited during site occupation and from surface duff. Although shell middens are renowned for their enhanced bone preservation, the calcium-rich environment still allows transport in solution of exchangeable calcium from bone and shell (Sawbridge and Bell 1972: 848; Noe-Nygaard 1977:232; for examples of bone destruction see Bullen et al 1967:17; Coutts 1970a:62). Goethite deposits form in some heavily leached shell middens, further indicating the effects of acid percolation (Palmer and Williams 1977:24).

If molluscs are heated to high temperature during roasting or steaming, calcium oxide is released, reacting with sodium bicarbonate solutions to form powdered calcium carbonate precipitate on the shells. If the calcination takes the form of hard calcareous lenses or concretions running throughout the lower strata of a site, then it is due to massive leaching of these calcium carbonate precipitates liberated from upper strata (Palmer and Williams 1977:25; Cipriani 1955:251-252).

A different sort of threat to shell middens has accompanied the spread of intensive agricultural practices around the world. For centuries, shell middens have been mined as a convenient source of calcium carbonate. Shells have been burned for lime, ground for use as road gravel and in chicken feed, and recycled as spat-fall in oyster grounds (Gaines and Cunningham 1878:290; Holmes 1907:114; Owen 1922:6; Goldthwait 1935:3; Kalm 1966 (I):53). More recently shell middens have succumbed in great numbers to riverfront and coastline development. In many ways, modern destructive processes act more quickly and thoroughly than scuffage, treadage, and leaching, and they threaten the very existence of these varied and provocative aspects of the archaeological record.

Midden Sampling

If an archaeologist has developed a research design calling for excavations in shell middens, an integral part of that proposal ought to be a detailed sampling strategy. Without a clear idea of the data required from such sites, undirected excavation can easily retrieve enormous quantities of redundant data which may prove totally inadequate for resolving important research questions. When dealing with shell middens, "even with a single site one is likely to be dealing with a potential population of hundreds of tonnes of material and tens of millions of molluscs" (Bailey 1975a:48). The task of the archaeologist, in such cases, is to minimize the acquisition of data while maximizing problem resolution (Cherry 1978:294). There are several alternative approaches to this dilemma, all involving sampling procedures.

In fact, archaeologists inevitably work with samples, as Wilfred Shawcross (1975:46) has noted.

> By now most archaeologists are aware that their assemblages are compound samples, products of archaeological technique, proportions of site area excavated, of sites as samples of a social unity, of the posthumous destruction of organic remains and prehistoric selection of a sample of the prehistoric animal population.

At least during the excavation, the archaeologist can exercise some control over the sampling process and even test for the representativeness of the excavated samples.

In this and previous chapters, I have mentioned some of the misguided notions associated with the California School of Midden Analysis, particularly the underlying concept of homogeneous middens in which rocks, bones and other artifacts were considered "disturbing factors" in a shell matrix (Treganza and Cook 1948:289). The truly variable nature of internal midden structure has already been belabored at some length. Ideally, sampling designs should adress this heterogeneity by treating each layer and feature as an independent population to be sampled. This ideal sampling method is often extremely difficult to implement for a number of reasons. First, in many shell middens, layers or zones seldom extend over the entire site and are frequently quite localized, so samples must be drawn from a large number of small populations. Secondly, when dealing with a stratified site, the nature of the stratigraphy is unobservable before the site is excavated, so the parameters of the population to be sampled cannot be known prior to excavation. Therefore, a rather flexible sampling strategy is most appropriate.

William Peacock (1978) has developed a well-reasoned approach to shell middens involving complementary non-probabilistic and probabilistic sampling. Basically, his non-probabilistic samples are aimed at uncommon or unevenly distributed populations (Peacock 1978:187). Such samples are taken from stratigraphic layers and involve screening all deposits to collect specimens of rare populations (e.g., unusual shell species, unevenly distributed artifact types), and water-sieving through fine mesh small subsamples (about 4 kg dry weight) of midden matrix removed from stratigraphic layers visible in profiles to recover all midden constituents (Peacock 1978:187-188). The probabilistic samples are small units scattered randomly over a site to retrieve representative samples of well-distributed populations, such as the shells in middens dominated by a few species (Willey and McGimsey 1954: 46; Hester and Conover 1970:138; Peacock 1978:182).

Column sampling is a widely applied technique with certain advantages and drawbacks. In comparison to Peacock's elaborate two-tiered approach, column sampling is relatively simple and can effectively sample stratified deposits in a probabilistic or non-probabilistic manner, depending upon whether the columns are distributed randomly or systematically throughout the excavated area. The technique was developed long ago by Gifford (1916) and has become associated with the California School (Cook and Treganza 1947, 1950). The major drawback to the technique is the tendency for archaeologists to rely solely on column sampling, instead of applying a range of sampling methods designed to recover all sorts of midden constituents, as suggested by Peacock.

Whatever sampling method is chosen, the samples should be drawn and analyzed with an eye toward the overall research design. An incredible number of shell midden analyses are flawed by the use of arbitrary levels, or spits, as sampling units (e.g., Maggs and Speed 1967:91; Terrell 1967). One recent article, which received favorable reviews, is a virtual primer on poor sampling procedures (Botkin 1980). A <u>single</u> column was selected for analysis and was <u>arbitrarily</u> divided into 6" vertical levels, <u>only</u> material remaining in the 1/8" or larger mesh screens was analyzed, and sample constituents were quantified by <u>weight</u> (see Chapter IV for criticisms of shell weight analyses). Although this is an extreme case, such errors as these could easily be avoided if archaeologists would routinely evaluate the relevance of their excavation and analytic methods to the research problems at hand.

Occasionally an ambitious archaeologist suggests that some of the disadvantages associated with sampling might be avoided by excavating and analyzing entire sites. If at all possible, total site excavation is highly preferable to partial excavation (Anderson 1973a:123-124); and if excavations must be limited to portions of a site, then they should be done in contiguous units rather than in disjunct, randomly distributed units. This is simply due to the great difficulty in extrapolating stratigraphic zones, and feature, component and activity area boundaries across unexcavated, intervening units. As for total analyses of shell middens, they may be hypothetically feasible, given a sublime disregard for time and money, but they are seldom possible in this world. Peter Coutts has described in some detail a field procedure employing at least 37 persons, whereby a shell midden could be simultaneously excavated and the shells analyzed on the spot (Coutts 1971a:183, 1972a:81). But even this plan does not account for the considerable amount of plant, animal and artifactual material left for later laboratory microanalysis.

The argument for sampling does not rest on a subconscious desire to shirk the tiresome, but essential, task of total analysis, but rather on the well-substantiated conclusion that sampling can be "highly accurate, efficient, and clearly justified" if properly executed (Casteel 1976:195; see Greenwood 1961:414-416; Ambrose 1963; Koloseike 1968, 1970; Koloseike and Peterson 1963; Hester and Conover 1970:150; Peacock 1978:188; Schaaf 1981; and Wagner 1982 for discussions of time/data ratios, subsampling procedures and flotation recovery rates).

Chapter IV

THE ZOOARCHAEOLOGY OF SHELL MIDDENS

Introduction

Successfully correlating predicted types of behavior with specific, unambiguous patterns of archaeological artifacts and features demands a thorough understanding of the myriad cultural and natural processes which have affected the evidence from the time an activity occurred until a site is excavated and the analysis is completed. Since the evidence, in the case of shell middens, consists predominantly of faunal remains, the most appropriate and profitable approach to understanding this type of site involves the systematic application of zooarchaeological, taphonomic and paleoecological analytic methods to the invertebrate remains (see Behrensmeyer and Hill 1980, and Gifford 1981 for reviews). The many advantages of this approach should quickly become apparent as we view molluscan remains (much as Mr. Venus, a "preserver of animals and birds" in Charles Dickens' Our Mutual Friend, regarded his prospective bride) in a bony light.

On Mixing Apples and Oranges: The Effects of Differential Preservation on Subsistence Analysis

North American archaeologists have recently reevaluated their interpretation of large shell middens, which conventional wisdom maintained were the legacies of people who depended on molluscan resources for the greater part of their sustenance (Wyman 1868b:

457-458; Rau 1872:371; Webb and DeJarnette 1942:308; Willey 1949:539; Cook and Treganza 1950:247; Sears 1963:40; Meighan 1969:415). Gradually the European view that shellfish were seasonally significant, supplemental subsistence resources has found acceptance in the United States and elsewhere in the world (Reynolds 1889:257; Morse 1967; Ritchie 1969; Salwen 1970; Snow 1972; Morel 1974; Clark 1975; Dillehay 1975; Bailey 1975b; Parkington 1976; Rozoy 1978:1036).

The originally divergent perspectives were based on essentially equivalent shell midden data interpreted according to two quite distinct analytic frameworks. In the United States, the preponderance of shells in proportion to bones and plant remains was rather naively thought to directly reflect the relative importance of each major resource category at those sites. In Europe, primarily thanks to some perceptive Danish archaeologists, the complex relationship between food remains and dietary contribution was quickly appreciated (Bailey 1975b). Due to the effects of differential preservation and differences in relative food values represented by shells, bones and charred plant remains, the large mass of shells was understood to belie their actual dietary significance. Archaeologists on both sides of the Atlantic excavated middens and counted shells with equal diligence and precision. The difference in interpretation lay in the more appropriate analytic units employed by the Europeans. Whereas archaeologists in California developed elaborate methods of counting and weighing various midden constituents (such as shell, bone, soil, ash, rock, etc.), the Danes attempted to estimate the number of animals represented by the bones and shells (Petersen 1922, cited by Bailey

1978:48, 1975b (VIII):40). Such conversions from units of observation to units of analysis (Osborn 1977b:173) are necessary to address the questions raised in this dissertation.

No matter whether food value is to be measured in terms of kilocalories, grams of meat, or another analytic unit, some estimate of the number of animals (or parts of animals) is necessary to bridge the conceptual gap separating observations of individual shells from conclusions about prehistoric subsistence. Many years ago paleontontologists devised a measure of relative species abundance, the minimum number of individuals (MNI), which zooarchaeologists have since almost universally adopted (Grayson 1973:433; Casteel 1977:125). The MNI for a species is that number of animals which most parsimoniously accounts for all of the excavated remains of that species. Initially, the technique involved simply identifying the skeletal elements of vertebrates, separating left from right elements and using the most abundant element, say distal left femur fragments, as the basis for the estimate. Later, the technique was adapted to invertebrate remains, and age and size sorting were also employed to increase the accuracy of the calculation (White 1953:397; Fraser and King 1954:91; Shotwell 1955:272; Chaplin 1971:70-75).

Although MNI's are widely used as ratio measures of species' relative abundance, serious inadequacies in the technique have recently become apparent through a series of penetrating critiques by Donald Grayson (1973, 1978, 1979, 1981). The foremost sources of error are attributable to effects of sample size, differential recovery, and the fact that they are minimum estimates. Grayson has demonstrated that in many, but not all, faunal samples, the MNI varies directly with sample size. The first elements identified to species tend to contribute a disproportionately higher number of MNI's compared to additionally identified elements. For example, a species with a single identified element necessarily has an MNI of one. As the number of identified elements increases, the chance that each additional element will result in an increased MNI often becomes progressively lower. If MNI estimates are demonstrably independent of sample size, then the faunal remains are more likely to be representative of the sampled population (Grayson 1978:58-60, 1981:82, 86).

A second source of error is differential recovery of archaeological faunal remains. Since sample size often directly affects MNI estimates, MNI's calculated for different areas or excavation units of a site cannot simply be added together for a cumulative MNI, but must be recalculated for each new aggregation of stratigraphic or excavation units. The total MNI's calculated for an entire site as a single unit will be considerably fewer than if MNI's are calculated for individual strata or arbitrary excavation units. Rankings of species abundance <u>may</u> not vary significantly because of this factor, but their relative numerical abundance will usually be markedly altered. Thus, MNI's may reliably provide only ordinal rankings of species abundance (Grayson 1973, 1979:214; Dennell 1976; Watson 1979:137).

Finally, since each MNI is by definition a minimum estimate, the actual number of animals represented may be equal to the MNI, but may just as likely be greater to an unknown degree, making any ratio comparison of two or more MNI's spurious and misleading (Grayson 1979: 221).

Grayson's devastating criticisms of the MNI technique have left a methodological void in subsistence studies. One of the lessons to be learned is that the MNI estimate was adopted by zooarchaeologists without rigorously questioning the validity of underlying assumptions. We need to make a fresh beginning, explicitly state our goals and assumptions, and then select or invent methods appropriate to our research problems.

Most archaeologists would probably prefer to totally excavate sites and completely recover all cultural material contained therein, but for any number of pragmatic reasons this seldom if ever happens. Given the necessity to sample sites, the first goal of subsistence research is to recover representative samples of plant and animal remains from the excavated area (sampling is discussed in Chapter III). If such remains have been preserved, the relationship between the preserved portion and the original amount of plants and animals brought to the site by human activity should be deduced, if possible. In other words, the second goal is to accurately estimate the actual (not minimum) number of plants and animals (or plant parts and animal parts) represented by the excavated archaeological remains. If this goal is achieved, then perhaps estimates can be extended to the entire site; and finally, arguments can be offered linking these estimates to the amount of food consumed, or at least prepared at the site.

Plant remains analysis lies beyond the scope of this chapter, so if we limit our consideration to faunal remains, how can progress be made toward our second goal, assuming that a representative sample is recovered during excavation? At present, the ranked order of species relative abundance based either on number of specimens or traditional MNI calculations is all that can be obtained from most faunal data, unless those data meet two critical qualitative standards:

1) the site was excavated by cultural strata or distinguishable occupation units,
2) the strata or occupation units were deposited in or occupied for relatively short periods of time.

Data fulfilling these preconditions can be analyzed with considerable confidence if it is realized that the relative preservation of different types of faunal remains is a direct result of the manner of preparation and discard.

Mollusc shells. A basic assumption, whether explicit or implicit, of most shell midden analysts is that the number of shells found in a midden equals, or at least closely approaches, the number brought to a site and prepared there (e.g., Petersen 1922; Cook 1946; Bailey 1975a: 48, 1978:48). This premise has been challenged on the grounds that bones and plant remains are frequently not recovered at all from archaeological sites, so "why burden shellfish with an assumption that cannot be carried by other subsistence resources?" (Perlman 1980:287-288). Leaving aside for the moment difficulties in recovering representative archaeological samples, shells are in fact more likely to survive in an archaeological context than bones or plant food remains (pollen and phytoliths are another matter). At most sites, seeds and other plant food parts must be carbonized to withstand the destructive forces incurred during centuries-long deposition. Since most plant food parts either are consumed or decay, that portion which becomes carbonized, inadvertantly or through use as fuel, and escapes complete oxidation is a highly (though probably systematically) skewed sample.

The paramount reason for the absence of vertebrate remains from archaeological sites is low soil pH, a generally recognized factor by which bones are leached and eventually totally dissolved by soil acids (Gordon and Buikstra 1981). Even when bones are deposited in a neutral or basic matrix, they may have already been subjected to human butchering and carnivore scavenging which crushed many of them to unidentifiable fragments and removed other bones from the site.

Though not immune to these sorts of processes, shells are more durable than bones or plant food remains. Shellfish are frequently opened in ways which leave the shells intact or only minimally damaged. In large accumulations of shells, a characteristic of shell middens by definition, calcium carbonate leached from shell surfaces by an acidic soil will eventually neutralize the soil and even create locally alkaline conditions. Shell dissolution in acid soils is most severe along the outer margins of middens, and even there, the lost portions can sometimes be estimated (Koike 1979:72).

The strongest argument for the representative nature of shell deposits rests with the way in which shells were discarded. Regardless of whether the shells were casually tossed onto a heap next to a living area during a meal or deliberately gathered together and dumped at a village site or shellfish drying camp, the resultant heap (or lens, or contents of a refuse pit) is relatively homogeneous, with matching fragments and matching valve pairs (if the molluscan species are bivalves). Hiroko Koike has demonstrated this homogeneity by matching Meretrix lusoria clam valves from a single feature in a Kofun period house, her analysis inspired by a valve-pairing game played by the Edo people of Japan (Koike 1979). Of 2,089 complete valves, 760 (36%) could be confidently paired. The soil pH around the feature ranged from 5.4 to 6.0, but was 7.0 in the shell lens, so many of the remaining complete valves had apparently lost their corresponding pairs to soil acid along the feature margins or simply to breakage which made pairing unreliable. Seasonality studies demonstrate that the shells accumulated over 5½ consecutive seasons.

A similar analysis of features in an Alabama freshwater shell midden likewise demonstrated their internal homogeneity resulting from the deposition of individual shell accumulations. An average of 24% of the intact valves were paired within each feature (Warren 1975: 127). These studies strongly suggest that shell deposition was an exceptionally structured activity in which all or nearly all refuse accumulating within limited periods of time was normally discarded together. This mode of discard has concentrated debris in recognizable archaeological features and, in some instances, even enhanced preservation by altering the chemistry of the soil matrix.

Bones of small vertebrates. Keeping in mind that the sort of excavated occupation area we are discussing has been deposited in a relatively brief time span and then excavated according to cultural strata, the recovered remains of small vertebrates can probably be analyzed accurately using MNI estimates. For one reason, smaller animal bones are not broken into as many fragments as are those of large animals, so surviving complete bones or end fragments are more likely to remain identifiable (Yellen 1977b:319). Bones of small animals are often thin-walled and, hence, more fragile than ungulate long bone shafts, for instance. But the small bones contain little marrow and so are not usually subject to much breakage during butchering. If dogs ingest them, small bones are likely to "emerge" etched by digestive acids but still essentially intact, not gnawed beyond recognition as marrow-containing bones typically are.

Among modern hunting peoples, small animals are seldom shared between camp members, in contrast to the widespread practice of distributing meat (and consequently the bones) from a large kill to relatives and other band members (Yellen 1977b:305). Thus, the bones of a small animal are liable to be discarded from a single living area and deposited in a relatively restricted refuse area (Shawcross 1972: 602). Furthermore, small animals are generally brought back to camp as whole carcasses, whereas a large animal might be partially butchered at a kill site and numerous bones left behind.

Finally, small items of any sort, including bones, tend to become incorporated into an unconsolidated matrix (such as sandy soil or a shell midden) more readily than large objects, increasing their chance of preservation (Yellen 1977b:323; Stockton 1973:115; Gifford 1980: 101; Cahen and Moeyersons 1977). For these reasons, an archaeologist can place considerable reliance on MNI estimates for small animal species remains from specific, short-term occupation and refuse areas (see Behrensmeyer et al. 1979:12 for a different point of view).

Bones of large vertebrates. Remains of large animals present us with a major analytic dilemma. As just noted, a large animal (e.g., deer, bison, gemsbok) may be butchered off-site and its parts distributed throughout a camp or village. A number of archaeologists have proposed that the units of analysis ought to correspond to anatomical segments or butchering units which were originally of human behavioral significance (Lyman 1979; Binford 1978:478). However, large animal bones are subject to so many potentially destructive processes that entire butchering units of an animal may leave no archaeologically recognizable trace, while there is less chance that the whole animal will be overlooked in a calculation of MNI's (Yellen 1977b:Table 14.9). On the other hand, if only a portion of a component is excavated, the calculated MNI may apply to a larger portion of the site than is excavated (because of the wide dispersal through meat sharing of large animal bones) and overrepresent the significance of that species in the faunal remains found in that area. Each archaeologist must decide which method, and concomitant source of error, is less objectionable for the particular problem at hand. One should also keep in mind that special treatment of particular bone refuse by prehistoric societies, such as the off-site disposal of fish and bear remains recorded for some historic North American groups (Oswalt and Van Stone 1967:73, 103; Hallowell 1926) can hopelessly skew the results of any analytic technique.

On Turning Sows' Ears into Silk Purses: The Analysis of Midden Shells

The matrix of a shell midden typically consists of some proportion of whole or nearly whole shells and a vast quantity of shell fragments, ranging from large identifiable pieces to microscopically small particles. Archaeologists have traditionally dealt with such assemblages in two ways, by either weighing the archaeologically recovered shell or counting the number of specimens. In order to evaluate the applicability of these alternative approaches to ascertaining relative meat contributions of various species, the zooarchaeologist must understand those cultural and natural processes which produce triturated shell midden deposits.

Reliance on weight ratios to determine the relative abundance of different molluscan species in a sample might at first seem preferable since this would eliminate a great deal of laboratory analysis involved in determining MNI's from fragments. But, as most shell midden archaeologists have discovered, calcium carbonate and other shell constituents are leached from shell through time, a process which can result in significant loss of shell weight. Shell deterioration is frequently most advanced in the lower levels of a shell midden (for reasons discussed in Chapter III), since those shells which were first deposited have been subject to leaching for the longest time (Linares de Sapir 1971:34-35; Warren 1975:219; also see Coutts 1969a: 82-89). Chemical studies have demonstrated that shell conchiolin decays with age and that carbonates are most actively leached from shell surfaces (Schoute-Vanneck 1960:70; Anderson 1973b; Stuiver and Borns 1975:102). The latter finding indicates that small shell particles, with their greater surface area/volume ratio, are more susceptible to leaching and weight loss than large fragments and intact shells (Driscoll 1970:898).

Attempts have been made to calculate correction factors for estimated weight loss by comparing weights of archaeological shells with weights of modern individual shells of equivalent linear dimensions. Estimated average weight losses in the archaeological specimens ranged from 18% to 60%, but in one case the archaeological shells actually weighed more than their modern counterparts (Shawcross 1967:122; Shenkel 1971:146; Bailey 1975a:51; Tartaglia 1976:167-168). Such correction procedures are only applicable to whole shells or large, measurable fragments. As with other zooarchaeological attempts to derive meat weight estimates from faunal remain weights, there is implicit in this approach an assumption of near perfect preservation of archaeological deposits, a "Pompeii premise" seldom met (Binford 1981).

Counting of individual specimens also has methodological limitations. Clearly, a dust-sized particle is in no way equivalent to a whole valve, so simple fragment tabulations are of little value for meat estimates. Most archaeologists have dealt with this problem by attempting to identify and count shell fragments which are representative of individual shells, for example, umbos or hinge segments or bivalves, apices or apertures of gastropods, and posterior plates of chitons (Figure 6). Ideally, the anatomical part selected for counting ought to be resistant to the destructive processes which fragment shells. Taphonomic studies of bones and shells suggest that thick, dense structures are less susceptible to breakage than thin parts of low specific gravity (Hallam 1967:35-37; Voigt 1975:97; Brain 1976:110; Binford and Bertram 1977:112). Fortuitously, many of the anatomical parts which permit species specific identifications of individual molluscs are also some of the densest and most commonly preserved.

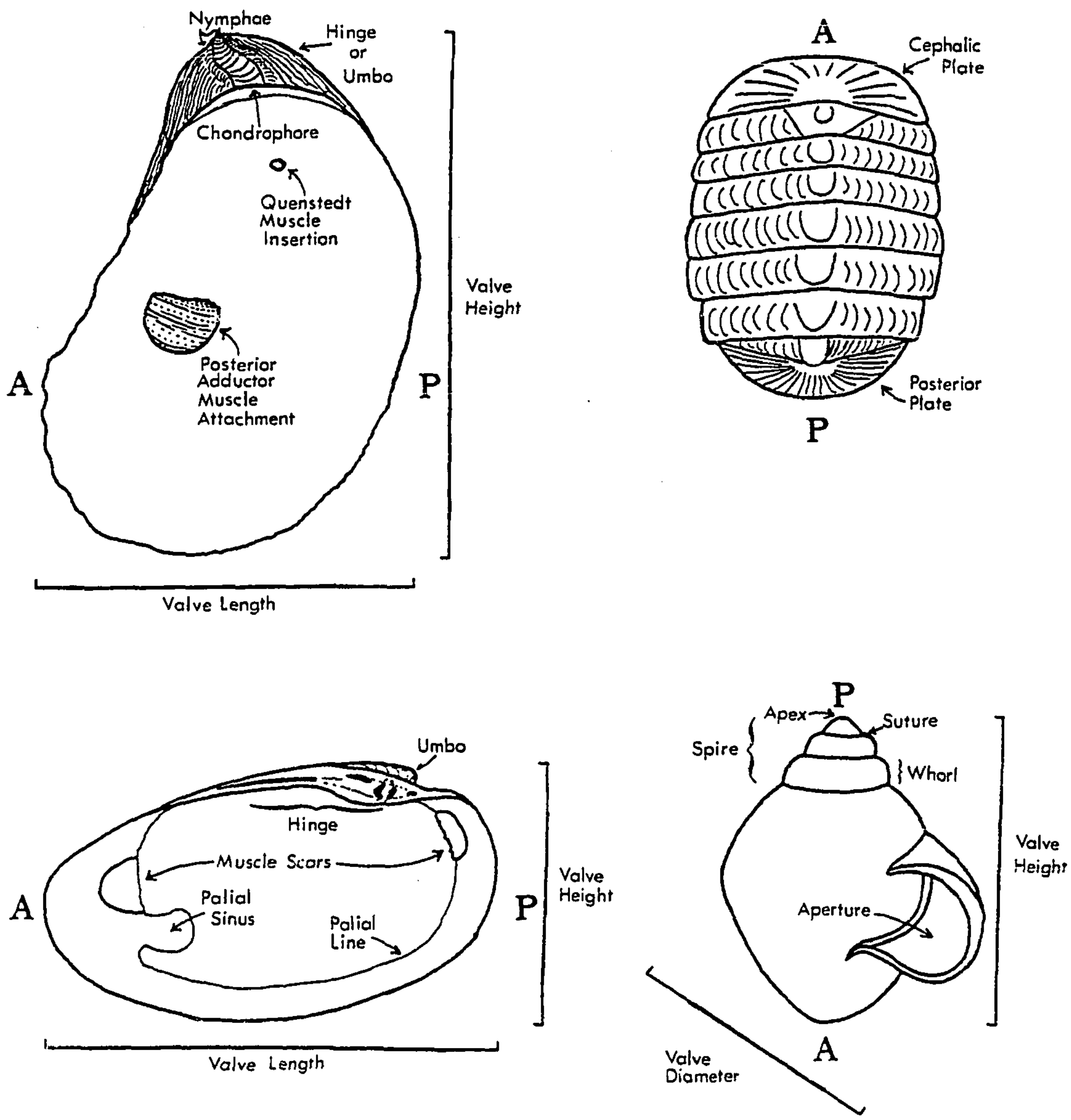


Figure 6. Molluscan Shell Topography.

Once single valves have been identified, the number of individuals per species must be calculated. For gastropods, chitons, scaphopods, and cephalopods there is a simple one-to-one equation between diagnostic valve or plate parts and an individual mollusc, since each animal has only a single valve apex, valve aperture, operculum or posterior plate.

A potential source of error can be avoided at this point in the analysis by omitting valves which were evidently dead when collected by the site occupants and could not have contributed meat to their diet (Nelson 1942:52; Coles 1971:357; Bailey 1975a:51, 1975b (VI):19). Such valves can be recognized by predator-bored holes (made by carnivorous gastropods, sponges or algae), or the shells of barnacles and molluscs attached to interior surfaces. Dead shells are especially common in oyster middens because oyster spat grow preferentially on shells and other hard-surfaced objects, so oyster gatherers unintentionally but inevitably carry away some dead valves attached to live ones.

Oysters and other bivalves have right and left valves. Archaeologists usually identify and count all recovered right and left valve fragments of a given bivalve species and use the larger of the two figures as the MNI for that species. However, considering the triturated nature of most shell midden matrices and the virtual certainty that some valves have been crushed beyond recognition, such a figure can be considered an underestimate. Furthermore, if, as is usually the case, the numbers of left valves and right valves are not equal, then according to probability theory it is quite unlikely that the larger of the two values equals the original number of whole shells.

For instance, let us assume that from a given meal of bivalves an equal number of left and right valves was deposited in a refuse heap. Such an assumption seems quite acceptable, according to our knowledge of shellfish gathering behavior patterns. Let us further assume that later cultural and natural destructive processes have equal chances of affecting right and left valves. This is also a reasonable assumption, if the bivalve species has bilaterally symmetrical valves (clams have symmetrical valves, oysters do not). If our excavation methods include systematic collection procedures, then our evidence of that prehistoric meal refuse constitutes an unbiased sample of the originally deposited population. Upon analysis, we might discover that 1,350 left valves and 1,638 right valves were recovered, and a traditional application of the MNI calculation would maintain that 1,638 individual shellfish are represented by the sample. But as several faunal analysts have pointed out, according to probability theory, it is extremely unlikely that all 1,638 right valves would survive from a population of that size, when only 1,350 left valves were found, even though they ought to have had an equal chance of survival. 1,638 is, in fact, the minimum number of individuals which could have produced such an assemblage, but the actual original population was probably larger and its size can be estimated using the appropriate equation.

If left and right valves can be confidently matched with their original pairs, then Hiroko Koike suggests the following equation:

$$n = (k^2 - k + 2i) / 4i \qquad (1)$$

where n is the number of pairs in the original population, k is the number of unbroken shells randomly chosen from n, and i is the number of pairs identified in the sample (Koike 1979:66-67). Unless a shell midden consists predominantly of species which can be matched only to their originally paired opposites, matching by size can be a highly subjective exercise (Klein 1980:227). In these other cases, one of the probability equations presented by Rolf Lie (1980:27) should be employed. If the minimum number of individuals is assumed to be less than the sum of left and right valves in the total excavated sample, then the following equation is applicable:

$$2 \cdot \sum_{v=0}^{\min(m-l,\, m-r)} \frac{\binom{m}{v}\binom{m}{m-l \;+\; m-r \;-\; v}}{\binom{2m}{(m+l) \;+\; (m+r)}} \geq 0.05 \qquad (2)$$

where l is the number of recovered left, valves, r is the number of recovered right valves, and m is the minimum number of individuals which produces the observed sample distribution, with a 95% probability. As noted above, the equations apply only to symmetrical bivalves; the standard method of calculating MNI's is still the best estimate available for unsymmetrical bivalves, if one of the valves is consistently underrepresented in random samples.

Once an estimate of MNI has been calculated, the faunal analyst can proceed with estimating the amount of meat obtained from the shells. For many years, archaeologists derived meat estimates directly from shell weights by means of a simple meat/shell ratio. Some applied a single ratio to all excavated shell remains, ignoring species differences (Cook 1946:51; Shawcross 1967:121; Coles 1971:358). Later, more sophisticated studies involved species-specific ratios (Salwen

1970:2-3; Bailey 1975a:52; Dillehay 1975:153; Ham 1976:50). All of these ratio-based estimates failed to account for the typically allometric growth of molluscs, whereby an exponential curve describes the decreasing meat/shell ratio during growth (Koloseike 1969:151; Thomas 1978). Parmalee and Klippel (1974:423) first calculated linear regression formulae for 39 species of modern freshwater pelecypods and concluded that valve length, height and weight measurements gave the best estimates of mussel weight. This sort of equation must be applied to individual shells and is not appropriate for aggregate shell weights. Parmalee and Klippel's technique has since been applied to fragmented shells with particular features whose dimensions are allometrically related to overall shell size or meat weight (Warren 1975:177; Wallace 1976:181; Hall 1980:280-281).

Live molluscan meat weights usually vary according to season of the year because of stress induced by spawning (and changes in water temperature in temperate waters). This seasonal factor can be ascertained, and the seasonal nature of shellfish exploitation likewise determined, by studies of shell growth patterns. Concentric growth layers can be seen macroscopically on the exterior surfaces of most mollusc shells, and these can be used to establish season of collection (Drover 1974:225-229; Dillehay 1975:160; Ham 1976:66; T. Ruppe 1980:69). Unfortunately, this inexpensive method is prone to considerable error. The subdaily, daily, bidaily, fortnightly, lunar monthly, and annual cyclical growth accretions are interrupted by intervening halts in growth caused by freezing temperatures, extreme heat, abrasion, spawning, neap tides, and storms. These growth breaks are nearly impossible to distinguish accurately on shell exteriors, but each type has a characteristic microstructural pattern which is visible when shells are cross sectioned (Kennish 1980:259-269). The interior chondrophore surface of some unsymmetrical bivalves also preserves microstructural patterns (Table 5).

Archaeologists have experimented with microstructure analysis and found it to be quite accurate (precise to within a three month range or less) for determining seasonality (Weide 1969; Coutts 1970b:874; Coutts and Higham 1971; Ham 1976:69; Koike 1979:68). Interpretation of growth patterns depends to a great extent on analogy to patterns observed in modern molluscan populations grown under known conditions. One way to avoid this dependence on modern analogues, with its concomitant implication of unchanged climatic and other environmental conditions since the occupation of the particular site in question, is to establish an annual water temperature profile from the archaeological shells. Since the ratio of the isotopes Oxygen-18 and O-16 as constituents of shell carbonates is largely dependent on water temperature at the time of shell growth, the specific seasonal growth cycle can be determined directly from archaeological shells (Coutts 1970a:72; Tite 1972:106-109, 360-364; Rye and Sommer 1980; Killingley 1981; Straus et al. 1981:671).

For meat weight estimates, however, resorting to analogy with modern specimens of comparable size or weight and season of collection seems unavoidable. This is an inherently undesirable situation which forces archaeologists to assume that past conditions were much like today's without any means of independent verification. The dilemma is

Table 5. Molluscan Incremental Growth and Seasonality Studies.

Common Name	Species	Shell Feature Analyzed: Exterior Surface	Cross Section	Interior Chondrophore	Sources
Cockles	*Chione fluctifraga*	E			Drover 1974
			CS		Hughes & Clausen 1980
			CS		Crabtree, Clausen & Roth 1980
	Chione stutchburyi		CS		Coutts 1970b
			CS		Coutts & Higham 1971
		E	CS		Coutts 1975
	Chione undatella	E			Drover 1974
	Clinocardium nutalli		CS		Evans 1972
		E	CS		Ham & Irvine 1975
	Protothaca staminea		CS		Clark 1979
			CS		Crabtree, Clausen & Roth 1980
Scallop	*Pecten diegensis*	E			Clark 1968
	Pecten irradians	E			Perlman 1973
Mussel	*Geukensia* (= *Modiolus*) *demissa*		CS		Lutz & Rhoads 1977, 1980
	Mytilus edulis		CS		Lutz 1976
Clam	*Arctica islandica*		CS		Lutz & Rhoads 1977
			CS		D. Jones 1980
	Astarte castanea		CS		Rhoads & Panella 1970

Table 5. (cont.)

Common Name	Species	Shell Feature Analyzed: Exterior Surface	Cross Section	Interior Chondrophore	Sources
Clam	*Callista chione*		CS		Hall, Dollase & Corbato 1974
	Calyptogena ponderosa		CS		Rhoads & Panella 1970
	Gemma gemma		CS		Rhoads & Panella 1970
	Malletia sp.		CS		Rhoads & Panella 1970
	Mercenaria mercenaria		CS		Panella & MacClintock 1968
			CS		Rhoads & Panella 1970
			CS		Gordon & Carriker 1978
			CS		Clark 1979
	Meretrix lusoria		CS		Koike 1973
	Nuculla cancellata		CS		Rhoads & Panella 1970
	Protothaca staminea	E	CS		Ham & Irvine 1975
	Rangia cuneata	E			Dillehay 1975
		E			Aten 1979: Appendix B
	Saxidomus giganteus	E	CS		Ham & Irvine 1975
	Spisula solidissima		CS		Jones 1980
	Tivella stultorum	E			Weide 1969
			CS		Hall, Dollase & Corbato 1974
	Tridacna squamosa		CS		Panella & MacClintock 1968

Table 5. (cont.)

Common Name	Species	Shell Feature Analyzed: Exterior Surface	Cross Section	Interior Chondrophore	Sources
Clam	*Venerupis tenerrima*	E	CS		Ham & Irvine 1975
Oyster	*Agerostrea mesenterica*			I	Sambol & Finks 1977
	Crassostrea virginica	E			Quick & Mackin 1971
			CS	I	Palmer & Carriker 1979
		E			T. Ruppe 1980

compounded by a series of calculations leading to estimates of molluscan dietary contributions. In an attempt to bypass some of these leaps of faith, techniques have been devised to measure the relative importance of meat in comparison to plant foods in diets, primarily on the basis of the ratio of strontium to calcium in human skeletal remains (Wing and Brown 1979:79-80). Molluscs contain unusually large quantities of strontium in comparison to other sorts of meat, so shellfish consumers are potentially distinguishable from other sorts of hunter-gatherers (Schoeninger and Peebles 1981). However, this and other trace element analyses indicate only general emphases in the diet; we are still largely dependent on charred plant remains and bits of bone and shell for our interpretations.

Let us finally consider the remaining calculations, and their underlying assumptions, which lead to estimates of molluscan dietary contributions. Once the zooarchaeologist has calculated estimated meat weights per species represented by a particular shell sample, this figure must be standardized to permit comparison with other kinds of meat, perhaps as kilocalories or grams of protein per gram of meat (Shawcross 1972:593). Some archaeologists have guessed at the number of site occupants and their length of stay to compute a daily consumption rate per person (Bailey 1975a:54, 1977:138-139; Morel 1974:318-320; Gilmore 1974:34, 39; Dillehay 1975:88). Such calculations may or may not be accurate; there is no means of independently verifying such results, which often are based on unjustified and widely discrepant estimates of human calorific needs (Dennell 1979:126).

At least three other important sources of error may impinge on these calculations. First, from our ethnographic review it is clear that members of shellfish gathering societies do not necessarily eat equal quantities of molluscan meat; women and children frequently consume more than men (e.g., Bigalke 1973:167; Voigt 1975:94). Another error factor is the possibility that shellfish gathering parties consume some of their harvest at the collecting site, before returning to the base camp or village (e.g., Warner 1937:144; Bigalke 1973:163). The low archaeological visibility of these "lunch" camps assures that many such sites will be overlooked and their food refuse omitted from relevant calculations. A third potential problem involves the standard assumption that "the amount of food represented on a site bears a consistent relationship to the amount of food consumed" (Shawcross 1972:590). Presumably this is true of most prehistoric archaeological sites in a general sense, but as Bailey (1975b (IV):4) has pointed out, evidence of food collection and preparation is not necessarily equivalent to evidence of consumption at that site. Shellfish are particularly amenable to preservation and trade, so their refuse may be left at one site though their dietary contribution occurred at another time and place. Such problems as these may or may not be reconcilable with the archaeological record, but archaeologists should at least be aware of their potential for mischief.

An Element of Discretion: Criteria for Site and Species Selection

So far we have emphasized the shared attributes which distinguish species of the phylum Mollusca from other animals. The considerable variation in size, form, protein and fat contents, habitat preference, mobility and other factors exhibited by these species also presumably was appreciated by the earliest human predators. Precisely what use shellfish gatherers made of this kind of information is still a subject of debate among archaeologists. For example, were the locations of shellbeds primary or secondary considerations for base camp or village placement decisions given the fact that shellfish are generally conceded to have been dietary supplements rather than staple food sources?

In some areas of the world there are very few estuaries with large molluscan populations; or, otherwise suitable shellfish habitats are located on wave-swept shores which are dangerous for wading shellfish gatherers; or, the shellfish habitats are difficult to reach because of sheer cliffs (Linares de Sapir 1971:26; Bailey 1975b (X):5; Baumhoff 1978:21). In such cases, shell middens are, not surprisingly, clustered around the few existing estuaries or near points of easy access. Difficulties in interpretation arise in valleys or along coastlines which have long stretches of suitable molluscan habitat, but where shell middens are concentrated at particular spots. Were these site locations selected for their proximity to extraordinarily productive mollusc beds or because of some other environmental determinant? Geoffrey Bailey has argued that marine resources other than molluscs, principally fish, had to be available in large quantities to justify coastal home base locations, and only the incidental proximity of shellbeds to resources of greater abundance resulted in shell midden accumulations (Bailey's Time-Distance Factor). Because so much energy must be expended to transport live shellfish with their large proportion of heavy, inedible shell, he maintains fishing must have provided the bulk of the subsistence base at shell middens (Bailey 1975b (VI):47-48, (X):1-5, 1978:61). Geoffrey Clark has advocated a similar view, reasoning that people locate adjacent to critical terrestrial resources, while making only minor adjustments to allow for access to secondary resources (1981:444).

The weight of archaeological evidence and ethnoarchaeological observations seems to contradict Bailey and Clark. Analyses of shell middens located in varied environments usually demonstrate a close correspondence between exploited species and locally available species, indicative of shellfish gathering in the immediate site environs (Vanuxem 1843:22; Morrison 1942:382; Salwen 1968:337-338; Deacon 1970: 45; Allo 1972:70; Warren 1975; Fairbridge 1976:355; Buchanan et al 1978:89). For the Anbara, proximity to shellbeds is an important consideration in selecting a base camp location (Meehan 1977b:523). Yellen notes a generally close relationship between local site environment, site specific subsistence activities, and discarded subsistence debris at !Kung San sites (1977a:73-75). The foraging range may be fairly substantial (from 2 to 8 km, according to Voigt 1973:309), but the evidence suggests a different interpretation of Bailey's Time-Distance Factor: if the subsistence strategy of a particular society included intensive exploitation of shellfish, then the relatively small quantities of energy derived from individual molluscs compared to the high energy expenditure required to transport large quantities of shellfish dictates that base camps will necessarily be located so as to minimize distance to shellbeds during the times shellfish are exploited.

Close examination of molluscan species representation in midden samples usually reveals the effects of one or more selection criterion favoring the collection of particular species from the variety locally available (Voigt 1975:96). The ethnographic literature is rife with examples of potential foods ignored or proscribed by certain societies. By way of illustration, the Onges on Great Andaman Island are said to abhor oysters (Cipriani 1966:78) and they were taboo to the Karankawa of the Texas coast (Gilmore 1974:12). Nineteenth century inhabitants of Swona, an island of the Orkneys, were despised by other Orcadians because they ate limpets (Clarke 1976:22-23). Adherents to a materialist philosophy might explain such prejudices as adaptive mechanisms to preserve easily overexploited resources for times of grave scarcity. Other apparent "dietary preferences" can be explained as scheduling adjustments to seasonal variations in molluscan populations, and interspecific differences in collection and processing rates.

Seasonal variation. Access to some molluscan habitats may be seasonally limited for gatherers employing a simple technology. In temperate regions, deep-dwelling species may be virtually inaccessible during winter months because either they are deeply buried in mud, or water temperatures are too low for divers (e.g., Ham 1976:71-74). In Arnhem Land, mangrove swamp species are exploited primarily during the dry season, when they are approachable by land (Meehan 1977a:366), although elsewhere they are preferentially collected in the wet season (Peterson 1973). Shellfish are often said to be most palatable, which generally means highest in fat content, just before spawning (e.g., Oberg 1973:67). Dinoflagellate blooms plague some species during hot weather, making them seasonally high risk resources (e.g., Drucker 1951:39).

On a longer temporal scale, entire shellbeds may be buried or killed by freshwater influx caused by hurricanes, forcing shellfish gatherers to find alternative resources (Speck and Dexter 1948:260; Meehan 1977a:369). Gradual climatic changes may result in local silting, sea level fluctuations, water temperature variation, and other environmental perturbations affecting molluscan growth, variety and abundance.

Collection and processing rates. Molluscan species can be differentiated on the basis of the amount of meat obtainable from a given population. Such "prey capture rate" calculations should take into account several factors: 1) effort required to locate the prey, 2) distance traveled to and from resource site, 3) energy expended in collecting resource, 4) size range of individuals of different species, 5) meat weights of individuals of different species, and 6) average processing time required to extract animals from shells. Applying these factors to the archaeological record involves extrapolating from analogous ethnographic observations and modern shellfish gathering experiments.

Molluscs are comparable to plant food resources in regard to the ease with which they are located, in contrast to highly mobile game animals, so the first factor can be held constant for shellfish species. Distance from land to particular shellbeds can, of course, differ significantly since species vary greatly in preferred habitats. Likewise, difficulty in collection is a function of specific habitat characteristics and the collecting technology employed. These two factors can only be estimated with a fairly precise knowledge of a site's paleoenvironment (based on geomorphological studies and oxygen isotope analyses of archaeological shells) and the culture of the site's inhabitants. Species also differ tremendously in size and meat content. "Package size" can influence collection procedures as well as determining the particular species sought. These five factors contribute to the overall potential collection rate for a given species and can be expressed in terms of meat weight obtained per units of collecting time or energy expended (Perlman 1977:203). A crude estimate of this rate can be derived by simply comparing amounts of meat obtainable from a given live weight, including shell (Bailey 1975b (III):6; Ceci 1977:90; Osborn 1977a:149, 1977b:175).

Estimates of processing time must consider archaeological evidence for the techniques employed by the shellfish gatherers in question. Gastropods were often opened individually with hammerstones, as evidenced by shells with detached apices or perforated spires, but most shellfish gatherers employed some means of mass processing, usually roasting or boiling, to simultaneously cook the animals and open the valves or aperatures. In these latter instances, processing time per individual animal was quite short, certainly much less than the 2 seconds per mussel suggested by Osborn (1977a:209).

Changes in the species predominantly exploited at a particular site could involve human selection, or they could be due to environmental change which limited the choice of species available to gatherers. In fact, environmental causes have usually been invoked by archaeologists (Greengo 1951:7-16; Coutts 1970a:84; Braun 1974:594; Foster 1975:192; Fairbridge 1976:355; Robertshaw 1978:139-140).

Several perspicaceous nineteenth century zoologists and archaeologists noted that average shell size commonly decreased from lower to upper horizons of coastal shell middens in Japan and eastern North America (Wyman 1875; Morse 1879:23, 1882:345, 1925:441; Moore 1892-1893:921-922). Changes in water temperature were then thought to be the most likely cause, and such an explanation is still credible given the numerous examples of molluscan species with late Pleistocene representatives generally larger than modern specimens (Thomas 1978: 10-17).

More recently, archaeologists have speculated that human predation pressure on a shellbed could gradually alter the molluscan population profile. By selectively gathering the largest available shellfish, average shell size could decrease through time in the accumulating midden if collection rate exceeded the molluscan population replacement rate (Linares de Sapir 1971:41; Swadling 1972). Pamela Swadling has correctly pointed out that, to differentiate between the processes of environmental change and intensified collection, age profiles of the affected population must be established (1972:42, 1976, 1977). Intensified human predation pressure will result in not only a decrease in average shell size, but also a lower average age among the collected specimens. Environmental changes, such as slight alteration in water temperature, may not affect mortality rates.

Despite the demonstrable validity of Swadling's model, only a few archaeological analyses have documented the predicted reduction in average age among heavily exploited molluscan populations (Hallam 1967:33; Swadling 1977:12-16; Moreau 1978; Anderson 1979:60, 1981:117). On the whole, archaeologists have been willing to interpret shell size reduction as a result of predation without attempting to provide the requisite supporting evidence from age profiles (Brennan 1962b, 1963, 1977:126; Salwen 1965:237; Warren 1975:216; Cumbaa 1976:57; Parkington 1976:134-135; Buchanan et al. 1978:89; Mellard 1978:389; Volman 1978:912; Klein 1979:154; Botkin 1980:133-135; Hall 1980:281; Straus et al. 1980:149-150, 1981:666).

Chapter V

MOLLUSCAN EXPLOITATIVE STRATEGIES

Introduction

The previous four chapters present some general propositions about shellfish gathering derived from ethnohistoric and ethnographic sources, and observable archaeological correlates of the adaptive behavior of shellfish gatherers. Up to now, the discussion has been limited to particular methods of shellfish collection and preparation, and to resultant forms or patterns of refuse which permit archaeologists to explicitly distinguish the different methods employed. This essentially structuralist approach to the archaeological record emphasizes the recognition of patterns in midden features, in food refuse and associated material culture and their comparison with similar or contrastive patterns predicted from the ethnohistoric and ethnographic analogues. The inquiry now turns to evolutionary explanations of the adoption and long-term changes in exploitative strategies involving shellfish gathering. The nature of molluscan exploitation is part of the broader problem of the nature of riverine and coastal adaptations, and so as other subsistence activities rose or fell in prominence, shellfish gathering must have undergone readjustments to maintain the dynamic equilibrium of the cultural system. Thus, I will finally examine the role of shellfish gathering as one potential element of a society's total subsistence procurement repertoire.

Optimal Foraging Models

One major emphasis of recent research in subsistence archaeology has taken the form of optimizing models (Jochim 1976, 1979; Tartaglia 1976; Osborn 1977b; Perlman 1977, 1980; Anderson 1979; Carlson 1979; Green 1980; reviewed by Bettinger 1980 and Earle 1980). Although these models differ in detail, they share many of the same basic assumptions, operationalizing procedures, and methodological shortcomings. For the purposes of this chapter, a brief review of optimizing models will serve to identify the critical resource characteristics and human behavioral constraints which determine molluscan exploitative strategies.

Optimal foraging models typically deal with the potential subsistence resources of a particular region inhabited by hunter-gatherers. Based on archaeological evdience for the presence of certain species during the period in question and on modern ethological studies, available resources are identified and their characteristics are assessed. Relevant characteristics include prey density, distribution, mobility, behavior, fecundity, and size, ideally taking into account seasonal and demographic variability. These spatial and temporal variables determined the time and energy expenditures ("costs") required of hunter-gatherers to locate, capture or collect, prepare and consume each resource at any point in their yearly round. The actual choice of resources and the intensity of their exploitation depended upon the relative yields ("payoffs") of the available resources, measured in calories or amount of nutrients, and the efficiency of their acquisition. In optimizing model terms, the "overall optimal foraging strategy" is to minimize costs while meeting subsistence needs by preferentially exploiting resources with the highest yield per unit of time or energy expended.

Both proponents and critics have indicated numerous weaknesses and unrealistic assumptions associated with the optimal foraging models developed to date (Dennell 1979:130; Jochim 1979a; Bettinger 1980:227; Clark and Lerner 1980:6; Earle 1980:6-25; Gould 1980:109-111; Yesner 1980:87-88). For instance, the quantified environmental variables used to rank resources are either based directly on, or extrapolated from, modern biological studies and are applied to the prehistoric environment as essentially untestable assumptions. The models further assume a stable environment with unvarying seasonal cycles, without allowing for highly probable variations over longer periods of time and the effects of human environmental manipulation. It is quite inaccurate to portray hunter-gatherers as adventitious foragers since most modern groups can skillfully alter their local environment to improve resource habitats or to concentrate dispersed resources. Calculations of exploitation costs are also dependent on modern analogy to either modern harvesting experiments or generalizations from ethnographic observations. Yield estimates are also suspect for all these reasons, but their drawback is due to the assumption that a single subsistence strategy is applied to the entire range of available resources.

Resource yields can be ranked according to a single measure (e.g., calories/individual, grams of protein/individual) or even according to some combination of attributes, but this approach misses the significant point that distinct exploitative strategies were frequently devised to fulfill different subsistence requirements. Protein and caloric needs will probably not be met most efficiently by following a single strategy, particularly if one such essential dietary element is in short supply. In such cases, when failure to obtain the least abundant, essential dietary element threatens the very existence of a human group, then every effort will generally be made to meet that requirement, while satisfying other needs in a fortuitous or less than optimal fashion (Gould 1980:11; Bettinger 1980:227). Certain societal subgroups based on sex, age, and other attributes may fulfill their individual subsistence requirements by pursuing strikingly different exploitative strategies.

Optimal subsistence modelers may eventually resolve many of these theoretical dilemmas. Their importance for this chapter is simply to identify topics for more detailed consideration regarding molluscan exploitation.

Nutritional Characteristics of Molluscs

Anyone interested in comparing the relative food values of different subsistence resources is bound to be dismayed by the widely varying figures published for a single species and the scant data available on wild animals and plants. Table 6 includes information on a few varieties of primarily Old World shellfish, as well as some other resources important in late prehistoric North America included for comparison.

Shellfish compare poorly with other animal species in several

Table 6. Average Nutritional Values of Some Selected Foods.

Species	Individual Meat Yield (g)	Edible Portion	Kcal/ 100g	Protein (g/100g)	Fat (g/100g)	Carbohydrate (g/100g)
Abalone	750	50%	98	18.7	0.5	3.2
Periwinkle (Littorina littorea)	1	22%	74	15.3	1.4	-
Whelk (Buccinum undatum)	unavailable	42%	91	18.5	1.9	-
Cockle (Cardium edule)	3	13%	48	11.3	0.3	3.4
Limpet	7	40%	70	13.0	-	-
Clam	30	15%	68	10.7	1.2	2.7
Scallop (Pecten maximus)	10	18%	105	17.5	0.1	-
Mussel (Mytilus edulis)	3	20%	87	17.2	2.0	2.9
Oyster (Ostrea edulis)	5	12%	51	10.8	0.9	-
(Crassostrea virginica)	5	15%	66	12.0	2.5	6.5
Walnut (Juglans nigra)	-	64%	525	10.6	51.5	5.0
Bean (Phaseolus vulgaris)	-	100%	272	22.1	1.7	45.0
Maize (Zea mays)	-	64%	123	4.1	2.3	22.8
Pumpkin (Cucurbita pepo)	-	81%	15	0.6	-	3.4

Table 6. (cont.)

Species	Individual Meat Yield (g)	Edible Portion	Kcal/ 100g	Protein (g/100g)	Fat (g/100g)	Carbohydrate (g/100g)
Eel (*Anguilla anguilla*)	400	67%	201	20.6	13.2	-
Duck (*Anas* sp.)	800	40%	339	19.6	29.0	-
Turkey (*Meleagris gallopavo*)	3500	57%	171	28.0	6.5	-
Rabbit (*Sylvilagus floridanus*)	800	62%	179	27.3	7.7	-
Deer (*Odocoileus virginianus*)	32,500	58%	198	35.0	6.4	-

Sources: Paul and Southgate 1978:106-237; Borgstrom 1962:117, 120; Watt and Merrill 1963; Bailey 1975b (III):6, 22.

regards. The proportion of edible flesh to gross weight is generally low among molluscs, with the notable exceptions of abalone, whelk and limpet. Individuals are also typically quite small, so each contains only a small portion of meat relative to many other animal species. These two characteristics in combination mean that gatherers must be willing to expend a great deal of energy in collecting heavy loads of shellfish, only a small proportion of which is edible meat, and laboriously extract the meat from each individual "package." In Chapter II, several procedures were discussed whereby shellfish gatherers were able to expedite the extraction process for some species, but the preparation of spiral-valved gastropods seems to have necessarily involved labor-intensive procedures.

The caloric content of shellfish also ranks lower than that of many other resources. Only in protein content do molluscs compare favorably with many other resources, generally ranking only slightly lower than most fish, and equivalent to or higher than the majority of plant foods. Oysters and several other species contain high quality protein with all the essential amino acids present in adequate amounts (Borgstrom 1962:124). Sunflower (Helianthus sp.) and pecan (Carya illinoensis) are among the few plant species which can provide equivalent complete proteins (FAO/WHO 1973:38-39; Paul and Southgate 1978:283).

Molluscs usually have low fat content, although this can vary seasonally in response to water temperatures and spawning. They also contain relatively large amounts of thiamine, iodine and trace minerals, but are deficient in vitamin C (Craig and Psuty 1971:131; Rostlund

1952:3).

Alan Osborn reviewed the nutritional content of coastal resources and drew several conclusions at odds with my interpretation. He maintains that marine food resources offer a low subsistence "pay-off."

> One can see, therefore, that shellfish collecting is a labor-intensive strategy in which not only does the food item contain less "optimal" amounts of protein, but also producers in the society would have to spend an inordinate amount of time each day or so collecting food for dependents (Osborn 1977b:172).
>
> Based upon this relationship between amount of protein and the amount which is edible in an animal resource, we can see that mollusks and echinoderms would be exploited less intensively than all other food items (Osborn 1977a:156, also see 1980).

I think Osborn errs in these conclusions. His characterization of shellfish gathering as a labor-intensive activity is accurate insofar as small packages of meat must be individually collected. But he wildly exaggerates the processing time for bivalves by applying a modern industrial hand-shucking rate of 2 seconds/animal (Osborn 1977a: 207-211), when mass roasting or boiling were very probably the most common methods used prehistorically, resulting in a tremendous savings in time and energy. That molluscs contain less "optimal" amounts of protein is true only in comparison with terrestrial animals. It is more appropriate to compare molluscs with other gathered foods (Suttles 1968:61n), the majority of which contain far less protein by weight. Osborn is also incorrect when he burdens "producers in the society" with long days spent collecting shellfish for dependents. The short periods of daily ebb tides are adequate time for successful gathering, to a large extent regardless of the physical strength and skill of the gatherer, who may in fact be a "dependent" (Gusinde 1937:

360; Goodale 1971:168; Meehan 1977b:524-527).

The intensity of molluscan exploitation is only partially determined by the average size and nutritional makeup of the different species. At least as important are molluscan habitat characteristics. The most commonly gathered species are either sessile in their mature forms or move within tightly limited ranges. In especially nutrient-rich habitats, such as tidal estuaries or river shoals, molluscs are concentrated in great abundance. From the point of view of a human food gatherer, these compact resource clusters offer animal protein, readily procured and constantly available throughout most or all of the year, to be found in predictable locations. Gatherers are virtually assured of successfully meeting their subsistence requirements with several such reliable resources available during lean times (Goodale 1971:168; Warren 1975:165; Meehan 1975b:526; Stark and Voorhies 1978:279; R. Jones 1980:136-138; Perlman 1980:283; Yesner 1980:729). Shellfish could serve as a small, constant dietary supplement or a critical emergency staple. In either case, the effect is to reduce survival risks, for individuals and the society.

The adaptive value of shellfish collecting may be disproportionately conferred among members of the society. During times of relative scarcity, adult male hunters may have to range widely for game, far from women, children and old people with few alternative protein sources. Since daily protein intake has more effect on an individual's health, particularly _in utero_ and during early childhood, than large periodic feasts (Meehan 1975:197), small quantities of molluscan meat can prove an essential element in a society's total exploitative strategy.

Origins of Intensive Molluscan Exploitation

By the end of the Pleistocene epoch in western Europe, where the excavated archaeological evidence is most adequate, there was a trend toward expanding subsistence bases to include many more small animals and molluscs. The dominant hunting specialization apparently characteristic of the Upper Paleolithic was dependent on the presence of large game, which became increasingly scarce with numerous species going extinct as the glaciers retreated. In those times of environmental fluctuations and stress, resources previously unavailable or of little importance compared to the abundant herd animals and other large mammals increasingly came to be depended upon on a regular basis. A strategy of resource generalization conveys an important adaptive advantage to a population by providing resources to fall back on in case the principal food source should temporarily fail (Segraves 1974: 537-538; Gould 1980:93). Why earlier humans did not also adopt generalized resource strategies is not clearly understood, but the new approach to meeting subsistence requirements may be partially attributable to "the presence of significantly more competent predatory hominids" (Klein 1975:267). In any event, all available evidence indicates that, aside from some wholly opportunistic shellfish exploitation during the Lower and Middle Pleistocene, the earliest significant incorporation of molluscs into regular subsistence regimens occurred in the late Upper Paleolithic (Whitehouse 1968; Volman 1978; Straus et al. 1980:150).

After this initial low-level utilization of molluscs, the first signs of an increasing dependence on shellfish began to appear in many areas, until by 3000 B.C. shell middens were a common feature of many of the world's coastlines. The process reflected in shell midden formation involved an intensification in scheduled subsistence activities, specifically, a focusing of efforts on high yield resources during appropriate seasons. Molluscs were no longer simply a redundant minor resource, but now fulfilled a recurrent seasonal need. This shift in strategy occurred on a global scale, so archaeologists attempting to explain this phenomenon usually turn to other equally wide-spread, contemporaneous phenomena. The most discussed, and most controversial correlate of intensified molluscan exploitation is the gradual increase in world-wide, post-Pleistocene human populations.

Martin Wobst (1976:57) has argued that linearly distributed resources, such as those found in littoral or riverine ecozones, can be successfully exploited only after the population density of a region reaches a certain minimum level. Below that density, a linearly arranged population could not maintain an effective mate exchange and communications network. According to Wobst's model, North America reached this population density by the end of the Plesitocene, when local variations in technology and adaptation began to appear. Cultural differentiation could also have been promoted by increased sedentism made possible by exploiting reliable and locally abundant coastal resources.

An alternative model stands on the premise that ever-expanding human population density would eventually place considerable stress on optimal food resources and lead to the use of less efficiently exploited resources, such as marine animals (Clark 1977:325-326; Cohen 1977:15; Osborn 1977b:161, 195; Straus et al. 1980:152, 1981:674; Clark 1981:444). This is just one of many "population pressure" models which has been advanced to explain almost every aspect of human cultural evolution, in spite of overwhelming evidence that modern human societies closely regulate and maintain population size and stability, and that population pressure is not an independent variable capable of explaining culture change (Hassan 1980). The first scenario, based on Wobst's ideas, does not explain the shift in exploitative patterns, but it does specify population density as a limiting factor and a necessary pre-condition for occupying a previously under-utilized niche (i.e., the successful adoption of a subsistence strategy which includes shellfish gathering as a significant element).

David Yesner (1981) suggests that coastlines must first have stabilized, following the rapid post-Pleistocene fluctuations and overall rise in sea-level, before shellfish could have become sufficiently abundant to permit intensive exploitation supporting large human populations. Although considered to have occurred quite rapidly in geological terms, sea-level fluctuations would have been barely, if at all, perceptible to early Holocene hunter-gatherers. As rising waters altered molluscan habitats or put offshore shellbeds beyond reach, estuaries and other suitable habitats were constantly being created and very probably were continually exploited to some extent. In most locations, the earliest shell middens are now inaccessible to archaeologists, being either submerged by modern seas or buried by alluvial silt. But in a few places, prehistoric accomodation to marine transgressions and regressions over modern land surfaces is evident in the locations of shell middens at varying distances from present shorelines (Holmes and Trickey 1974:122; Fairbridge 1976:359; Jardine and Morrison 1976; Taira 1980:79).

Coastal and riverine resources are not homogeneously distributed, but are, instead, most diverse and abundant in locations of high nutrient influx, such as estuaries, river mouths, and areas of upwelling currents. Since the most densely clustered molluscs are filter feeders, relying on nutrients of no direct use to humans (O'Shea 1981:169), their exploitation would seem to simply involve the addition of a highly productive resource to a terrestrially-based economy (Tartaglia 1980:180). However, the exploitation of coastal resources may present serious difficulties to hunter-gatherers. Assuming that a region's population meets Wobst's density requirements, there may still be considerable advantage to locating home base camps away from the coast, where hunters would have access to a larger hunting range than if the camp were located along shore (Bailey 1978: 44). The earliest intensively exploited coastal zones must have been exceptionally productive (of a variety of resources, not just molluscs) for hunter-gatherers to abandon portions of their terrestrial range. The most common solution to this dilemma apparently was to maintain group mobility (Bailey 1975b (X):6; Whitlam 1981) and exploit coastal resources only during seasons of low terrestrial productivity (Clarke 1976; Osborn 1977a:173; Perlman 1980:290).

Internal Variation in Molluscan Exploitative Strategies

Once shellfish gathering was incorporated into a subsistence system, various environmental or social changes might occur which could alter the role of that resource in the overall economy. For example, a shift in average size or variety of the collected molluscs could dramatically affect the amount of meat obtained and the efficiency of collection procedures. Explanations for such changes in strategy are still elusive but a number of possibilities have been proposed.

Several archaeologists have reported decreases in average limpet shell size between the late Pleistocene and early Holocene times (Volman 1978:911-913; Klein 1979:154; Straus et al. 1980:149-150, 1981:666). They attribute this change to an intensification of shellfish gathering. According to their line of reasoning, gatherers would naturally attempt to maximize yields and minimize energy expenditure by preferentially selecting large individuals. Given a low intensity of collection and a rapidly reproducing species, the average size of collected molluscs will remain large. However, if collecting activities are intensified while the species' reproduction rate remains constant, then the average size of the remaining shellfish will decrease over time.

Ethnographic sources are rather equivocal on this point. Among several modern societies, shellfish gatherers generally attempt to gather large amounts of meat (Meehan 1975:118), although this does not necessarily imply that only the largest shellfish are selected. Since shell weight increases in an allometric relationship to shellfish meat weight, the additional energy expended to collect a heavy, large individual may nullify any advantage gained from the extra meat. But, in general, the argument seems plausible that continued intense collecting pressure on a finite mollusc population will eventually depress size range and average size of individuals. One should not infer from this that the decrease in size of archaeological limpets (mentioned above) is necessarily due to intensified exploitation, since the archaeologists have neglected to rule out environmental changes as causative factors. In this instance, warming of coastal waters at the close of the Pleistocene is an equally likely explanation (Bailey 1975b (IX):56). In at least one situation, where environmental change was unlikely and intensifying exploitation was predicted, no significant change in average shell size was observed (Voorhies 1976:49-51).

A few attempts have been made to estimate prehistoric annual predation rates, measures of the actual intensity of molluscan collection by human gatherers. Based on experimentally determined collecting rates and modern biological analogues for shellfish population dynamics, annual predation rates as high as 40% have been calculated (Goldthwait 1935:6-7; Parkington 1976:135; Voorhies 1976:50; Lightfoot and Ruppe 1980:52; Anderson 1981:117). These studies emphasize the vulnerability of most shellbeds to overexploitation.

Changes in relative proportions of species or of absolute presence and absence of exploited species are also frequently reported from stratified archaeological sites. The explanation most often given is that localized environmental change radically altered available shellfish habitats. In some cases, environmental disturbances do appear to be the ultimate cause of shifts in species representation in shell middens. Two well-documented examples are the virtual absence of oysters from the upper strata of middens 1) surrounding San Francisco

Bay due to bay subsidence and siltation which produced unfavorable bottom conditions for oysters (Nelson 1909:375-378; Greengo 1951:7-16) and 2) in northern coastal New England, due to cooling water temperature (Braun 1974). In both cases, the archaeological interpretations are independently confirmed by geological evidence.

In numerous other instances, there was a tendency through time to exploit species with smaller individuals, either in place of or in addition to the large species originally collected. Archaeologists have generally treated each of these situations by recourse to ad hoc suggestions of local environmental perturbation without offering any corroborative evidence. These trends toward increased species diversity and smaller sized individuals occur in a wide variety of environmental settings, including the Fraser River Delta of British Columbia (Ham 1976:77-78), southern Brazil (Hurt 1974:5-8), southern California (Meighan 1959; Tartaglia 1976:128; Botkin 1980:131-132), Okinawa (Pearson 1969:180), New Zealand (Coutts 1971a:190-191; Allo 1972:70, 78; Anderson 1979:59), Australia (Lampert 1971:59-61; Coutts 1970a:26, 75, 84), Spain (Straus et al. 1908:150), the Capsian escargotieres (Lubell et al. 1976:915-919), and the South African coast (Voigt 1975: 89-92). Because of the seeming universality of the trend, the problem begs to be resolved from a generally applicable theoretical stance, instead of perpetually appealing to an environmental deus ex machina.

As noted immediately above, exploitation of molluscan populations at least occasionally reached very high rates of predation, up to 40% annually. If a preferentially selected species was exploited beyond its ability to reproduce, then molluscan exploitation may halt temporarily to permit the shellfish population to recover, or other less desirable species with faster replacement rates could be collected in the interim. If the preferred species was repeatedly overexploited, one might expect that that species would be perceived by the gatherers as an undependable resource, and a permanent shift in strategy would ensue. The new strategy would probably simply involve an addition of resources to the subsistence base, but the original resource might not be retained if its continued exploitation entailed scheduling difficulties. This scenario is similar to the model presented by Atholl Anderson, who argues that the optimal molluscan collecting strategy is to readjust selection criteria constantly so as to obtain the most meat by collecting the largest individuals available regardless of species (Anderson 1979, 1981). While Anderson's model may be too simplistic, efforts by shellfish gatherers to continue obtaining high meat yields in the face of depleted resources are primarily responsible for the archaeologically observed trend toward great species diversity in shell midden refuse.

Shellfish Gathering, Population Growth, and the Origins of Agriculture

A commonly proferred explanation for both the intensification of shellfish gathering and the development of agriculture is that of inexorably increasing and expanding human populations which eventually were unable to support themselves by hunting and gathering a limited range of "preferred foods." Mark Cohen, one of the foremost proponents of this viewpoint, maintains that, after about 11,000 B.P., hunter-gatherers

> ... were forced to become even more eclectic in their

> food gathering, to eat more and more palatable foods, and in particular to concentrate on foods of low trophic level and high density [e.g., shellfish]. In the period between about 9000 and 2000 B.P. populations throughout the world, already using very nearly the full range of available palatable foods, were forced to adjust to further increases in population by artificially increasing, not those resources which they preferred to eat, but those which responded well to human attention and could be made to produce the greatest number of edible calories per unit of land (Cohen 1977:15; also see Osborn 1977b and Straus et al. 1980).

Other theorists have responded to this sort of population-pressure model by pointing out that human population does not inevitably increase, and that selective pressures on group size and cultural population controls can effectively maintain, decrease or increase the size of a small population depending on their perceived ability to support the group (Hassan 1980:313). Furthermore, population growth is more likely to have been an effect rather than a cause of increased technological efficiency, intensified subsistence exploitation, and changes in social organization which raise the potential human carrying capacity of an area (Hassan 1980:316, 1981:173; Earle 1980:4, 25; Perlman 1980:292). If such innovations reduce the need for infanticide, abortion, and other malign forms of population control then there may be a strong selective advantage in their adoption (Harris 1979:68-69), even if the innovation demands greater energy expenditures per individual. Given our present understanding of the relationship between subsistence intensification and population growth, the best evaluation of the function of intensive molluscan exploitation is that this subsistence strategy permitted the maintenance of higher population levels than would have been possible otherwise, by supplying high-quality protein during seasons of low resource availability -- albeit at high procurement and preparation costs and enforced seasonal movement to the coast for inland groups.

In several places around the world, the earliest evidence for the use of plant domesticates occurs either at shell middens or at non-shell sites occupied by seasonal shellfish gatherers involved in other pursuits. This frequent co-occurence emphasizes the general pattern of resource diversification and the intensified exploitation of selected species which characterized the Mesolithic/Archaic to Neolithic/ Woodland transition. However, the relationship between shellfish gathering and plant domestication is even more complex, because in most instances when domesticates began to play a significant role in a subsistence strategy, shellfish gathering declined rapidly in importance. In these cases, the plant domesticates which appear to have precipitated the eventual abandonment of shellfish gathering contain large amounts of proteins and fats. It has already been argued that protein acquisition was very probably the principle reason for shellfish gathering by many societies, so one might surmise that a plant domesticate which provided equivalent benefits at lower cost would quickly replace that activity. If available domesticates did not fulfill this need, then shellfish gathering would remain an essential activity (as suggested by Osborn 1977a:354-355).

Although evidence for incipient agriculture in most areas of the world is still quite meager, a pattern seems to be emerging from archaeological cultures with shell midden sites. In riverine shell middens of eastern North America, squash remains have been discovered which date as early as 2400 B.C. Domesticated sunflower and sumpweed achenes are found in some abundance in sites slightly post-dating the large shell middens (c. 900-400 B.C.) (Chomko and Crawford 1978; Brewer 1973). Since the seeds of both species have high protein contents, it seems logical to infer that their use could have obviated the need for river mussels. They seem to have continued as significant dietary constituents until they in turn were largely superceded by even higher protein beans, Phaseolus vulgaris (Richard A. Yarnell, personal communication, 1982).

From Japanese Jomon period shell middens, small quantities of gourd, millet, barley, and buckwheat have been recovered from early contexts, but not until Late Jomon do high protein beans appear to have been domesticated (Crawford et al. 1978; Gary Crawford, personal communication, 1981). Canavalia beans have recently been discovered in early Valdivia period (c. 3300 B.C.) shell middens on the Ecuador coast (Damp et al. 1981), but domesticates do not seem to have played an important dietary role until the end of intensive shellfish gathering (Cohen 1977:266). Similar developments probably occurred in pre-ceramic Peru (Craig and Psuty 1971:130), Ertëbølle period Denmark (Bailey 1975b (VIII):6), and elsewhere, but the precise sequence of events is unknown. In situations where agriculture was not adopted, such as by the Australian aborigines on the Torres Strait, abundant marine protein sources, including molluscs, supported a dense population without necessitating recourse to plant domesticates (Bailey 1981:10). In other cases, low protein/high calorie root and seed crops were grown on a large scale by such groups as the New Zealand Maori and Virginia Powhatan, but the need for protein was still met mainly by hunting, fishing and shellfish gathering.

All of these cases can be considered to be populations limited by the least abundant essential element, which seems to have been protein. When a more efficient means of procuring protein appeared, then intensive shellfish exploitation could safely be replaced as a supplemental protein source, even though coastal populations still might turn to shellfish during times of famine or starvation. Increased regional integration of subsistence economies, from Neolithic times to the present, also contributed to the decline in importance of molluscan resources. Even the most intensive exploitation of limited shellfish resources could not supply significant amounts of meat to large inland populations, so shellfish frequently assumed the role of luxury items on the regional scale (e.g., as oysters did in the Roman Empire), although some species might remain elements of local diet (Bailey 1975b (II):12; Lethbridge 1928; Prummel 1975:228).

Part 2

A SPECIFIC LOCALE

Chapter IV

SHELLFISH EXPLOITATIVE STRATEGIES IN THE LOWER POTOMAC RIVER VALLEY

Introduction

In the previous five chapters I have tried to sort through the large number of archaeological reports dealing with shell midden excavation and interpretation and extract any concepts and methods of proven worth. This has involved critically selecting and reworking procedures and models employed by other archaeologists and interjecting many of my own ideas to produce a unified approach to shell midden archaeology, which focuses attention on the internal structure of middens consisting predominantly of faunal remains. If such a structural approach has any value, it lies in the enhanced understanding obtained from applications to specific research problems. In this chapter, I present an analysis of data on shellfish gathering at a stratified site in the lower Potomac River Valley dating from c. 3000 B.C. to A.D. 1700. The research problems in this particular case were threefold: 1) to determine the role of shellfish gathering in relation to the total seasonal subsistence round during this period, 2) to determine the significance of shellfish gathering to the overall settlement-subsistence strategies employed, and 3) to ascertain the relationship of shellfish gathering strategies to changes in other aspects of subsistence (especially, the introduction of cultigens) and to changes in social organization (i.e., the development of chiefdoms).

Previous Research

The history of archaeological investigations of Potomac River shell middens, and indeed of Chesapeake Bay middens in general, is essentially a long series of conjectures and hypotheses with only an occasional reference to the archaeological record for support or refutation. One exception was William H. Holmes, who took considerable interest in the shell middens in the late nineteenth and early twentieth centuries and initiated a survey of them for the Bureau of Ethnology, conducted mainly by William Dinwiddie in 1891 and 1892 (Holmes et al. 1891). Holmes thought that the Chesapeake Bay oyster shell middens may have accumulated during winter and spring occupations, and that the inhabitants had spent the remainder of the year further inland (1907: 120). The importance of oysters to the general subsistence was a matter of some debate, with viewpoints ranging from "more of a luxury than a necessity" (Reynolds 1889:257) to an important "means of sustenance" (Holmes 1907:127).

William Marye noted a close correspondence between locations of shell middens and locations of large oyster bars, during a survey of northern Chesapeake Bay in 1916 (Marye 1938:123). But aside from a few notable attempts at reconstructing lower Potomac Valley culture history (e.g., Manson 1948; Evans 1955; Stephenson and Ferguson 1963; Schmitt 1965), little progress was made in unravelling the region's prehistoric past for the next five decades. Interest in shell middens revived in the early 1970's when Charles McNett and William Gardner surveyed portions of the Maryland shore of the river and excavated at several sites. Their only published interpretations of these sites, considered specifically as shell middens, are contained in two short preliminary articles and were presented simply as testable hypotheses. They suggested that oyster collection occurred mainly in the fall and winter, in contrast to Holmes' proposition (McNett and Gardner 1971: 28). Furthermore, they hypothesized that oysters had been of little importance during the Late Archaic period, but that intensive oyster exploitation began in the Early Woodland period and increased during the Middle Woodland -- all due to the appearance and improvement of pottery which made possible the boiling or steaming of the shellfish (Gardner and McNett 1971:50-51). In offering this proposition, they ignored considerable evidence (in the form of characteristic projectile point types and steatite bowls found on numerous shell middens) that many large Chesapeake Bay shell midden sites were occupied during at least the Late Archaic and possibly the Middle Archaic periods (cf. Holmes 1907:Figure 17, 1897:Plates 35, 36, 42; Stearns 1943). Even a brief review of world prehistory would indicate that pottery was not a prerequisite for intensive shellfish exploitation.

Stephen Gluckman expanded somewhat on McNett and Gardner's hypotheses by predicting that both fishing and shellfish gathering would be found to have increased in importance during the Early and Middle Woodland periods. Furthermore, he suggested that the locations of these activities were probably the largest sites occupied during those periods (Gluckman 1973:103-105).

Very little else has been published on the subject for the Chesapeake Bay region, neither tests of these propositions nor further hypothetical musings.

White Oak Point Site: Research Design and Implementation

Considering our vast ignorance of prehistoric shellfish gathering in the Chesapeake Bay region, the primary need seemed to be to combine intensive survey with excavations in a number of sites of broad temporal range. These requirements were met by a survey of a portion of Northumberland County and excavations at three archaeological sites in Westmoreland and Northumberland counties, Virginia. The survey was directed by Stephen R. Potter and assisted for one season by this writer. The survey data, analyzed and incorporated in Potter's recent dissertation (1982), form the basis of some of the final conclusions of this chapter. The bulk of the excavated data considered here comes from the White Oak Point site, 44WM119, a large, deeply stratified shell midden located near the mouth of Nomini Creek, a tributary of the Potomac (Figure 7). In the course of these excavations, evidence of 26 occupation areas or archaeological components was found and is presented in some detail in Appendix A and summarized in Table 7. Some additional comparative information was made available by Stephen Potter in the form of faunal remains from three components at two sites in Northumberland County (presented in Waselkov 1982).

Since so much of the following analysis is based on material excavated from a single site, the advantages and disadvantages of such a situation ought to be made explicit. By observing culture change over a long period of time at one location as opposed to comparing several different sites, certain environmental variables can be held constant or at least the effects of their variation lessened. A potential disadvantage may be that the location selected for intense

Figure 7. Nomini Bay and the White Oak Point Site, 44WM119.

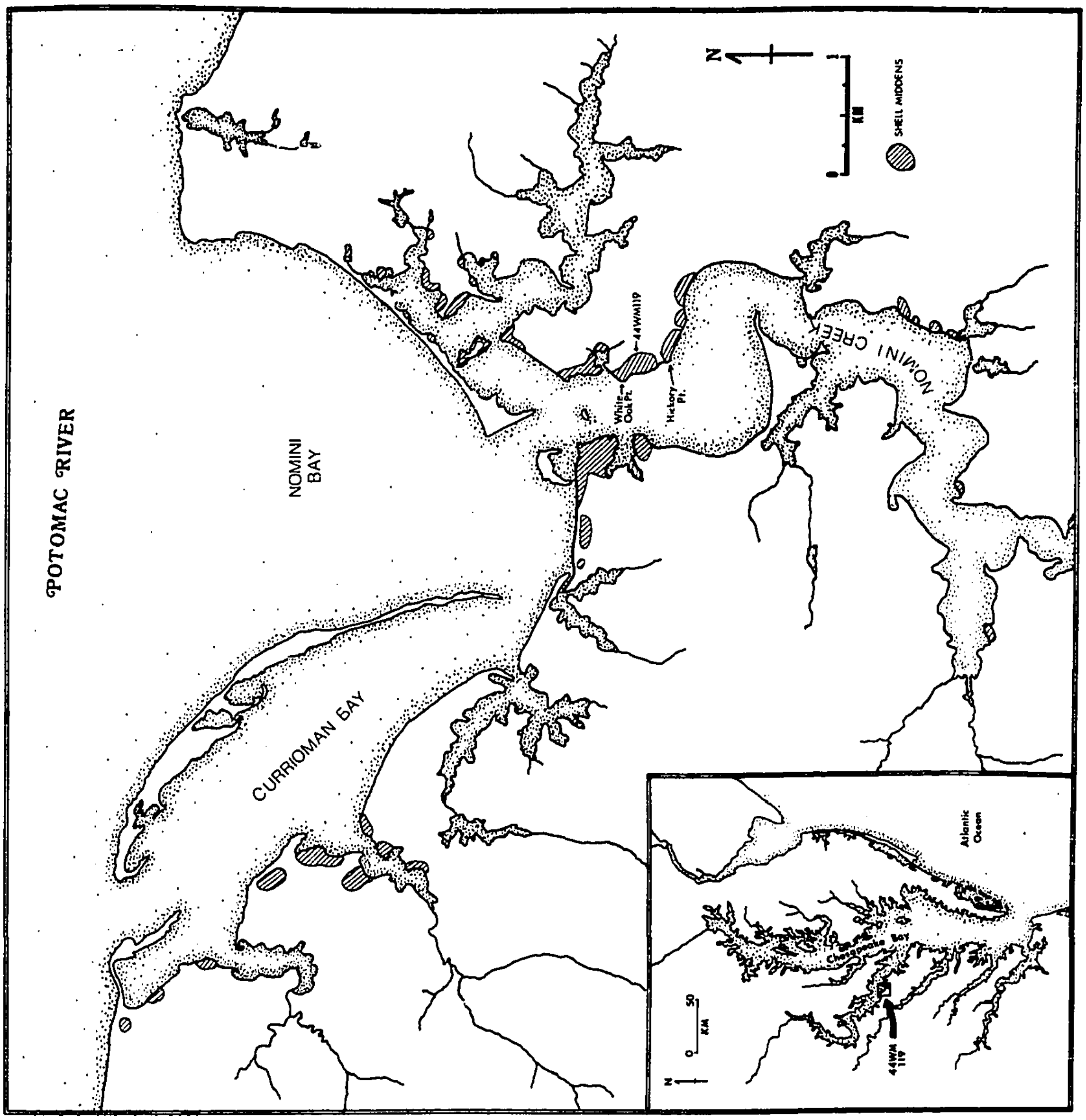

POTOMAC RIVER
NOMINI BAY
CURRIOMAN BAY
NOMINI CREEK
White Oak Pt.
Hickory Pt.
44WM119
KM
SHELL MIDDENS
N
Atlantic Ocean
Chesapeake Bay
KM
44WM 119

Table 7. Archaeological Components at the White Oak Point Site.

Period	Component	Approximate Date	Volume of Excavated Midden (m^3)
Late Archaic	LA1	2000 B.C.	-
	LA2	1550 B.C. ± 75, uncorrected	1.21
	LA3	3000 B.C.	-
Early Woodland	EW1	1110 B.C. ± 75, uncorrected	1.27
	EW2	1160 B.C. ± 70, 1070 B.C. ± 70, uncorrected	4.57
	EW3	900-400 B.C.	0.23
	EW4	900-400 B.C.	1.03
Middle Woodland	MW1	400 B.C.-A.D. 300	2.91
	MW2	400 B.C.-A.D. 300	3.00
	MW3	400 B.C.-A.D. 300	1.30
early Late Woodland	LW1	A.D. 700-900	-
	LW2	A.D. 700-900	0.58
	LW3	A.D. 700-900	0.77
	LW4	A.D. 880 ± 60, uncorrected	1.81
	LW10	A.D. 860 ± 60, uncorrected	1.39

Table 7. (cont.)

Period	Component	Approximate Date	Volume of Excavated Midden (m^3)
late Late Woodland	LW5	A.D. 1100-1300	1.46
	LW6	A.D. 1310 ± 50, A.D. 1460 ± 45, uncorrected	0.48
	LW7	A.D. 1005 ± 70, uncorrected	0.95
	LW8	A.D. 1340 ± 55, uncorrected	2.54
	LW9	A.D. 1300-1450	1.12
	LW11	A.D. 1400-1500	1.06
Protohistoric/Early Historic	P/EH1	A.D. 1500-1640	0.84
	P/EH2	A.D. 1500-1640	0.09
	P/EH3	A.D. 1510 ± 75, A.D. 1540 ± 55, A.D. 1630 ± 55, uncorrected	3.55
	P/EH4	A.D. 1640-1700	0.23
Historic Euramerican	HE1	A.D. 1700-1800	-

scrutiny is atypical of the region and that results obtained there may not be widely applicable. Whenever possible, the White Oak Point findings have been compared to other sites in the region and have been found to be substantially corroborated.

Specific sampling procedures and analytic methods are described when appropriate in the following discussion.

Midden Composition and Structure

Of the 26 archaeological components recognized in the excavated portion of the White Oak Point site, four were represented only by artifacts found in the plowzone or mixed in later cultural context (i.e., Late Archaic 1 and 3, Late Woodland 1 and Historic Euramerican 1; hereafter component designations are abbreviated, such as LA1 or LW1). The remaining 22 components consisted of clusters of associated features, principally refuse heaps and various intrusive pits and basins. Since all of the components were only partially excavated, the proportions which were excavated and precise dimensions of the components remain unknown. Perhaps some notion of the original extent of the occupation areas can be obtained from the largest "maximum linear dimensions" observed in the excavated area (see Appendix A), ranging from about 6 to 12 m, except for one component (P/EH3), which was 19.6 m across. In each component, there were activity areas with little refuse buildup, and contiguous piles of primary refuse, which together constitute the fundamental unit of midden accumulation. These components closely resemble the ethnoarchaeological example of an "incipient shell mound" described and illustrated by Peterson in Cape York, Australia (1973:187, Plate 3). Isolated components of comparable size and composition also occasionally are found in archaeological contexts. Three are reported from coastal Virginia (44NB147 - 5.0 m x 3.5+ m, 44NB172 - 5.5 m x 3.6 m, 44NB174 - 6.1 m x 9.8 m; Potter 1982:209, 235), and one has been discovered in western Tennessee (40HR212 - 3.5 m x 7.0 m; Dye 1980:15, 97, 221). Successional occupation of the same general location at White Oak Point eventually resulted in an archaeological site covering about 6 hectares.

While the White Oak Point components do indeed seem to represent discrete occupation and shellfish preparation areas, their temporal relationship one to another is a more difficult problem to resolve. Even though considerable advances have been made recently in our understanding of Middle Atlantic prehistoric culture chronology, temporal resolution is only to within 200-300 years at best for most of the Woodland period. So adjacent components with similar pottery and projectile point types may have been precisely contemporary, occupied by different families of a larger social group, or the components may have been occupied successively. There is little in the archaeological record to distinguish between these two alternatives. At White Oak Point, attempts were made to match broken artifact fragments (e.g., potsherds and projectile point fragments) between components dating to the same era. But no matches were found, in striking contrast to the considerable number of matches made within components. So one can somewhat hesitantly conclude that occupations of at least this portion of the site were by only a few people (perhaps 10 to 12) at a time, whose on-site activities were confined to a relatively limited area.

The components are composed of a rather narrow range of feature types. The most basic distinction can be drawn between intrusive features (pits or basins) and extensive features (lenses of material deposited directly on the ground surface). In the excavated portions of the site, 81 extensive features were recognized, including 78 layers or heaps of midden and two clay lenses. The clay lenses, located in components MW2 and LW3, were formed when pits were dug into the subsoil, through the B_1 horizon yellow clay, to reach the B_2 horizon blue clay, probably a raw material for pottery manufacture. The unwanted yellow clay was piled adjacent to the pits from which it had been dug.

The remaining 78 extensive features are shell midden heaps which are diverse in form, varying both in depth and shape, both of which are usually quite irregular. In general, the layers are thickest near their centers and taper gradually toward the edges. The largest intact example of this sort of feature was found in Component EW2 (Figure 8). All of these features are interpreted as refuse heaps, for reasons to be explained shortly.

Among the 41 intrusive features were 35 broad shallow basins, 3 deep symmetrical pits (LW6 - Feature #4, P/EH2 - Feature #25, P/EH4 - Feature #129), 2 shallow burial pits containing human skeletal remains (P/EH3 - Feature #127 and P/EH4 - Feature #131), and one probable clay extraction pit (MW2 - Feature #126). Another probable clay extraction pit corresponding to the clay lens (Feature #69) in Component LW3 was located, with the aid of a soil auger, in the unexcavated unit immediately to the east of that feature.

Intrusive features became more common in the later periods of occupation at White Oak Point (Table 8). The deep pits closely

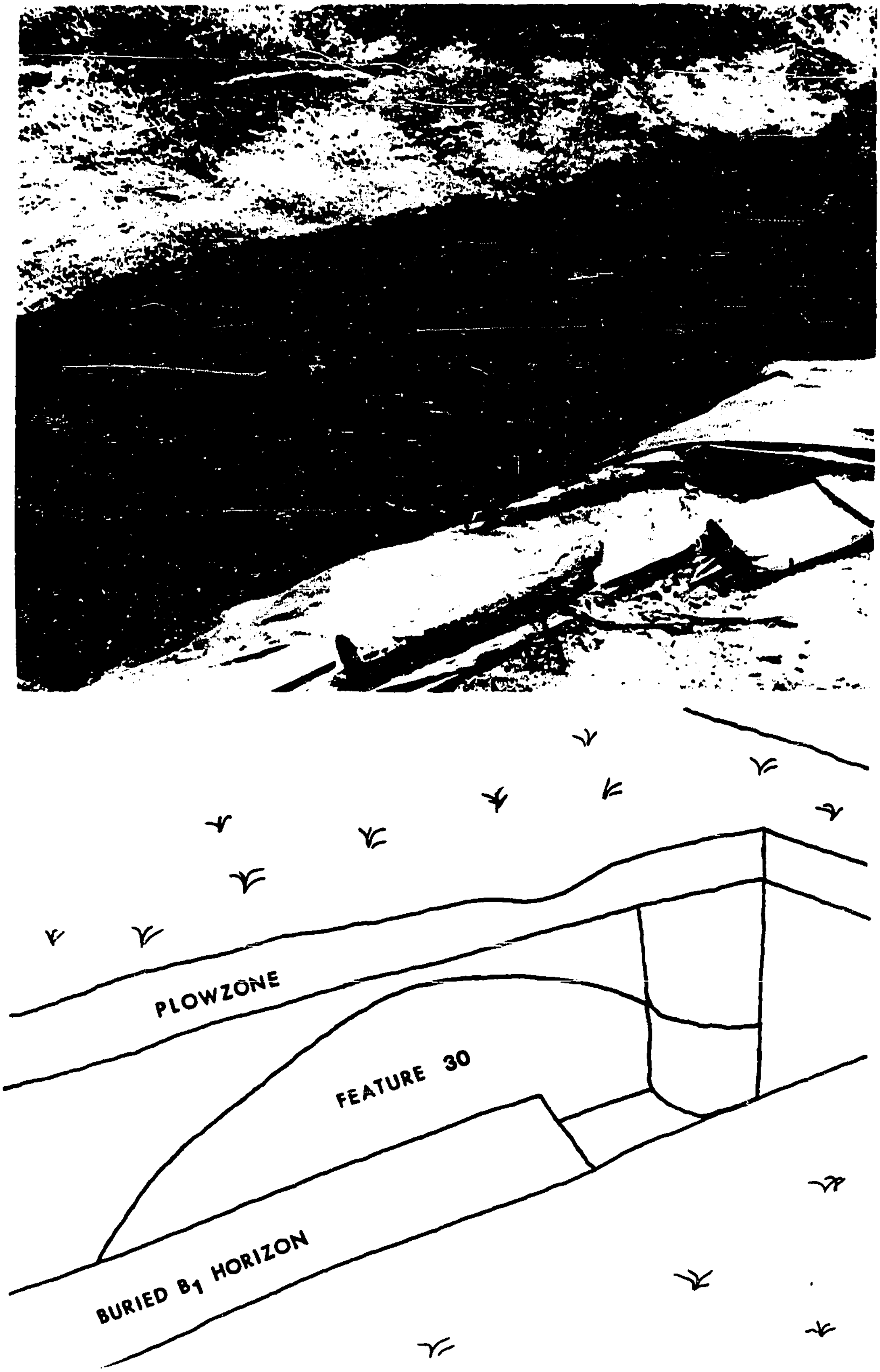


Figure 8. Cross Section of Extensive Feature #30, Component EW2.

Table 8. Feature Tabulation.

Cultural Period	Extensive Features	Intrusive Features	n
Late Archaic	100%	-	2
Early Woodland	100%	-	16
Middle Woodland	90%	10%	20
Late Woodland (early)	88%	12%	17
Late Woodland (late)	54%	46%	37
Protohistoric/Early Historic	33%	67%	30

resemble storage pits commonly found on non-shell sites in the Middle Atlantic, and they probably served a like function here in late Prehistoric/Protohistoric contexts. However, it is the increase in the number of basins which accounts for most the observed trend. The basins are probably shellfish roasting (including baking and steaming) basins.

Roasting was the principal method used to open bivalves by all inhabitants of the site. Tremendous numbers of calcined shells were found in most components, which indicates that the shells had been heated to high temperatures (such as during roasting) creating a powdered calcium carbonate precipitate. During early occupations of the site, shellfish were apparently roasted directly on the ground surface and the discarded shells form the bulk of the extensive layers and heaps. The thinnest of these extensive layers may have been living areas where primary refuse disposal was minimal. Not until the second half of the Late Woodland period was most shellfish preparation done in shallow basins. The refuse discarded from this operation formed the familiar extensive features and also filled the intrusive basins. This alteration in shellfish preparation methods may seem minor, but it had an important effect on the nature of the archaeological site by mixing some of the deposits. The shift in procedure also may have significantly improved the efficiency of shellfish cooking.

In Chapter III, several processes were enumerated which could create mixed assemblages from previously distinct strata: downward filtration of objects through loosely consolidated midden matrix, slumping of steeply piled debris, intentional levelling of uneven ground surfaces, and the digging and subsequent filling of intrusive features are some of the primary ones. Although slumping and intentional levelling probably occasionally occurred at White Oak Point, I have not been able to identify any specific instances of those processes. Downward filtration definitely occurred, but to what extent is difficult to quantify. Based on the vertical distribution of potsherds, which are the most sensitive temporal indicators at this site, downward filtration seems to have been limited to small items, less than 1 cm in size, and apparently did not occur systematically or on a large scale (that is, most small objects were not affected and remained in original stratigraphic context). Redeposition during the digging and filling of the basins and the few other intrusive pits was responsible for most of the mixing evident at this site. Even so, the problem was not as serious as it could have been. Just three of the features dating from Late Archaic through the early Late Woodland periods contain redeposited material. And many of the later intrusive features are intrusive into nearly contemporaneous features (i.e., features deposited only a short time previously during the same occupation). The mixing has created some interpretative difficulties, however. When particular features contained considerable amounts of mixed ceramics, the associated balk flotation samples were not used for plant and animal remains analyses.

In two cases, radiocarbon dates were obtained from Late Woodland features which actually applied to underlying components. Eight grams of charcoal found in LW8 Feature #53, an extensive midden, were dated to A.D. 880 $\pm$ 60 (DIC-1763), a perfectly acceptable date for Component LW4 from which much of the midden in the feature was derived.

Apparently the feature consists of LW4 midden redeposited during the digging of a LW8 intrusive basin. Similarly, in LW7 Feature #22, an intrusive basin, 8 grams of charcoal gave a reasonable date of A.D. 1005 ± 70 (SI-4374), while 98 grams of oyster shell from the same feature dated to 1110 B.C. ± 75, the age of an underlying EW1 component. In both cases the unexpected dates are closely corroborated by other radiocarbon determinations from unimpeachable contexts, so there is no reason to suspect radiocarbon sample contamination. For example, paired oyster shell and charcoal samples from EW2 Feature #118 yielded dates of 1160 B.C. ± 70 and 1070 B.C. ± 70, respectively; statistically identical results at the 95% level of confidence.

The postulated increased efficiency of shellfish preparation with the introduction of basin roasting is suggested by the possibility that large masses of dead shells might serve the same heat retaining function as sandstone and quartzite cobbles used in the cooking process. An attempt to directly test this hypothesis by calculating the average number of oysters processed per kilogram of fire-cracked cobbles (Table 9) produced ambiguous results with no obvious correlation with the use of cooking pits. However, there is some reason to think that the presence of deep deposits of dead shells was a necessary prerequisite for the adoption of this cooking method. To appreciate the evidence supporting this statement, differences in midden composition throughout the site must first be discussed.

Balk flotation samples from 57 features were analyzed for the proportion of shell to soil (including ash) and the percentages of shell fragments of different size-grades (Table 10). It was discovered that,

Table 9. Standardized Measures of Midden Constituents.

Cultural Period	Oysters/m^3	Projectile Points/m^3	Stone & Ceramic Vessels/m^3	Oysters/kg of Fire-cracked Cobbles
Late Archaic	11,261	5.0	0.8	1,212
Early Woodland	24,876	2.0	2.1	3,479
Middle Woodland	17,706	1.2	1.5	1,669
Late Woodland (early)	32,095	1.8	5.3	7,569
Late Woodland (late)	27,706	1.4	3.7	3,174
Protohistoric/Early Historic	32,459	1.5	3.8	3,705

Table 10. Balk Flotation Samples - Analysis of Midden Features.

Feature Type	Component	Feature #	Shell Size (mm) % ≥5.66	Shell Size (mm) %<5.66	% of Soil in Sample by Weight	Sample Size (kg)
Extensive Middens:						
Sandy Loam/Loamy Clay Soils and Shells	LA2	62	78.1	19.9	66.2	7.4
	EW1	66	84.0	16.0	65.6	12.5
	EW2	111	87.5	12.5	69.8	10.8
		112	92.3	7.7	66.0	10.0
		117	95.9	4.1	33.8	8.0
		118	95.1	4.9	44.8	6.7
		123	83.5	16.5	38.4	2.3
	EW4	71	57.0	43.0	99.9	2.4
		93	82.8	17.2	54.0	4.3
	MW1	57	79.2	20.8	64.1	27.6
	MW2	107	80.6	19.4	78.1	3.5
		119	80.8	19.2	62.9	11.6
	LW2	65	78.6	21.4	54.5	2.2

Table 10 (cont.)

Feature Type	Component	Feature #	Shell Size (mm)		% of Soil in Sample by Weight	Sample Size (kg)
			%≥5.66	%<5.66		
	LW3	68	91.6	8.4	42.8	2.8
	LW4	81	85.1	14.9	66.2	14.2
		96	83.8	16.2	63.0	5.6
		97	83.4	16.6	62.8	7.0
	LW8	83	89.2	10.8	63.1	6.5
		84	78.9	21.1	50.0	4.0
Shells, Dark Sandy Loam and Ash	LA2	61	78.4	21.6	35.2	12.8
	EW1	67	81.8	18.2	32.2	5.1
	EW3	20	74.7	25.3	34.8	2.3
	MW1	11	84.9	15.1	30.5	8.2
		58	83.3	16.7	28.6	5.6
	MW2	120	89.0	11.0	36.2	11.6
	LW2	60	81.7	18.3	37.1	5.2
	LW3	72	89.0	11.0	38.3	1.7
	LW4	114	81.9	18.1	27.4	6.2

Table 10. (cont.)

Feature Type	Component	Feature #	Shell Size (mm) %≥5.66	Shell Size (mm) %<5.66	% of Soil in Sample by Weight	Sample Size (kg)
	LW5	59	76.8	23.2	36.8	5.7
	LW6	56	77.2	22.8	48.1	2.7
	LW7	28	82.6	17.4	26.4	5.3
		50	83.2	16.8	34.3	6.7
	LW8	95	88.1	11.9	40.7	5.4
	P/EH1	55	85.1	14.9	45.0	2.0
Broken Shells and Dark Sandy Loam	LW4	101	71.2	28.8	30.8	10.7
	LW8	94	67.6	32.4	26.7	6.0
	LW9	34	69.3	30.7	26.1	2.3
	P/EH3	99	69.5	30.5	25.6	3.9
Calcined Shells, Ash, and Dark Sandy Loam	EW2	30	90.8	9.2	20.6	25.2
	LW2	24	86.7	13.3	25.0	9.6
	LW4	45	85.2	14.8	22.2	9.9
		80	95.8	4.2	5.6	3.6
	LW7	26	87.1	12.9	22.2	1.8

Table 10. (cont.)

Feature Type	Component	Feature #	Shell Size (mm) %≥5.66	%<5.66	% of Soil in Sample by Weight	Sample Size (kg)
	LW8	85	88.3	11.7	23.9	6.7
		87	90.2	9.8	18.4	17.9
		92	92.1	7.9	22.7	8.8
	P/EH3	51	82.0	18.0	24.0	2.5
		74	89.6	10.4	24.1	2.9
		75	91.4	8.6	23.2	2.0
		88	89.2	10.8	22.1	14.5
Intrusive Basins:						
Calcined Shells, Ash and Dark Sandy Loam	LW2	21	82.8	17.2	19.2	2.6
	LW5	16	84.2	15.8	37.5	16.8
	LW8	86	88.1	11.9	24.0	2.5
	LW9	35	88.9	11.1	20.0	4.5
		42	84.0	16.0	20.0	8.0
	P/EH1	7	74.4	25.6	37.0	2.7
	P/EH3	98	86.8	13.2	20.0	6.0

based on these characteristics, the analyzed features could be clustered into four broad categories roughly equivalent to midden descriptions recorded during excavation (Appendix A). The largest group of features are the extensive midden lenses which contained mainly whole shells or large shell fragments and large proportions of soil to shell. The soil in these features consisted either of the buried A horizon sandy loam/silt loam or the B_1 horizon loamy yellow clay. Apparently when shell refuse was first deposited on the original land surface of any given spot in the site, the midden became mixed with the upper soil zones, probably by a combination of human trampling and bioturbation, thereby creating a distinctive type of feature. As can be seen from Table 10, most of the original ground surface was covered with an initial layer of shell midden by the late Late Woodland period. Once this had occurred, intrusive basins, dug into shell layers, not into the clay subsoil, became more common. Later occupations may perhaps have been situated preferentially in this area of deep midden, reflecting a positive feedback relationship between the presence of old midden and deposition of new midden.

The other three categories of midden are also of interest. Four of the analyzed features contained disproportionately large quantities of finely crushed shell, approaching a third of the samples by weight. Since only a single such crushed shell feature was found in each of four components, perhaps these features indicate the principal activity areas utilized during those occupations.

A larger group of features, including both extensive and intrusive types, consisted mainly of calcined shells, ash and relatively small amounts of dark sandy loam soil. The nature of the midden, indicative as it is of shellfish roasting, and the occurrence of this sort of midden as fill in the intrusive basins, are further evidence that those features were originally used for oyster cooking. The roasted oysters were then raked from the basins, the meat was extracted and the resultant debris fell or was tossed back into the basins.

The fourth class of midden includes a rather disparate group of extensive features with intermediate proportions of broken shell and amounts of soil. The major unifying characteristic is the presence of dark brown sandy or silty loam soil and ash, constituting approximately one-third of the midden by weight. Judging from the soil color, the features would seem to be rich in humus, and considerable quantities of artifactual debris and faunal remains were typically found in them. Whereas the calcined shell heaps seem to have derived principally from oyster preparation, these other features developed from a broader range of activities, the evidence of which is incorporated in the more diverse midden constituents.

This might be an appropriate place to mention that nothing resembling W.H. Holmes' "house depressions" was found at White Oak Point. He described them as follows:

> These depressions are not more than a foot or two in depth and are fifteen to thirty feet in diameter. They are approximately circular... Within the lodge pockets the shells are much blackened with vegetable matter and kitchen refuse... The shells between the lodge depressions... are comparatively free from other classes of refuse and of artifacts (Holmes 1907: 120-122).

Holmes was generally an astute observer and may, indeed, have seen such features. But at White Oak Point, the "depressions" or intrusive basins contained mainly calcined shells -- the intervening extensive refuse was richer in organic debris and artifacts.

The final element of midden composition to be discussed is the nature and origins of the soils incorporated in the shell midden. I have already mentioned that the deepest features mainly consist of shell and other refuse which have become mixed with the upper horizons of the buried soil profile. The dark brown silty or sandy loam soil found in other features cannot be so accounted for, and since the site is not prone to flooding and is not surrounded by higher land forms, alluvial and gravitational deposition were not responsible. Human transport, whether intentional or inadvertant, seems to be the most likely explanation for the presence of this soil.

To try to determine the origin of this soil, several testable hypotheses were devised.

H_1 - The soil may have been brought to the site unintentionally with the oysters.

Several other archaeologists have suggested that the small waterworn pebbles commonly found in shell middens were introduced in the same manner (Nelson 1909:335; Stearns 1943:7; Brennan 1974:85). Fortunately, the type of sediments likely to be found in oyster beds (and, hence, adhering to the collected oysters) can be roughly predicted from the shape of the shells.

> Oysters growing singly on firm bottoms have a tendency to develop round shells ornamented with radial ridges and foliated processes. Specimens living on soft, muddy bottoms or those which form clusters and reefs are, as a rule, long, slender, and sparsely ornamented (Galtsoff 1964:18).

The "firm bottoms" in this section of the Potomac River are either stone or sandy substrates (Frey 1946:59-66), but they seem to have been seldom exploited by the White Oak Point inhabitants, since round shells are rarely found in the midden. So presumably they were frequenting reefs or soft, muddy bottoms. If oysters were primarily collected from reefs, then only small amounts of sediment would have been brought to the site. But if oysters from soft, muddy bottoms were regularly collected then one would expect either clay or fine silt (depending on the specific collecting locale) to be transported to the site on shells.

H_2 - The soil may have been carried to the site on marsh tubers.

> In many cases, however, the pebbles and small fragments of rock doubtless were attached to roots and bulbs dug elsewhere for food. Some of the ordinary earth or dirt in the shell mounds must have been brought in a similarly adventitious fashion (Gifford 1916:6).

Tuckahoe and other marsh plants were used extensively by the coastal Virginia Algonquians in early historic times. Marshes were once extant adjacent to the White Oak Point site, although they have since been destroyed by being used for dredge spoil sites. The marshes could have been a source of clay or silt sediments if tubers actually were gathered by site inhabitants.

H_3 - Soil could have been carried to the midden from the surrounding forests and fields by humans.

H_4 - Another possible source is the soil buried beneath the midden. These last two hypotheses imply that the dark brown silt loam should be nearly identical to nearby surface soils (H_3) or the buried soil (H_4).

In order to test these four propositions, five soil samples were collected: two from features (#132, #133) containing dark brown silt loam, one from the buried B_1 soil horizon (a clay loam), one from the B_1 soil horizon (also a clay loam) from just beneath the plowzone in a field east of the site, and a fifth sample from the sandy bottom of Nomini Creek at the base of the bluff where the site is located.

These samples were processed using a hydrometer method of particle-size analysis (Day 1965). The only necessary modification was to pick out all macroscopic shell fragments and to remove the microscopic shell particles with hydrocloric acid, so that the midden samples would produce comparable results. The acid-treated samples were washed with distilled water, which was decanted after the samples had settled for several days. The acid also removed the organic content of these samples.

Particle-size analysis was deemed to be most appropriate for this problem because soil texture is one of the most stable soil characteristics, little modified by cultivation and other human activities (Day 1965:546; Davidson 1973). Soil pH, phosphorus content and soil structure would all have been unsuitable measures of similarity because of the nature of the shell midden.

The results of this analysis (Figure 9), show that the Nomini Creek sample is quite distinct from the other samples, supporting the conclusion that hard sand oyster bottoms were not extensively exploited, and that the dark brown silt loam certainly did not originate there. Of the remaining four samples, all are rather similar, with the two B_1 samples containing more clay and the midden samples containing more fine silt. According to hypotheses 3 and 4, the four samples should be virtually identical. One possible explanation of the

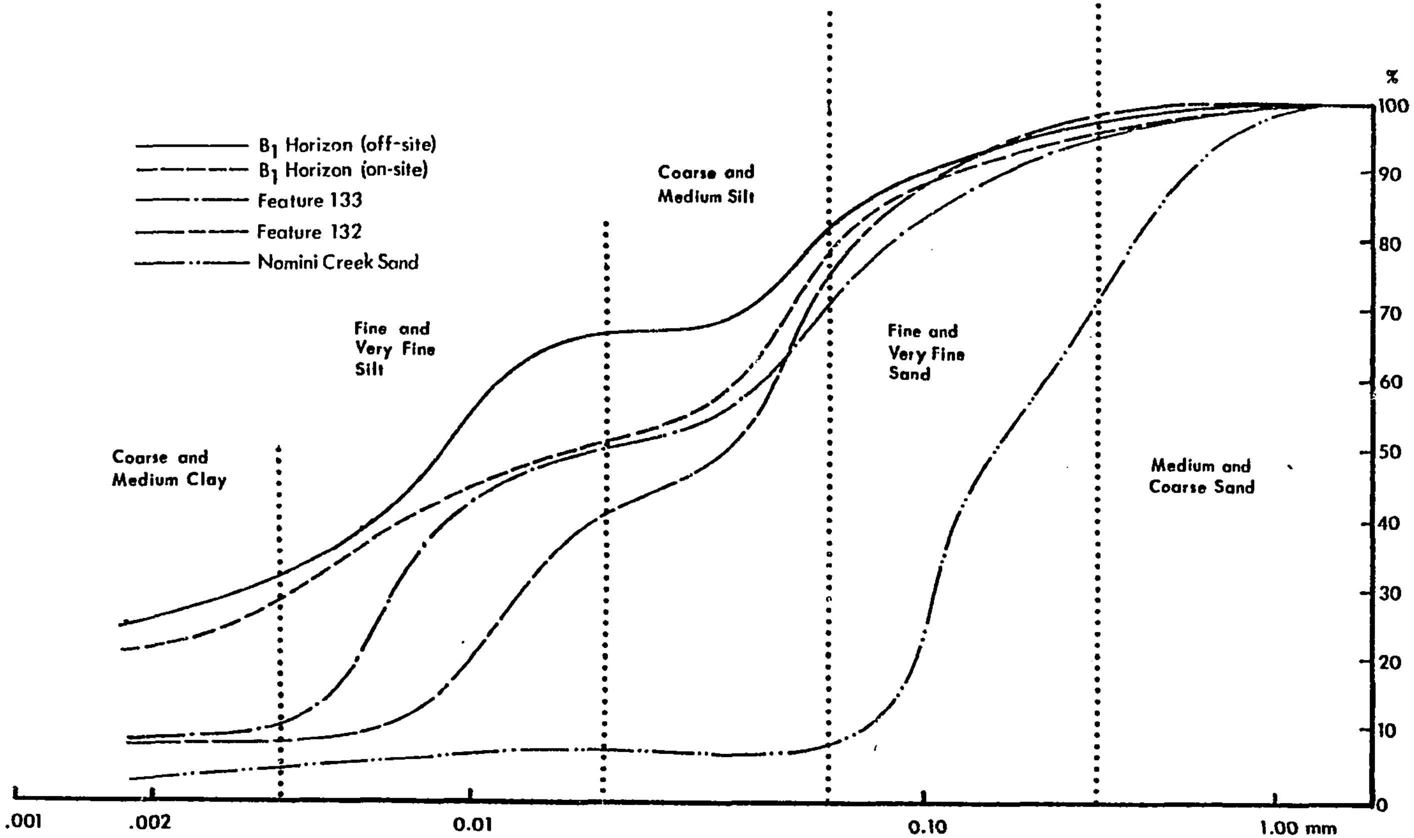


Figure 9. Cumulative Frequency Curves for Particle-size Distribution of Five Samples.

discrepancy is that clay colloids were eluviated from the shell layers and deposited in a lower soil zone. But this is unlikely since the buried soil profile does not show an increase in colloids in comparison with the off-site B_1 horizon sample.

Hypotheses 1 and 2 both predict that clay or silt will be carried to the site in large quantities, and silt does seem to have been introduced to the site by some means. The most reasonable explanation for the dark brown silt loam midden soil is that some material from the buried A and B_1 horizons was brought to the surface during the digging of the intrusive oyster cooking basins. Additional sediments, especially silt, were carried to the site adhering to oysters, and possibly to tubers (although these plant parts are seldom preserved, so their absence at White Oak Point is inconclusive regarding their use). So the resultant midden soil is probably a mixture from these two sources. Water-worn pebbles were recovered in great quantities at White Oak Point, and, since they do not occur in the buried soil horizon, their presence is presumably due to accidental transport from the oyster beds. Unfortunately, a suitable sediment sample from a soft oyster bottom was not obtained for comparative analysis.

Biotic Resource Exploitation

The environment of Chesapeake Bay and its brackish tributaries, including the lower Potomac River, has been discussed at length in at least three archaeological dissertations (Binford 1964:7-66; Turner 1976:16-81; Potter 1982:8-26; also see Roberts 1979), so only a few essential facts are required here to acquaint readers with the region.

Chesapeake Bay is the largest estuary in the United States, and one of the largest in the world, created during the early Holocene by rising sea levels resulting from the melting of the Pleistocene continental ice-sheets. Modern water salinity ranges from 33 parts per thousand (ppt) near the mouth of the Bay to completely fresh water at the head. In the vicinity of White Oak Point, surface water salinity remains about 9 ppt throughout the year. Shallow, sheltered waters support saltmarsh communities dominated by Spartina alterniflora (saltmarsh grass) and S. patens (saltmeadow grass). Lowlying lands have Myrica cerifera (wax myrtle) and Pinus sp. (pine) as the major vegetation, but an upland hardwood forest covered most of the Virginia Coastal Plain in Protohistoric times. This forest was composed of Quercus alba (white oak), Fagus grandifolia (beech), Liriodendron tulipifera (yellow poplar) and Quercus falcata (southern red oak), with lesser numbers of Acer rubrum (red maple), Carya tomentosa (mockernut hickory), Ilex opaca (American holly), and other species of oak, hickory and pine (DeWitt and Ware 1979).

The tidal saltmarsh community includes some important invertebrate species, most notable of which are Littorina irrorata (Gulf periwinkle) and Callinectes sapidus (blue crab); the latter is highly mobile, but frequently is abundant in saltmarshes. Mya arenaria (soft-shelled clam) is always subtidal in the Chesapeake, in contrast to its intertidal mud flat habitat in New England waters (Warner 1976: 174). Oysters are extremely numerous in the brackish waters and they once formed huge reefs, which were removed in the last two centuries as hazards to shipping. The ichthyofauna of the Chesapeake Bay is extremely varied, since some generally freshwater species can tolerate the low salinities found in the tributaries and northern reaches of the Bay (Lee et al. 1976). These rivers still attract huge runs of spawning anadromous fish in the spring, and in the fall to a lesser extent (Hildebrand and Schroeder 1972; Mansueti and Hardy 1978).

The amphibian, reptile and mammal species are fairly typical of the eastern United States, with the largest native land mammals being Odocoileus virginianus (white-tailed deer), Ursus americanus (black bear), and Canis lupus (gray wolf) (see Martof et al. 1980; Paradiso 1969). There is a large, seasonally transient bird population in the bay, with an extensive variety of waterfowl overwintering along the shores (Stewart and Robbins 1958).

In fact, to a large extent, the region's biota fluctuates seasonally in distribution and actual numbers, providing a potentially rich and varied environment for human hunters and gatherers, but also one which had recurrent seasonal lows in available biomass.

Faunal Data

The faunal remains found during excavation and in flotation samples are summarized in Tables 11 through 32. During excavation and coarse screening, elements and fragments of all species except Crassostrea virginica were saved for analysis. Since numerous zooarchaeological studies have shown that this sort of sample consistently underrepresents small-sized species, especially fish, the systematic balk samples and other judgmentally-selected samples were processed by flotation to recover small bones and plant remains.

The flotation procedure was quite simple. The apparatus consisted

Table 11. Late Archaic 2 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, Littorina irrorata	1	1	43	4	341	818
Oyster, Crassostrea virginica				160	13,626	46,609
Soft-shelled Clam, Mya arenaria	1	1	1,064	17	1,449	10,143
Ribbed Mussel, Geukensia demissa			19	5	426	3,365
Stout Tagellus, Tagellus plebeius			4	4	341	2,182
Unidentified Fish, Class Osteichthyes			25	-	-	
Unidentified Snake, Suborder Serpentes	1	-	10	-	-	
Black Racer, Coluber constrictor			10	1	1	400
Garter Snake, Thamnophis sp.			1	1	1	300
Unidentified Mammal, Class Mammalia	32	-	99	-	-	
White-tailed Deer, Odocoileus virginianus	5	2			2	66,000

Table 12. Early Woodland 1 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, *Littorina irrorata*	6	6	3	1	111	266
Oyster, *Crassostrea virginica*				185	29,548	64,127
Soft-shelled Clam, *Mya arenaria*			654	12	1,262	8,834
Ribbed Mussel, *Geukensia demissa*			4	2	210	1,659
Stout Tagellus, *Tagellus plebeius*			5	3	315	2,016
Blue Crab, *Callinectes sapidus*			1	1	1	60
Unidentified Fish, Class Osteichthyes			26	-	-	
White Basses, *Morone* sp.	1	1			1	240
Unidentified Mammal, Class Mammalia	66	-	179	-	-	
Squirrel, *Sciurus* sp.			1	1	1	450
Raccoon, *Procyon lotor*	3	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	2	1	2	-	1	25,000

Table 13. Early Woodland 2 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, *Littorina irrorata*	383	373	74	16	2,413	5,791
Oyster, *Crassostrea virginica*				687	114,030	555,112
Quahog, *Mercenaria mercenaria*	1	1			1	48
Soft-shelled Clam, *Mya arenaria*	22	3	957	19	2,426	16,982
Ribbed Mussel, *Geukensia demissa*	50	9	2,982	35	4,473	35,337
Stout Tagellus, *Tagellus plebeius*			2	1	1	6
Angel Wing, *Cyrtopleura costata*			1	1	1	15
Blue Crab, *Callinectes sapidus*			16	8	1,020	61,200
Unidentified Fish, Class Osteichthyes	1	-	28	-	-	
White Basses, *Morone* sp.	1	1	2	-	1	240
Unidentified Amphibian, Class Amphibia			2	-	-	
Unidentified Turtle, Order Chelonia	1	-			-	
Eastern Box Turtle, *Terrapene carolina*	4	1			1	130

Table 13. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Cooter, *Chrysemys* sp.	3	1			1	110
Unidentified Snake, Suborder Serpentes	4	-	1	-	-	
Black Racer, *Coluber constrictor*	4	1	1	-	1	400
Unidentified Bird, Class Aves	9	-	1	-	-	
Duck, *Anas* sp.	1	1			1	900
Unidentified Mammal, Class Mammalia	365	-	221	-	-	
Gray Squirrel, *Sciurus carolinensis*	2	1	1	-	1	450
Fox Squirrel, *Sciurus niger*	2	1			1	400
Southern Bog Lemming, *Synaptomys cooperi*			3	1	1	
Meadow Jumping Mouse, *Zapus hudsonias*	1	1			1	
Domestic Dog, *Canis familiaris*	5	1			1	3,600
Gray Fox, *Urocyon cinereoargenteus*	1	1			1	2,300
Raccoon, *Procyon lotor*	5	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	11	2			2	61,000

Table 14. Early Woodland 3 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, _Littorina irrorata_	1	1	1	1	165	396
Oyster, _Crassostrea virginica_				29	4,764	11,450
Quahog, _Mercenaria mercenaria_	1	1			1	48
Soft-shelled Clam, _Mya arenaria_			35	2	329	2,303
Angel Wing, _Cyrtopleura costata_			1	1	1	15
Blue Crab, _Callinectes sapidus_			5	3	493	29,580
Unidentified Fish, Class Osteichthyes			95	-	-	
Croaker, _Micropogon undulatus_			52	1	1	700
Unidentified Amphibian, Class Amphibia			1	1	1	
Unidentified Snake, Suborder Serpentes	2	-	3	-	-	
Unidentified Mammal, Class Mammalia	61	-	15	-	-	
Shrew, _Blarina_ sp.			1	1	1	
White-tailed Deer, _Odocoileus virginianus_	5	1	1	-	1	25,000

Table 15. Early Woodland 4 Faunal Remains.

Species	Excavated		Flotation		Estimated Total	Estimated Meat
	#	MNI	#	MNI	MNI	Weights (g)
Gulf Periwinkle, Littorina irrorata	15	15			15	36
Oyster, Crassostrea virginica				271	28,277	126,756
Soft-shelled Clam, Mya arenaria	8	2	8	1	86	602
Ribbed Mussel, Geukensia demissa	1	1	1	1	85	672
Unidentified Fish, Class Osteichthyes	5	-	8	-	-	
Cooter, Chrysemys sp.	2	1	18	-	1	110
Unidentified Bird, Class Aves	5	-			-	
Unidentified Mammal, Class Mammalia	18	-	10	-	-	
White-footed Mouse, Peromyscus leucopus			1	1	1	
White-tailed Deer, Odocoileus virginianus	1	1			1	30,000

Table 16. Middle Woodland 1 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, Littorina irrorata	30	28	316	62	3,387	8,129
Saltmarsh Snail, Melampus bidentatus	1	1			1	
Oyster, Crassostrea virginica				325	30,774	106,289
Soft-shelled Clam, Mya arenaria	2	1	618	14	759	5,313
Ribbed Mussel, Geukensia demissa	1	1	45	5	272	2,149
Stout Tagellus, Tagellus plebeius			7	4	217	1,389
Angel Wing, Cyrtopleura costata			3	2	108	1,620
Blue Crab, Callinectes sapidus			7	4	217	13,020
Unidentified Fish, Class Osteichthyes	18	-	16	-	-	
White Perch, Morone americana	2	1			1	240
Eastern Box Turtle, Terrapene carolina	4	1			1	130
Unidentified Bird, Class Aves	3	-			-	

Table 16. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Mammal, Class Mammalia	186	-	95	-	-	
Domestic Dog, *Canis familiaris*	1	1			1	3,600
Raccoon, *Procyon lotor*	3	1	2	1	2	6,200
White-tailed Deer, *Odocoileus virginianus*	19	2			2	72,000

Table 17. Middle Woodland 2 Faunal Remains.

Species	Excavated		Flotation		Estimated Total	Estimated Meat
	#	MNI	#	MNI	MNI	Weights (g)
Gulf Periwinkle, *Littorina irrorata*	288	284	37	1	348	835
Saltmarsh Snail, *Melampus bidentatus*			1	1	1	
Oyster, *Crassostrea virginica*				1,162	73,868	243,018
Soft-shelled Clam, *Mya arenaria*	20	2	416	5	320	2,240
Ribbed Mussel, *Geukensia demissa*	76	7	70	2	134	1,059
Stout Tagellus, *Tagellus plebeius*			5	3	191	1,222
Blue Crab, *Callinectes sapidus*	1	1	8	4	255	15,300
Unidentified Fish, Class Osteichthyes			88	-	-	
Atlantic Sturgeon, *Acipenser oxyrhynchus*	7	1			1	29,500
White Catfish, *Ictalurus catus*	3	1			1	120
Rockfish, *Morone saxatalis*	8	2	2	-	2	520
Unidentified Amphibian, Class Amphibia			1	-	-	
Southern Leopard Frog, *Rana sphenocephala*	1	1			1	20

Table 17. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Cooter, Chrysemys sp.	8	1			1	110
Eastern Box Turtle, Terrapene carolina	25	2	3	-	2	260
Unidentified Snake, Suborder Serpentes	58	-			-	
Corn Snake, Elathe sp.	18	1			1	400
Eastern Coachwhip, Masticophis flagellum	1	1			1	400
Water Snake, Nerodia sp.	1	1			1	500
Garter Snake, Thamnophis sp.	21	1			1	300
Copperhead/Cottonmouth, Agkistrodon sp.	16	1			1	500
Unidentified Bird, Class Aves	61	-			-	
Diving Duck, Subfamily Aythyinae	1	1			1	900
Unidentified Mammal, Class Mammalia	1,140	-	320	-	-	
Opossum, Didelphis marsupialis	8	1			1	3,800
Groundhog, Marmota monax	1	1			1	1,800
Eastern Chipmunk, Tamias striatus			3	1	1	

Table 17. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Fox Squirrel, *Sciurus niger*	3	2			2	1,080
White-footed Mouse, *Peromyscus leucopus*	1	1	1	-	1	
Domestic Dog, *Canis familiaris*	1	1			1	3,600
Gray Fox, *Urocyon cinereoargenteus*	4	1			1	2,300
Raccoon, *Procyon lotor*	12	3	1	-	3	12,600
White-tailed Deer, *Odocoileus virginianus*	62	3			3	88,534

Table 18. Middle Woodland 3 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, _Littorina irrorata_	2	2			2	5
Unidentified Fish, Class Osteichthyes			7	-	-	
Unidentified Mammal, Class Mammalia	27	-	15	-	-	
White-tailed Deer, _Odocoileus virginianus_	4	1			1	30,000

Table 19. Late Woodland 2 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, _Littorina irrorata_	6	6	10	2	126	302
Oyster, _Crassostrea virginica_				286	17,112	71,260
Soft-shelled Clam, _Mya arenaria_			134	4	239	1,673
Ribbed Mussel, _Geukensia demissa_			14	2	120	948
Blue Crab, _Callinectes sapidus_			10	5	299	17,940
Unidentified Fish, Class Osteichthyes	1	-	87	-	-	
White Catfish, _Ictalurus catus_	1	1	1	-	1	120
Yellow Perch, _Perca flavescens_			1	1	1	280
White Perch, _Morone americana_	16	1			1	240
Unidentified Amphibian, Class Amphibia			4	-	-	
Eastern Box Turtle, _Terrapene carolina_	10	1			1	130
Unidentified Snake, Suborder Serpentes	2	-			-	
Eastern Coachwhip, _Masticophis flagellum_	2	1			1	400

Table 19. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Mammal, Class Mammalia	121	-	156	-	-	
Southern Flying Squirrel, Glaucomys volans			3	1	1	20
White-tailed Deer, Odocoileus virginianus	3	1			1	30,000

Table 20. Late Woodland 3 Faunal Remains.

Species	Excavated		Flotation		Estimated Total MNI	Estimated Meat Weights (g)
	#	MNI	#	MNI		
Gulf Periwinkle, *Littorina irrorata*	42	40			40	96
Oyster, *Crassostrea virginica*				68	16,207	64,899
Soft-shelled Clam, *Mya arenaria*	4	1	88	1	238	1,666
Unidentified Fish, Class Osteichthyes			24	-	-	
Unidentified Bird, Class Aves	1	-			-	
Unidentified Mammal, Class Mammalia	37	-	4	-	-	
White-footed Mouse, *Peromyscus leucopus*			2	1	1	
White-tailed Deer, *Odocoileus virginianus*	3	1			1	30,000

Table 21. Late Woodland 4 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, Littorina irrorata	29	28	19	1	104	250
Oyster, Crassostrea virginica				829	68,101	274,564
Soft-shelled Clam, Mya arenaria	5	1	91	2	153	1,071
Ribbed Mussel, Geukensia demissa			95	5	380	3,002
Stout Tagellus, Tagellus plebeius			2	1	1	6
Blue Crab, Callinectes sapidus			7	4	304	18,240
Unidentified Fish, Class Osteichthyes	2	-	209	-	-	
Atlantic Sturgeon, Acipenser oxyrhynchus	3	1			1	29,500
White Catfish, Ictalurus catus			1	1	1	120
Yellow Perch, Perca flavescens			2	1	1	280
White Basses, Morone sp.			89	-	-	
White Perch, Morone americana	3	1			1	240
Salamander, Order Caudata			4	1	1	
American Toad, Bufo americanus			2	1	1	30

Table 21. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Cooter, *Chrysemys* sp.	5	1			1	110
Eastern Box Turtle, *Terrapene carolina*	20	1	37	-	1	130
Black Racer, *Coluber constrictor*			3	1	1	400
Water Snake, *Nerodia* sp.	1	1	1	-	1	500
Unidentified Bird, Class Aves	3	-			-	
Unidentified Mammal, Class Mammalia	214	-	309	-	-	
Shrew, *Blarina* sp.			1	1	1	
Eastern Cottontail, *Sylvilagus floridanus*	2	1			1	900
White-footed Mouse, *Peromyscus leucopus*	1	1	1	-	1	
Raccoon, *Procyon lotor*	2	1			1	2,000
White-tailed Deer, *Odocoileus virginianus*	11	1			1	30,000

Table 22. Late Woodland 5 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, *Littorina irrorata*	4	3	32	4	193	11,580
Oyster, *Crassostrea virginica*				235	22,299	78,464
Soft-shelled Clam, *Mya arenaria*	1	1	627	12	570	3,990
Ribbed Mussel, *Geukensia demissa*			16	2	95	750
Stout Tagellus, *Tagellus plebeius*			6	3	142	909
Unidentified Fish, Class Osteichthyes	5	-	183	-	-	
Longnose Gar, *Lepisosteus osseus*	2	1			1	800
Eel, *Anguilla rostrata*			1	1	1	400
Yellow Perch, *Perca flavescens*			1	1	1	280
Rockfish, *Morone saxatalis*	4	1	93	1	2	520
Blue Parrot Fish, *Scarus caeruleus*	1	1	1	-	1	900
Unidentified Amphibian, Class Amphibia			1	-	-	
Eastern Box Turtle, *Terrapene carolina*	18	2			2	260
Unidentified Snake, Suborder Serpentes	5	-	2	-	-	

Table 22. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Corn Snake, *Elathe* sp.	4	1			1	400
Garter Snake, *Thamnophis* sp.	5	1			1	300
Copperhead/Cottonmouth, *Agkistrodon* sp.	5	1			1	500
Unidentified Bird, Class Aves	14	-	1	-	-	
Snow Goose, *Chen caerulescens*	1	1			1	1,800
Unidentified Mammal, Class Mammalia	595	-	125	-	-	
Domestic Dog, *Canis familiaris*	57	1			1	Burial
Raccoon, *Procyon lotor*	3	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	70	2			2	68,000

Table 23. Late Woodland 6 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, _Littorina irrorata_			1	1	1	2
Oyster, _Crassostrea virginica_				36	5,760	15,520
Soft-shelled Clam, _Mya arenaria_			10	1	1	7
Ribbed Mussel, _Geukensia demissa_			1	1	1	8
Unidentified Fish, Class Osteichthyes			19	-	-	
Unidentified Amphibian, Class Amphibia	1	-			-	
Unidentified Mammal, Class Mammalia	125	-	7	-	-	
White-tailed Deer, _Odocoileus virginianus_	4	1			1	30,000

Table 24. Late Woodland 7 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, <u>Littorina</u> <u>irrorata</u>	5	5	5	-	5	12
Oyster, <u>Crassostrea</u> <u>virginica</u>				215	23,576	88,119
Soft-shelled Clam, <u>Mya</u> <u>arenaria</u>	2	1	440	6	240	1,680
Ribbed Mussel, <u>Geukensia</u> <u>demissa</u>			1	1	1	8
Stout Tagellus, <u>Tagellus</u> <u>plebeius</u>			4	3	119	762
Unidentified Fish, Class Osteichthyes	2	-	53	-	-	
White Catfish, <u>Ictalurus</u> <u>catus</u>	1	1	1	-	1	120
Black Drum, <u>Pogonias</u> <u>cromis</u>	2	1	1	-	1	350
Unidentified Amphibian, Class Amphibia			1	-	-	
Eastern Box Turtle, <u>Terrapene</u> <u>carolina</u>	141	2			2	260
Unidentified Bird, Class Aves	44	-			-	
Unidentified Mammal, Class Mammalia	426	-	252	-	-	
Gray Squirrel, <u>Sciurus</u> <u>carolinensis</u>	3	2			2	1,360

Table 24. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Southern Bog Lemming, *Synaptomys cooperi*			1	1	1	
Raccoon, *Procyon lotor*	2	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	19	1			1	36,867

Table 25. Late Woodland 8 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
.Gulf Periwinkle, Littorina irrorata	27	21	29	5	238	571
Oyster, Crassostrea virginica				943	93,297	349,033
Soft-shelled Clam, Mya arenaria	6	2	87	2	89	623
Ribbed Mussel, Geukensia demissa	4	2	108	3	132	1,043
Blue Crab, Callinectes sapidus			25	13	565	33,900
Unidentified Fish, Class Osteichthyes	93	-	3,417	-	-	
Atlantic Sturgeon, Acipenser oxyrhynchus	306	3	3	-	3	88,530
Longnose Gar, Lepisosteus osseus			1	1	1	800
Herrings, Family Clupeidae			4	1	1	1,400
White Catfish, Ictalurus catus	14	2	71	8	120	14,400
Yellow Perch, Perca flavescens			8	1	1	280
White Perch, Morone americana			18	3	29	240
Rockfish, Morone saxatalis			596	7	304	79,040
Black Drum, Pogonias cromis			2	1	1	350

Table 25. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Amphibian, Class Amphibia			5	-	-	
Cooter, *Chrysemys* sp.	70	2			2	220
Eastern Box Turtle, *Terrapene carolina*	36	1	2	-	1	130
Unidentified Snake, Suborder Serpentes	1	-			-	
Water Snake, *Nerodia* sp.			4	1	1	500
Unidentified Bird, Class Aves	17	-			-	
Duck, *Anas* sp.	2	1			1	900
Quail, *Colinus virginianus*	1	1			1	200
Unidentified Mammal, Class Mammalia	761	-	374	-	-	
Shrew, *Blarina* sp.			1	1	1	
Eastern Cottontail, *Sylvilagus floridanus*	2	1			1	900
Gray Squirrel, *Sciurus carolinensis*	2	1	1	-	1	450
Meadow Vole, *Microtus pennsylvanicus*			8	1	1	

Table 25. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Domestic Dog, *Canis familiaris*	3	1			1	3,600
White-tailed Deer, *Odocoileus virginianus*	30	2			2	74,000

Table 26. Late Woodland 9 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, *Littorina irrorata*	26	25	1	-	25	60
Oyster, *Crassostrea virginica*				280	36,542	149,326
Soft-shelled Clam, *Mya arenaria*	4	-	34	2	140	980
Ribbed Mussel, *Geukensia demissa*	4	3	29	3	214	1,691
Scallop, *Aequipecten* sp.	1	1			1	
Blue Crab, *Callinectes sapidus*	8	4	11	6	426	25,560
Unidentified Fish, Class Osteichthyes	29	-	304	-	-	
Atlantic Sturgeon, *Acipenser oxyrhynchus*	13	1	4	-	1	29,500
White Catfish, *Ictalurus catus*	3	1	2	1	21	2,520
Yellow Perch, *Perca flavescens*	1	1			1	280
Rockfish, *Morone saxatalis*			113	1	1	260
American Toad, *Bufo americanus*			2	1	1	30
Southern Leopard Frog, *Rana sphenocephala*	1	1			1	20

Table 26. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Cooter, *Chrysemys*, sp.	35	2			2	220
Eastern Box Turtle, *Terrapene carolina*	4	1	17	-	1	130
Eastern Coachwhip, *Masticophis flagellum*			2	1	1	400
Water Snake, *Nerodia* sp.	4	1			1	500
Garter Snake, *Thamnophis* sp.	79	2			2	600
Copperhead/Cottonmouth, *Agkistrodon* sp.	6	1			1	500
Unidentified Bird, Class Aves	14	-	8	-	-	
Unidentified Mammal, Class Mammalia	826	-	639	-	-	
Opossum, *Didelphis marsupialis*	2	1			1	3,800
Shrew, *Blarina* sp.	1	1			1	
Eastern Cottontail, *Sylvilagus floridanus*	6	2			2	1,800
Groundhog, *Marmota monax*	1	1			1	1,800
Squirrel, *Sciurus* sp.			1	1	1	450
Raccoon, *Procyon lotor*	6	2			2	6,200
White-tailed Deer, *Odocoileus virginianus*	27	3	3	-	3	102,000

Table 27. Late Woodland 10 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, Littorina irrorata	4	4			4	10
Soft-shelled Clam, Mya arenaria	1	1	115	2	3	21
Ribbed Mussel, Geukensia demissa			2	1	1	8
Blue Crab, Callinectes sapidus			10	5	5	300
Unidentified Fish, Class Osteichthyes	1	-	35	-	-	
Eastern Box Turtle, Terrapene carolina	2	1			1	130
Unidentified Bird, Class Aves	1	-			-	
Unidentified Mammal, Class Mammalia	136	-	1,330	-	-	
Beaver, Castor canadensis	2	1			1	9,100
White-footed Mouse, Peromyscus leucopus			2	1	1	
Raccoon, Procyon lotor	1	1			1	4,200
White-tailed Deer, Odocoileus virginianus	12	2	3	-	2	61,000

Table 28. Late Woodland 11 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Blue Crab, *Callinectes sapidus*			8	4	4	240
Unidentified Fish, Class Osteichthyes	3	-	23	-	-	
White Bass, *Morone* sp.			13	2	2	480
Unidentified Salamander, Order Caudata	1	-	2	1	1	
Cooter, *Chrysemys* sp.	24	1			1	110
Unidentified Snake, Suborder Serpentes			2	-	-	
Unidentified Bird, Class Aves	2	-			-	
Unidentified Mammal, Class Mammalia	205	-	381	-	-	
Meadow Vole, *Microtus pennsylvanicus*			4	1	1	
Raccoon, *Procyon lotor*	1	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	9	1			1	33,000

Table 29. Protohistoric/Early Historic 1 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, _Littorina irrorata_			16	6	329	790
Oyster, _Crassostrea virginica_				44	6,314	24,696
Soft-shelled Clam, _Mya arenaria_	2	1	34	1	56	392
Ribbed Mussel, _Geukensia demissa_	1	1			1	8
Unidentified Fish, Class Osteichthyes	22	-	23	-	-	
Longnose Gar, _Lepisosteus osseus_	1	1			1	800
White Catfish, _Ictalurus catus_	1	1			1	120
Rockfish, _Morone saxatalis_	6	2			2	520
Cooter, _Chrysemys_ sp.	1	1			1	110
Eastern Box Turtle, _Terrapene carolina_	26	2			2	260
Water Snake, _Nerodia_ sp.	6	1			1	500
Unidentified Bird, Class Aves	6	-			-	
Marsh Duck, Subfamily Anatinae	6	1			1	900

Table 29. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Mammal, Class Mammalia	339	-	48	-	-	
Opossum, *Didelphis marsupialis*	1	1			1	3,800
Squirrel, *Sciurus* sp.	2	1			1	450
Meadow Vole, *Microtus pennsylvanicus*	1	1			1	
Domestic Dog, *Canis familiaris*	2	1			1	3,600
Raccoon, *Procyon lotor*	4	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	24	2			2	66,878

Table 30. Protohistoric/Early Historic 2 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Black Drum, Pogonias cromis	6	1			1	350
Eastern Box Turtle, Terrapene carolina	2	1			1	130
Unitentified Bird, Class Aves	5	-			-	
Unitentified Mammal, Class Mammalia	50	-			-	
Beaver, Castor canadensis	1	1			1	9,100
Raccoon, Procyon lotor	2	1			1	4,200

Table 31. Protohistoric/Early Historic 3 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Gulf Periwinkle, <u>Littorina</u> <u>irrorata</u>	58	49	5	2	188	451
Saltmarsh Snail, <u>Melampus</u> <u>bidentatus</u>	1	1			1	
Oyster, <u>Crassostrea</u> <u>virginica</u>				667	136,180	556,725
Soft-shelled Clam, <u>Mya</u> <u>arenaria</u>	5	3	27	3	212	1,484
Ribbed Mussel, <u>Geukensia</u> <u>demissa</u>	4	2	36	2	141	1,114
Blue Crab, <u>Callinectes</u> <u>sapidus</u>	6	3	3	1	73	4,380
Unidentified Fish, Class Osteichthyes	120	-	347	-	-	
Atlantic Sturgeon, <u>Acipenser</u> <u>oxyrhynchus</u>	93	2	63	-	2	59,000
Longnose Gar, <u>Lepisosteus</u> <u>osseus</u>	1	1			1	800
Herrings, Family Clupeidae			7	1	1	1,400
Eel, <u>Anguilla</u> <u>rostrata</u>			3	1	1	400
White Catfish, <u>Ictalurus</u> <u>catus</u>	9	2			2	240
Yellow Perch, <u>Perca</u> <u>flavescens</u>			2	1	1	280
White Basses, <u>Morone</u> sp.	13	3	61	-	3	720

Table 31. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
White Perch, *Morone americana*	4	1			1	240
Rockfish, *Morone saxatalis*	3	1			1	260
Black Drum, *Pogonias cromis*	2	1			1	350
Unidentified Amphibian, Class Amphibia	1	-			-	
Cooter, *Chrysemys* sp.	385	5	34	-	5	690
Eastern Box Turtle, *Terrapene carolina*	196	4			4	520
Unidentified Snake, Suborder Serpentes	1	-			-	
Water Snake, *Nerodia* sp.	3	1			1	500
Copperhead/Cottonmouth, *Agkistrodon* sp.	1	1			1	500
Unidentified Bird, Class Aves	96	-	10	-	-	
Marsh Ducks, Subfamily Anatinae	3	1			1	900
Wild Turkey, *Meleagris gallopavo*	2	1			1	3,800
Passenger Pigeon, *Ectopistes migratorius*	1	1			1	130

Table 31. (cont.)

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Mammal, Class Mammalia	1,798	-	493	-	-	
Opossum, *Didelphis marsupialis*	2	1			1	3,800
Eastern Cottontail, *Sylvilagus floridanus*	10	2			2	1,800
Groundhog, *Marmota monax*	1	1			1	1,800
Gray Squirrel, *Sciurus carolinensis*	14	2			2	900
Raccoon, *Procyon lotor*	2	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	76	4			4	139,771

Table 32. Protohistoric/Early Historic 4 Faunal Remains.

Species	Excavated #	Excavated MNI	Flotation #	Flotation MNI	Estimated Total MNI	Estimated Meat Weights (g)
Unidentified Fish, Class Osteichthyes	3	-			-	
Blue Parrot Fish, *Scarus caerulescens*	2	2			2	1,800
Cooter, *Chrysemys* sp.	1	1			1	110
Unidentified Bird, Class Aves	2	-			-	
Domestic Chicken, *Gallus domesticus*	1	1			1	800
Unidentified Mammal, Class Mammalia	26	-	40	-	-	
Raccoon, *Procyon lotor*	2	1			1	4,200
White-tailed Deer, *Odocoileus virginianus*	2	1			1	30,000

of a #12-size galvanized bucket with the bottom replaced by a ¼ inch mesh screen, which supported an overlying 1.2 mm mesh. This bucket was placed in a #1-size galvanized tub filled with slowly running water from a garden hose. The water ran out of a spout, which had been soldered to the lip of the tub, into a geological sieve with 0.5 mm mesh. A sample was first air-dried and weighed, then slowly poured into the bucket. Most of the light fraction charcoal immediately floated and was caught in the 0.5 mm sieve. The remaining material was allowed to soak for a few minutes, after which the bucket was gently rotated to dislodge any charred plant remains trapped in the mass of shell fragments, and these too were caught in the sieve. The heavy fraction (all material remaining in the bucket, i.e., mainly non-floating specimens larger than 1.2 mm in diameter) and the light fraction (material which floated and was retrieved in the 0.5 mm sieve) were emptied onto newspapers to dry. The heavy fractions were hand-sorted by analytic categories: shell, vertebrate remains, stone, ceramics, other artifacts. The shell was then size-graded in 5.66 mm, 4.00 mm, 2.00 mm, and 1.00 mm sieves, and valves from oysters which were dead when originally gathered were withdrawn from further analysis.

The method used to estimate Minimum Number of Individuals (MNI) depended heavily on the flotation-recovered animal remains. Estimates were first based on the elements found during the excavations. Additional individuals represented in the flotation heavy fraction were then calculated. Then the total number of individuals represented in the excavated volume of midden was extrapolated from the number represented in the volume of midden sampled for flotation. When a species was apparently not uniformly distributed throughout all of the flotation samples from a component, then the extrapolation was limited to those features where the species remains were concentrated. Extrapolation was not attempted if remains of only a single individual of a species was recovered. As expected, the addition of heavy fraction flotation material mainly affects the MNI estimates (and, consequently, the available meat estimates) for invertebrates and small-sized vertebrate species.

Finally, a brief mention should be made of a fragmentary dog burial (apparently scattered by a treefall) found in Feature #15, Component LW5. Table 33 presents cranial osteometric data on this skeleton of a very old individual, with extensively worn teeth. This individual is rather large compared to other American aboriginal dogs (Haag 1948:229-230), but it shares with many of them the congenital absence of the first lower premolar (Allen 1920).

Local Environment (Figure 10). Between 1872 and 1905, a navigation channel was dredged in the portion of Nomini Creek just off White Oak and Hickory points, extensively altering estuarine substrates in the vicinity of the archaeological sites. However, reports on the dredging operations (e.g., Abert 1885, 1889) provide some information on prior nineteenth century conditions. The shoreline at the base of the bluff was a shallow water (1 m deep) saltmarsh substrate extending up to 100 m to the west, at which point the creek bottom sloped rapidly to the 3 m deep natural channel. In the intermediate zone between channel and saltmarsh dense oyster populations were clustered in

Table 33. Measurements of Dog Burial Found in Component LW5.

Description	Dreisch Reference*	Length (mm)
Cranium		
total length	1	180.1
condylobasal length	2	170.7
basal length	3	162.4
basicranial axis	4	46.1
basifacial axis	5	116.3
upper neurocranium length	7	87.6
viscerocranium length	8	72.9
facial length	9	105.7
greatest length of nasals	10	48.0
length of palatine	14	23.8
length of molar row	16	32.4
length and greatest breadth of carnassial	18	a-18.8, b-10.0
length and breadth of M^1	20	a-13.9, b-15.4
length and breadth of M^2	21	a-6.9, b-10.5
diameter of auditory bulla	22	21.3
greatest mastoid breadth	23	63.2
breadth dorsal to auditory meatus	24	61.0
breadth of occipital condyles	25	35.6
breadth of paraoccipital processes	26	50.3
breadth of foramen magnum	27	16.6
height of foramen magnum	28	14.4
greatest neurocranium breadth	29	46.6
least breadth of skull	31	35.3

Table 33. (cont.)

Description	Dreisch Reference*	Length (mm)
frontal breadth	32	45.0
breadth between orbits	33	33.0
greatest palatal breadth	34	61.8
least palatal breadth	35	31.0
breadth at canine alveoli	36	34.4
skull height	38	52.4
skull height w/o sagittal crest	39	45.9
height of occipital triangle	40	37.8
height of canine	41	26.1
Mandible		
total length	1	129.6
length (2)	2	127.4
length (3)	3	125.0
length (4)	4	115.6
length (5)	5	110.2
length (6)	6	113.6
length (7)	7	75.3
length of cheektooth row, M_3-P_2	9	68.3
length of molar row	10	33.9
length of premolar row, P_2-P_4	12	34.0
length of carnassial	13	21.4
length of carnassial alveolus	14	20.5
length and breadth of M_2	15	a-8.9, b-7.0
greatest thickness of body of jaw	17	11.0

Table 33. (cont.)

Description	Dreisch Reference*	Length (mm)
height of the vertical ramus	18	51.3
height of mandible behind M_1	19	22.4
height of mandible between P_2 and P_3	20	21.0
height of canine	21	32.0

*Dreisch 1976:42-45, 60-61.

fringe reefs (Baylor 1894; Stenzel 1971:N10406). A third estuarine sedimentary substrate was to be found just upriver and in Nomini Bay, namely, the shallow sandy nearshore substrate where clams, stout tagellus and angel wings could be found (Davis 1972). While the precise configuration of resources undoubtedly changed slightly through time, all three substrates have probably always been easily accessible to site occupants since the stabilization of Chesapeake Bay water levels during the Late Archaic period.

The faunal remains show that these three substrates were all exploited throughout the 3,700 years of human occupation represented in the 22 excavated components, but the oyster reefs were most heavily exploited. Other aquatic species are also prominently represented, including various fishes, water snakes, cooters, waterfowl and beaver. The other terrestrial animals could have been found throughout the coastal plain. Some of the smallest terrestrial species, such as Peromyscus leucopus (white-footed mouse) and Microtus pennsylvanicus (meadow vole) may or may not have been food resources, but their component distribution may be indicative of changing site environment. Peromyscus remains were found in Early Woodland, Middle Woodland and early Late Woodland contexts, while Microtus bones were found in late Late Woodland and Protohistoric/Early Historic contexts, perhaps reflecting an increase in field clearance in the late Late Woodland period. Remains of hunted species are suggestive of the same trend: Glaucomys volans (southern flying squirrel), a forest species, is found only in early Late Woodland context, but Sylvilagus floridanus (cottontail), a species which prefers brushy edges and old fields, is most common in the latest components.

Available Meat Estimates. Calculating the amounts of meat represented by all of the faunal remains and the corresponding MNI estimates is a rather complex process. For two of the major meat sources, oysters and white-tailed deer, regression equations were employed to correlate specific element dimensions to probable meat weights per individual. In other cases, average meat yields from particular species were used, unless the size of archaeologically recovered elements suggested that the averages were either too high or low and should be modified. For example, there was little intra-specific variation in quahog, ribbed mussel, stout tagellus and Gulf periwinkle specimens, so average meat yields for these species were derived from Price et al. (1976:29) and applied to the archaeological remains. The approximate size of an individual fish could be determined from certain elements by comparison with published ratios (e.g., element length:individual length:whole weight:dressed weight, or length:age:weight) established for a few species (McHugh et al. 1959; Muncy 1962; Harrington et al 1979; Paloumpis n.d.). Usable meat weight estimates for white-tailed deer were obtained from regression equations based on astragalus length measurements (Emerson 1978; Table 34). Since so few measurable deer astragali were recovered, weight estimates for other individual deer were based on age, determined from the tooth eruption sequence and stages of tooth wear (Severinghaus 1949; Table 35). The purpose of these calculations is simply to allow comparison of species within a component, with the understanding that the figures are estimates and that the totals indicate only the amount of available meat, not

Table 34. Measurable Deer Astragali.

Component	Length (mm)	Live Weight (g)	Usable Meat Weight (g)
MW2	36.8	46,444	24,228
	41.6	66,148	37,134
	37.9	50,939	27,172
LW7	41.5	65,739	36,867
LW10	41.8	66,965	37,669
P/EH1	38.9	55,070	29,878
P/EH3	42.0	67,782	38,205
	37.3	48,487	25,566

Table 35. Deer Age Estimates from Tooth Eruption and Wear.

Component	Specimens	Estimated Age at Death
LA2	R-M^3	20-24 months
	R-P^3	8 years
EW1	R-M_1	11 months
EW2	L-M_2	11-13 months
	R-M^2	7 years
EW3	L-M_1	11-13 months
MW1	L-M^2, R-M^1 M_3	5 years
	R-P_1 M^2	6 years
MW2	L-M_3	4 years
LW5	L-P_3, R-P^1	3 years
	R-P^3 M^2	8+ years
LW8	L-M_3, complete maxilla	4 years
	L-P^3 M^3	5 years
LW9	L-m^1	11-13 months
	L-P_1	3 years
	L-M^2, R-P_2 P^1 P^2	9 years
LW10	R-M_1 M_2 M_3	9-13 months
	R-P_2	6 years
LW11	R-M^1 M^2	4 years
P/EH1	L-P_2 M_2, R-P_3 M_1 M_2 M_3	4 years
P/EH3	R-P^3	20-24 months
	L-P^2 M^2 M_3, R-M_2	3 years
	L-complete maxilla	5 years
	R & L-complete mandibles, L-M^1	7 years

necessarily the amount consumed at the site. Estimates of meat storage and trade remain elusive.

Because oyster valves were by far the most common faunal remains recovered at White Oak Point, extra effort was expended in oyster meat weight calculations. To this end, a sample of 102 oysters was obtained from Pocomoke Sound, in Maryland waters 70 km east of the site, on 13 October, 1977. These modern valves were opened, the drained meat was weighed and left and right valves were measured for height, length, thickness, height:length ratio and weight. In addition, left valve volume was calculated. Regression equations were calculated for all these measurements, and left valve volume and left valve height were found to be the most accurate predictors of meat weight (correlation coefficients of .69366 and .67477, respectively). From a practical point of view, height is the more useful parameter since less time is required to make each measurement, for an insignificant sacrifice in accuracy (Newcombe 1950:210; Dame 1972:1126; Murawski and Serchuk 1979:40). The left valve height (H, mm):meat weight (W, g) regression equation is $\log_e W = -6.94 + 2.09 \log_e H$. This equation was applied to each measurable left valve in the balk flotation samples, and estimates of available oyster meat were then extrapolated to the entire volume of excavated midden per component.

The relative meat contributions of various categories of animals are shown in Tables 36 and 37, from which at least four conclusions can be drawn. First, invertebrates were the principal source of meat in all but three instances, when mammals were dominant. Among the invertebrates, oysters were the most significant meat source, with one

Table 36. Relative Meat Weight Contributions of All Animal Resources.

Components	Invertebrates (%)	Fish (%)	Reptiles (%)	Birds (%)	Mammals (%)
LA2	48.6	-	0.5	-	50.8
EW1	72.0	0.2	-	-	27.7
EW2	90.1	tr	tr	0.1	9.6
EW3	63.0	1.0	-	-	36.0
EW4	81.0	-	tr	-	19.0
MW1	62.7	0.1	tr	-	37.2
MW2	64.2	7.3	0.6	0.2	27.7
LW2	74.7	0.5	0.4	-	24.3
LW3	69.0	-	-	-	31.0
LW4	82.2	8.3	0.3	-	9.1
LW5	55.0	1.7	0.8	1.0	41.5
LW6	34.1	-	-	-	65.9
LW7	67.7	0.4	0.2	-	31.7
LW8	59.2	28.4	0.2	0.2	12.1
LW9	54.0	9.9	0.7	-	35.3
P/EH1	24.0	1.3	0.8	0.8	73.1
P/EH3	71.7	8.1	0.3	0.6	19.3

Table 37. Relative Meat Weight Contribution of Invertebrates.

Components	Oyster	Periwinkle	Mya/Geukensia Tagellus	Crab
LA2	73.8	1.3	24.8	-
EW1	83.3	0.3	16.2	-
EW2	82.3	0.8	7.8	9.1
EW3	26.1	0.9	5.3	67.5
EW4	99.0	-	1.0	-
MW1	77.1	5.9	6.4	9.4
MW2	92.2	0.3	1.7	5.8
LW2	77.4	0.3	2.8	19.5
LW3	97.4	0.1	2.5	-
LW4	92.4	-	1.4	6.1
LW5	82.0	12.1	5.9	-
LW6	99.9	-	0.1	-
LW7	97.3	-	2.7	-
LW8	90.6	0.1	0.4	8.8
LW9	84.1	-	1.5	14.4
P/EH1	95.4	0.3	1.5	-
P/EH3	98.7	-	0.5	0.8

exception (EW3) when crabs supplied more meat. A third general trend in the data is the greater importance of invertebrates during the Early Woodland, Middle Woodland and early Late Woodland periods, than during either previous or succeeding periods. Finally, one should note that, although the major subsistence activity at most components apparently was oyster gathering and preparation, significant quantities of meat came from other activities (i.e., clam digging, crabbing, fishing and deer hunting).

<u>Hunting and Gathering Strategies</u>. There is very little evidence for changing subsistence strategies in the White Oak Point faunal data. In fact, the site is remarkable for the extraordinarily stable subsistence pattern exhibited throughout nearly 3,700 years. Shell midden studies by archaeologists elsewhere in the world usually report some intensification, decline or internal variation in shellfish exploitation through time, but such changes are not at all obvious at White Oak Point.

One frequently proposed hypothesis is that intensified shellfish collecting would have resulted in progressively smaller shellfish being gathered, if collection rates outpaced shellfish reproduction and growth rates. This possibility was tested in two ways at White Oak Point. Oyster left valves in the balk flotation samples were measured (Table 38), but the results from 15 components, and from a Protohistoric/Early Historic shell midden in Northumberland County (Waselkov 1982), are quite consistent and no temporal trend is present.

Since oyster shell growth rates vary tremendously, even in

Table 38. Average Dimensions of Oyster Left Valves.

Components	Average Height (mm)	Average Length (mm)	n
LA2	57.1	45.0	110
EW1	55.7	42.8	109
EW2	62.9	50.7	567
EW3	sample too small		16
EW4	59.3	44.1	225
MW1	59.8	45.9	206
MW2	56.2	43.8	188
LW2	59.2	45.7	215
LW3	60.4	44.7	45
LW4	58.1	42.9	639
LW5	55.8	44.2	174
LW6	sample too small		23
LW7	59.9	45.8	147
LW8	56.8	43.3	853
LW9	56.9	42.9	227
P/EH1	57.3	44.8	35
P/EH3	60.0	44.6	493
44NB149	56.9 (range: 24-174)	40.1	1151

different areas of the same reef, size distributions alone do not provide an adequate basis from which to infer oyster population age structures and annual recruitment rates (Steneck et al. 1978). Certain structural features of oysters can be measured to directly determine annual growth rates. Some biologists and archaeologists estimate age and growth rates from growth layers visible on oyster valve external surfaces (Quick and Martin 1971; T. Ruppe 1980). However, this method was shown long ago to be inaccurate and unreliable (Massy 1914), especially in archaeological contexts where many valves are fragmented and incomplete.

Fortunately for archaeologists, annual shell growth layers are also visible in the ligament attachment areas of the umbos, a portion of oyster valves which is frequently well preserved. Annuli are most conspicuous on the left valve in a thin layer (8 to 16 μm thick) of prismatic shell on the chondrophore and the anterior and posterior nymphae (Stenzel 1971:N991; Carriker et al. 1980:143, 162-168, 177-178). The chronological significance of the annuli has not been determined for oysters, but such features are fairly well understood in other species, so their basic significance can be inferred. Oysters living in regions where winter water temperatures drop below 6^{o}C cease feeding and stop growing until water temperatures again rise above that temperature. In the vicinity of Chesapeake Bay, growth begins between March and June, is most rapid during the summer and gradually slows until the winter dormant period begins. This growth cycle is probably reflected in the ligamental annuli, with widely spaced annuli being deposited during periods of rapid growth, and narrow ones during times of slow growth. In warmer regions, where oysters grow continuously throughout the year, the spawning stresses may be a more important cyclical factor than low temperatures (Loosanoff and Nomejko 1949; Ingel and Dawson 1952; Hancock and Simpson 1962:34; Galtsoff 1964: 407; Stenzel 1971:N1014). This scenario should eventually be tested by O-18 isotope analyses of annuli, but the basic argument is supported by recent work with other species (e.g., Clark 1979).

Left valve umbo fragments from the balk flotation samples were cleaned and each individual was aged by counting the number of complete annual growth layers. In some cases, the oldest part of the shell was eroded so age could not be determined. Measurements were also made of growth past the last annulus and the width of the last annulus (Table 39). These data again indicate a very consistent pattern of oyster exploitation at White Oak Point, with the average age of harvested oysters fluctuating around 4 years of age. The width of the last complete year's growth also remained quite stable, indicating that environmental conditions and exploitative pressures did not change dramatically if at all during the time period in question.

The number of oysters per unit of midden (Table 9) may be the only indication that an intensification in oyster collecting occurred during the occupation of this site. This standardized measurement is quite low for the Late Archaic component, increases in Early Woodland times, and rises again in the early Late Woodland period, remaining high after that. Such a trend, which is not terribly clear from these data, may correspond to a gradual increase in the numbers of

Table 39. Average Age of Oysters (left valves).

Component	Average Growth (in mm) Past Last Annulus	Average Previous Year's Growth (mm)	Average Age (yrs)	n
LA2	0.4	2.4	3.8	77
EW1	0.2	2.4	4.1	36
EW2	0.4	2.6	4.1	236
EW3	0.2	2.6	4.0	28
EW4	0.2	2.6	3.6	63
MW1	0.2	2.3	4.3	42
MW2	0.3	2.2	4.1	26
LW2	0.1	2.6	4.2	67
LW3	0.1	2.4	5.1	65
LW4	0.2	2.4	4.3	168
LW5	0.2	2.1	3.4	34
LW6	0.2	2.5	4.1	33
LW7	0.2	2.4	4.2	109
LW8	0.2	2.5	3.7	80
LW9	0.2	2.6	4.0	154
P/EH1	0.2	2.5	4.1	44
P/EH3	0.4	2.3	4.2	190

oysters collected per occupation, perhaps as oyster drying assumed greater significance, especially toward the end of the sequence.

The Shannon-Weiner Index of Diversity and species equitability or evenness was calculated for each component (Table 40), and these results show a drop in species diversity between Middle Woodland and Late Woodland components, indicating an increase in subsistence specialization (cf. Wing 1963, 1977; Yellen 1977a:107; Anderson 1979: 56; Bettinger 1980:204-205). While the number of species varies somewhat between components, the number of individual oysters vastly outweighs the number of collected or hunted individuals from all other species after the beginning of the Late Woodland period.

Finally, some mention of deer hunting techniques should be made. The ages of hunted deer can be used to discern whether individual stalking or mass capture techniques, such as drives and surrounds, were employed at a specific site (Waselkov 1978, also see Klein 1979). The component samples of ageable deer teeth are quite small from the White Oak Point site, but the overall period samples seem to indicate that mainly young and fairly mature deer were killed most often (Table 35, also Waselkov 1982). This sort of kill is thought to result from stalking. There is no evidence of a shift from stalking to drives, as was predicted to accompany the development of chiefdoms in eastern North America (Waselkov 1978). On the other hand, the species diversity index results demonstrate these components to have been specialized oyster collecting camps during the Late Woodland and Protohistoric/Early Historic periods, so specialized deer hunting camps or permanent villages might be the most appropriate places to

Table 40. Species Diversity and Evenness by Component.

Component	# of Species	# of Individuals	Species Diversity (H')	E*
LA2	8	16,187	.6197	.2980
EW1	10	31,451	.2886	.0279
EW2	19	124,376	.3931	.0335
EW3	9	5,756	.6399	.0739
EW4	6	28,465	.0462	.0045
MW1	12	35,741	.5530	.0527
MW2	25	75,142	.1140	.0102
LW2	12	17,903	.2410	.0246
LW3	4	16,486	.0929	.0096
LW4	18	69,055	.0913	.0082
LW5	17	23,314	.2332	.0232
LW6	5	5,764	.0066	.0008
LW7	11	23,948	.0933	.0092
LW8	22	94,792	.1853	.0162
LW9	23	37,391	.1389	.0132
P/EH1	16	6,715	.0265	.0301
P/EH3	28	136,833	.0436	.0037

*Equitability or Evenness

seek and discover evidence for deer drives.

Seasonality. The White Oak Point components are exceedingly rich in reliable faunal indicators of occupation seasonality (Table 41). The oysters provide strong evidence for spring occupations -- more precisely, for March to May occupations -- in the small amount of growth past the last complete annual layer (Table 39). Many oysters showed no growth whatsoever past the last annulus, and the new growth averages range only from 0.1 to 0.4 mm, compared to averages of previous year's growth of 2.1 to 2.6 mm. This is rather convincing evidence, both in terms of internal logic and in the consistency of results from 17 components, that oyster gathering was limited to the first few months of warm weather.

The presence of crabs in some components corroborates the spring attributions. Crabs are rarely found in the bay by modern professional crabbers from December to March, and are most common from April to June (Warner 1976). A number of the fish identified in the faunal samples are either anadromous species which enter freshwater rivers to spawn in the spring, or they are freshwater species which congregate to spawn at that season. For example, sturgeon enter rivers such as the Potomac late in April or in May. Herring, croakers, white perch and rockfish spawn between March and June, but mostly in April and May (Hildebrand and Schroeder 1972).

The few migratory birds found at White Oak Point, mainly waterfowl and the passanger pigeon, would seldom have stayed in the Chesapeake Bay region past March, except for some nesting mallards. The ages of young deer, determined from tooth eruption sequences

Table 41. Season of Occupation of Archaeological Components.

Component	Probable Season of Occupancy	Seasonal Indicators
LA2	April-May	Oysters, Deer
EW1	April	Oysters, Crabs, White Bass, Deer
EW2	April-May	Oysters, Crabs, White Bass, Duck, Deer
EW3	April	Oysters, Crabs, Croaker, Deer
EW4	(Spring)	Oysters
MW1	April-May	Oysters, Crabs, White Perch
MW2	May	Oysters, Crabs, Sturgeon, Rockfish, Duck
MW3	(unknown)	
LW2	April-May	Oysters, Crabs, White Perch
LW3	(Spring)	Oysters
LW4	May	Oysters, Crabs, Sturgeon, White Perch
LW5	March-May	Oysters, Snow Goose, Rockfish
LW6	(Spring)	Oysters
LW7	March-May	Oysters, Black Drum
LW8	April-May	Oysters, Crabs, Sturgeon, Herring White Perch, Rockfish, Ducks
LW9	May	Oysters, Crabs, Sturgeon, Rockfish, Deer
LW10	April-June	Crabs, Deer
LW11	April-June	Crabs
P/EH1	March-May	Oysters, Rockfish, Duck
P/EH2	April-May	Black Drum
P/EH3	April-May	Oysters, Crabs, Sturgeon, Herring, White Perch, Rockfish, Black Drum, Ducks, Deer
P/EH4	(unknown)	

for May-born deer, also indicate spring occupations, between March and June (Table 35).

The only contradictory evidence might be the acorns, hickory nuts and a few seeds found in the components (Appendix B). But since these plant foods are easily stored, and the bulk of evidence comes from animals which must have been killed within a closely delimited period of the year, one must conclude that the components were occupied in the spring and that the pattern of specialized oyster exploitation at small spring camps continued from the Late Archaic period until the destruction of Indian lifeways by invading English colonists.

Conclusions and Comparisons

The conclusions drawn in the course of this chapter can now be summarized, roughly in order of most general to most temporally specific.

1) White Oak Point was occupied during the spring by small groups of Indians, who established temporary camps for the primary purpose of gathering and subsequently roasting oysters. This basic pattern persisted from the Late Archaic through Protohistoric/Early Historic periods.

2) While most of the available meat procured at the site came from oysters, other activities such as clam digging, crabbing, fishing and deer hunting were also significant meat sources. Acorns and hickory nuts were consumed at the site, but aside from the possible use of marsh tubers and corms, plant foods were stored and brought to to site from elsewhere.

3) Hunting and gathering techniques practiced at these camps changed little, if at all, with deer being stalked by individual hunters and oyster populations never so heavily harvested as to result in decreased sizes or ages of the collected oysters.

4) During the Late Archaic occupation, shellfish other than oysters contributed a larger proportion of the total meat yield than during any succeeding period, indicating less of a specialization in oyster gathering than that which later developed. Deer hunting may also have been a more important activity at this early date, as suggested by the exceptionally large meat yield and, indirectly, by the numerous projectile points per volume of midden (Table 9).

5) The average number of oysters per volume of midden increased after the Late Archaic, and throughout the Early Woodland, Middle Woodland, and early Late Woodland periods invertebrates provided most of the available meat, indicating the specialized nature of the seasonally occupied camps.

6) Beginning in the early Late Woodland period, the species diversity index dropped, roasting basins were first used, mammals and fish began to contribute increasingly larger proportions of the available meat, and the average number of oysters per volume of midden sharply increased, until, by the end of the Late Woodland period, the cumulative effect of these changes was a subtly altered subsistence strategy. I interpret the data as evidence for intensified oyster gathering and preparation, probably including large-scale drying of oyster meat for storage and trade. The larger meat contribution from vertebrates would have replaced the loss of

immediately consumable oysters available to site occupants. The shift in strategy may have accompanied the introduction of maize agriculture (the earliest evidence for which is found in late Late Woodland Component 9), and consequent scheduling conflicts arising from spring planting. Increased specialization and production of storable commodities by a portion of the population would have freed other individuals for additional tasks. This conclusion also illustrates the error in assuming that shell middens, because of their superficial visual similarity, resulted from a single subsistence strategy, or even a few closely related strategies. They are varied phenomena requiring more detailed attention.

Captain John Smith's description of the Virginia Powhatan subsistence round, which he witnessed from 1607 to 1609, is similar in many respects to the model of late Late Woodland and Protohistoric/ Early Historic oyster exploitation developed from archaeological evidence.

> In March and Aprill they live much upon their fishing, weares, and feed on fish, Turkies and squirrels. In May and June they plant their fieldes and live most of Acornes, walnuts and fish. But to mend their diet, some disperse themselves in small companies & live upon fish, beasts, crabs, oysters, land Torteyses, strawberries, mulberries, & such like. In June, Julie, and August they feed upon the rootes of Tockwough, berries, fish, and greene wheat [i.e., maize] (Barbour 1969 (II):357; also Wright and Freund 1953:80).

Other early English accounts of the Powhatan specifically mention Indians roasting oysters in April, May, and possibly July (Quinn 1967: 8-9; Hamor 1957:43; Wharton 1957:10); dried oysters were obtained by the English from the Indians at all times of the year (Wharton 1957:6; Arber 1910:xlii).

As stated in the introduction to this chapter, one goal of this study was to ascertain the relationship of shellfish gathering strategies to changes in other aspects of subsistence, settlement patterns and social organization, especially the development of chiefdoms in the region. Although the data from White Oak Point apply only to a single seasonal element of subsistence-settlement patterns, spring oyster gathering camps, archaeological survey data from adjacent Northumberland County, Virginia, recently analyzed by Stephen Potter (1982:345-361), provides some of the requisite complementary information. Potter's data corroborate the White Oak Point conclusion that small, seasonally occupied oyster gathering sites were a characteristic settlement type at least as early as A.D. 200, the earliest sites considered in his analysis. However, other aspects of the settlement pattern changed radically in the following fourteen centuries. Shoreline sites of intermediate size with some shell midden refuse (and apparently occupied for a large part of the year), and small upland hunting camps constituted the rest of the settlement pattern during this early period. But around A.D. 700, the first large villages were occupied for much of the year, with small and intermediate upland hunting camps and oyster gathering camps serving as temporary, special activity sites. Beginning about A.D. 900-1000, the large villages dispersed, with individual houses and house clusters being the dominant settlement types. Around A.D. 1300, the small, permanent settlements coalesced somewhat to form large villages with some outlying house clusters. By A.D. 1500, the villages had absorbed the remaining outliers and were slightly more consolidated, but still remained internally dispersed; that is, houses within a village were widely spaced so the associated village midden is thinly distributed over a large area, quite distinct from the dense, localized middens of nucleated villages enclosed by palisades, such as are found further west.

Potter (1982) suggests that plant husbandry may have intensified at about A.D. 1000, and that the settlement pattern adopted at A.D. 1300 closely resembles the early historic pattern of internally dispersed villages organized into local chiefdoms. As already mentioned, the White Oak Point data indicate that oyster exploitative strategy was altered during this same period, with the apparent aim of producing dried oysters for storage and trade by a portion of the local population. The dispersed settlement pattern and increasingly specialized subsistence round may eventually have required the institution of chiefly control to insure equitable redistribution of stored foods produced by social subgroups. The Coastal Plain chiefdoms seem to have relied on internal trade and redistribution to insure that all members of a society met their food requirements.

Since the oyster gathering and processing sites, such as White Oak Point, were primarily oriented toward that one specialized activity, they were situated in close proximity to large oyster beds, regardless of other estuarine resource distributions. The few instances when oysters provided less than half of the available meat per component may indicate times in the past when the usually abundant and reliable oyster resource temporarily failed for some reason. The White Oak Point site is located in an area of relatively low water salinity and was certainly on occasion affected by unusually large rainfalls causing oyster mortalities and reproduction failures such as occurred in 1973 following Hurricane Agnes (Galtsoff 1964:405; Chesapeake Bay Research Council 1973:xiii, 90). During most years, however, the oysters and other estuarine resources obtained at White Oak Point in the spring would have provided considerable quantities of high quality protein and probably some plant foods during the season of lowest terrestrial plant and animal availability (Binford 1964:163; Turner 1976:65; Osborn 1977b:172-173). The fact that stored plant foods were brought to the site indicates that protein obtainable from oysters was almost certainly the dietary nutrient most immediately required at that season and for future use.

Finally, one can deduce from the long record of successive reoccupations at this site, and at other large Chesapeake Bay shell middens, that shellfish were not simply a starvation food utilized during rare seasons of extreme deprivation. Instead, shellfish gathering evidently was an integral element of the seasonal round, contributing additional protein during an annual low point in the regular fluctuations of available resources.

Appendix A

EXCAVATIONS AT WHITE OAK POINT, 44WM119

Introduction

The first archaeological survey of Virginia's Northern Neck was initiated by W.H. Holmes of the Smithsonian Institution's Bureau of Ethnology. In 1891 and 1892 William Dinwiddie, at times accompanied by Holmes and Gerard Fowke, surveyed the shores of the lower Potomac and recorded the locations and nature of the numerous archaeological sites, particularly the shell middens, found in that area of the Tidewater. Dinwiddie's notebooks, which are preserved in the National Anthropological Archives, contain sketch maps (Figure 10) and descriptions of major sites, including the one here designated the White Oak Point Site, 44WM119 (Holmes, Dinwiddie and Fowke 1891). This site is located on the right bank of Nomini Creek, just above the mouth where that stream enters Nomini Bay and thence the Potomac River. Dinwiddie noted the resemblance between Nomini Creek and a location visited by Captain John Smith in 1608, during his explorations of the Potomac River.

> The 16 of June we fel with the river of Patawomeck: feare being gone, and our men recovered, wee were all contented to take some paines to know the name of this 9 mile broad river, we could see no inhabitants for 30 myles saile; then we were conducted by 2 Salvages up a little bayed creek toward Onawmament where all the woods were laid with Ambuscadoes to the number of 3 or 400 Salvages,... (Barbour 1969:403).

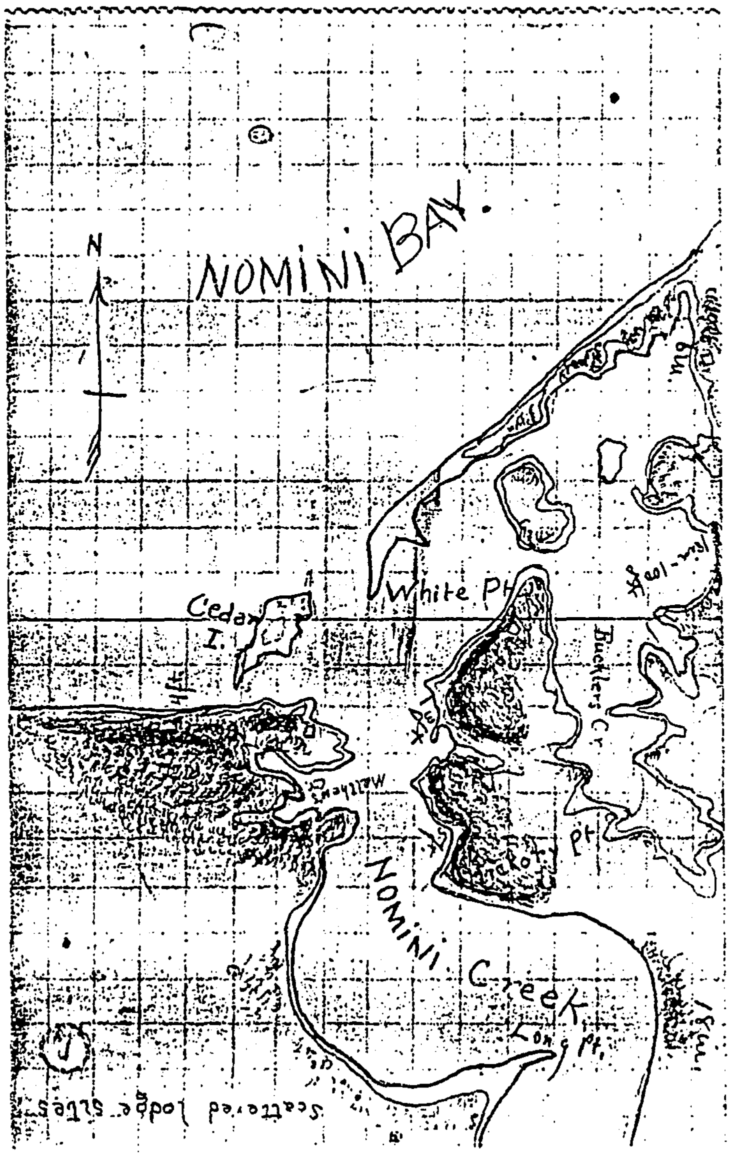


Figure 10. William Dinwiddie's 1891 Map of Nomini Shell Middens.

Dinwiddie reasoned that

> This little bayed creek was undoubtedly our Nomini, a corruption of the original Onawmanient, the distance from Point Lookout [on the Chesapeake] being but little short of thirty miles and no other bayed creek occurring on the south side until the Nomini cliffs are passed, some ten miles farther up. The great shell banks now found about the mouth of this creek were therefore probably occupied by the numerous savages with whom the explorers skirmished, and the site may fairly be considered a historic one....
>
> The largest shell field is the one on the left bank. Its area is not less than 45 acres and may be as much as 60.... On the right bank of Nomini, at the mouth and continuing for a mile along the shore, another tremendous shell deposit occurs. This field, though covering as much acreage perhaps, is not so deep nor quite as thick as the first one described. It offers, however, more interesting features in the way of vertical exposures, one of which has a depth of 5 feet of solid shell, filling up an old gully;...
>
> The two above shell deposits form the main shell fields of the Nomini and, taken together in extent and depth, they compare favorably with the Pope's Creek fields and are undoubtedly larger than any others on the Potomac (Holmes, Dinwiddie and Fowke 1891).

Despite the readily apparent significance of the Nomini shell middens, no excavations were conducted on these sites until the summer of 1976. At that time, the author and Stephen R. Potter (who had rediscovered Dinwiddie's nineteenth century fieldnotes) visited the area and determined that portions of the 6 hectare right bank shell midden still were essentially intact. Two 1.5 m^2 units were excavated by arbitrary levels to sterile subsoil and remnants of a human burial lying partially exposed on the eroded bluff were also excavated.

After analysis of the test excavation's stratification and correlated cultural material from 44WM119, this writer concluded that further excavations would be most enlightening on a number of counts.

The test excavations adjacent to the 3 to 4 m high bluff had been placed in a small area which had never been plowed and consequently yielded an unusually complete profile. This profile showed overlapping and intrusive features from which could be deduced the local cultural chronological sequence. Such a basic discovery was important since previous archaeologists excavating in nearby shell middens either had not discovered stratified deposits or had incorrectly interpreted the undeniably complex stratification of Tidewater shell middens (Dalton 1971; MacCord 1972; Buchanan 1976a, 1976b). The White Oak Point site also promised to provide ample data in reliable stratigraphic contexts on shellfish gathering from the Late Archaic through Protohistoric periods. Of all the nearly 200 sites located by Potter and me in Northumberland and Westmoreland counties during 1976, White Oak Point was the only one which fulfilled this last criterion.

As plans for our dissertations progressed, Potter continued working in Northumberland County and focused his research on the development of the chiefdom of Chicacoan, particularly as reflected in changing settlement patterns (Potter 1976, 1982). Although I was involved with quite different research problems in neighboring Westmoreland County, a unified approach to questions of culture history was obviously desirable, so every effort was made jointly to resolve any dilemmas. The results of this experiment in distinct yet complementary dissertation research designs have been most gratifying.

From May through October, 1978, 37 additional 1.5 m^2 units were excavated at 44WM119 (Figure 11). The 1976 north-south baseline was retained. One of the new units was placed adjacent to the 1976 test excavation, but the remaining units were arranged contiguously to

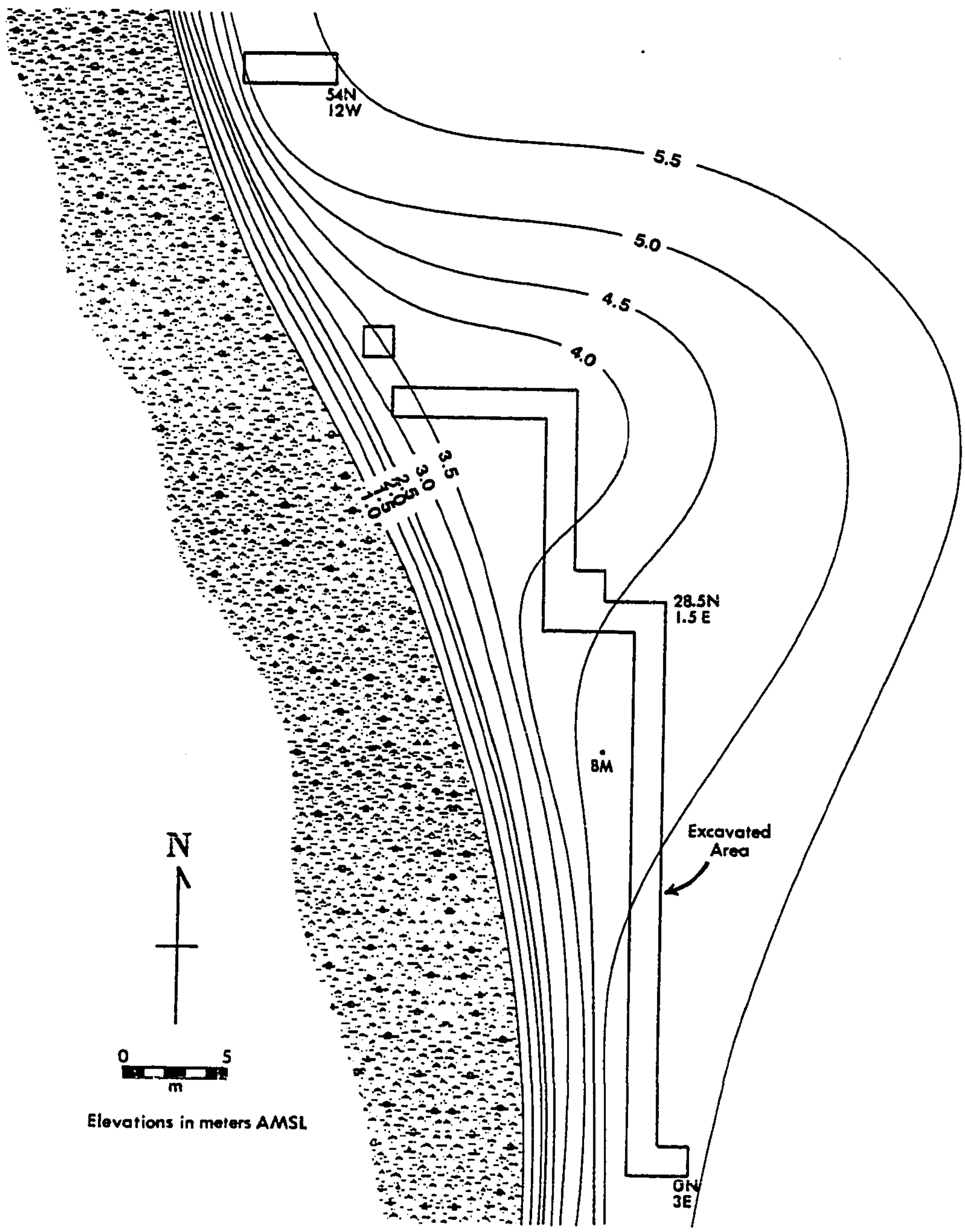


Figure 11. Excavations at 44WM119

form a trench running generally parallel to the bluff. At the northern end, the trench turned 90^{o} to intersect the bluff (at the gully mentioned by Dinwiddie in 1891). Current trends in archaeological sampling strategies might have dictated that, on a site so extensive, excavation units ought to be dispersed in order to sample as many areas of the site as possible. However, the 1976 test excavations suggested that 44WM119 consists of not simply a few sequentially occupied components, each covering about 6 hectares; rather, the site apparently comprises hundreds and possibly thousands of small, discrete occupation areas, the contemporaneity of which could not be assumed. The homogeneous shell midden evident in the plowed portions of the site was an illusion. Thus it was concluded that a site of this complexity could not be adequately studied by any number of dispersed test units, primarily because the lack of continuous stratigraphic profiles would seriously hamper interpretation.

Once we realized that the site itself was not an appropriate sampling universe, the only logical alternative was to sample as many occupation areas as possible, while obtaining continuous profiles which would establish the relationship between different occupation areas. Within the time and budgetary constraints of the project, the most effective method possible was to excavate a long trench in an area of deep midden near the bluff, although ideally the excavations should be expanded in later work to totally uncover some of the components, and to explore inland areas of the site.

The entire 1978 trench was placed in second-growth woods, but excavation quickly established that this entire area had been plowed to a depth of 20 to 30 cm. The plowzone was shoveled by square and sifted through ¼-inch wire mesh. At the base of the plowzone (Figure 12), a horizontal plan of visible features was then drawn, photographs were taken, and field specimen (F.S.) numbers were assigned. The excavation procedure thereafter employed pointing trowels and three-tined garden forks and began by removing intrusive features to a depth of 10 cm below the base of the plowzone. Then the usually numerous overlapping horizontal accumulations of midden were excavated in the reverse order of their deposition to complete the 10 cm zone. Material from each cultural layer was bagged and recorded separately by unit and zone. Then the entire process began again, from 10 to 20 cm below plowzone, and was repeated until sterile subsoil was reached. In effect, this procedure involved stratigraphic excavation of cultural layers within each 10 cm deep arbitrary level, a method which proved useful because the relatively slight visual and textural differences between cultural layers were very difficult to recognize while digging. At each 10 cm level, the excavator had an opportunity to reassess the stratigraphic situation, with a marked increase in precision over earlier attempts to totally excavate each stratum in turn. A further advantage was a reduction in the accidental displacement of artifacts during excavation, which can be a serious problem at shell middens with poorly consolidated deposits. The major drawback was the increased work involved in interpreting the field notes and reconstructing (on paper) the shape and dimensions of the numerous cultural layers, a small disadvantage in exchange for enhanced data quality.

A number of different sampling strategies were employed during

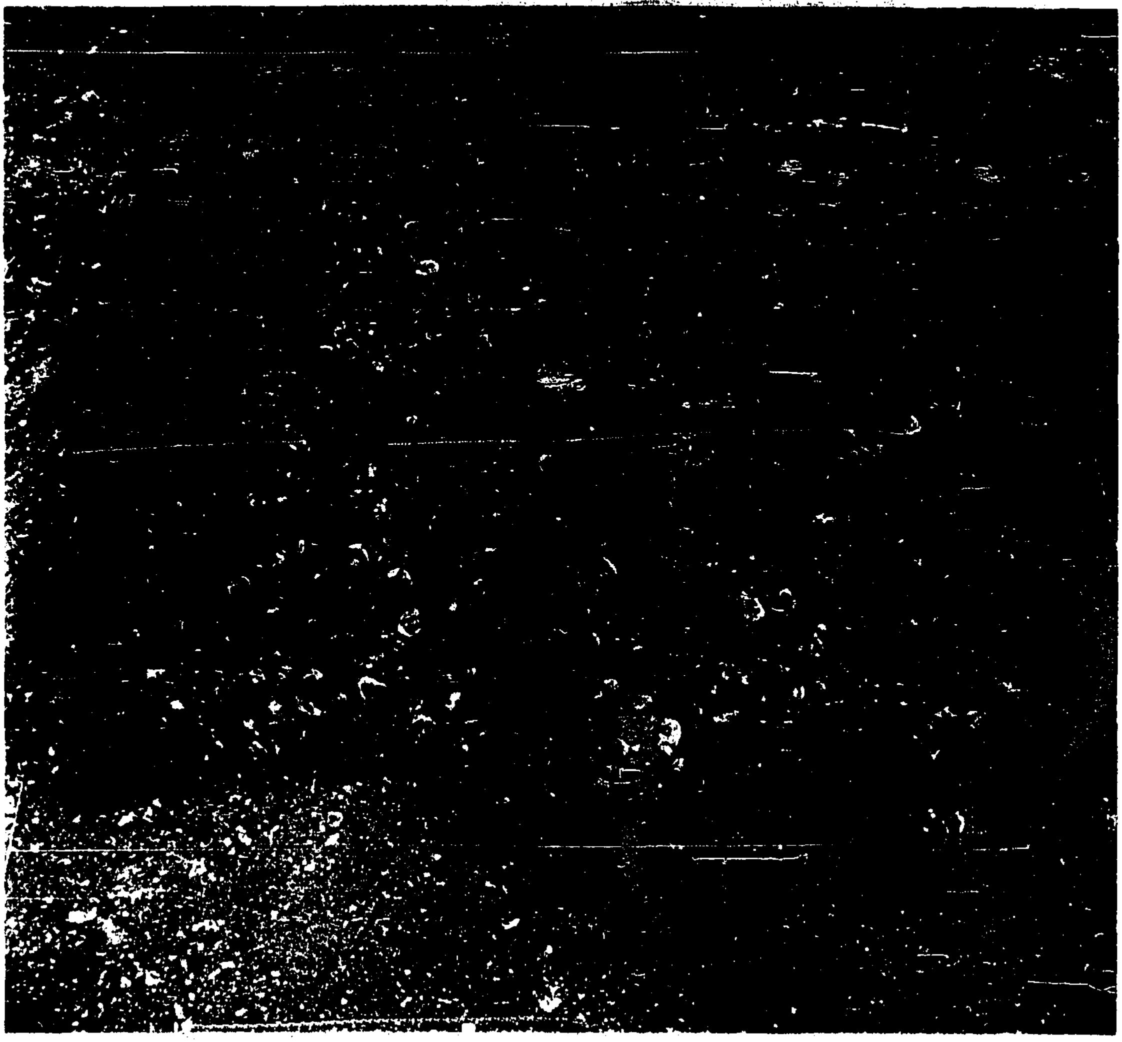


Figure 12. Horizontal View (Unit 37.5N9W, Base of Plowzone).

the excavations, each oriented toward specific types of artifacts. Oyster shells were extremely abundant and fairly regularly distributed throughout the excavated portion of the site, so a systematic sampling strategy was deemed most appropriate for their collection. Balks measuring 10 x 20 cm were retained at one grid coordinate in each excavation unit for this purpose. As the last stage in site excavation, the balks were dug according to cultural strata and the total contents were saved for laboratory analysis. Large, common artifacts (e.g., potsherds, lithics, bone tools, large animal bones) with irregular spatial distribution were not sampled, but instead were collected whenever found during excavation and sifting through ¼-inch mesh. Small, common items with irregular spatial distribution (e.g., plant remains, small animal bones, and small shells) were sampled systematically in the balk flotation samples and selectively in other flotation samples collected during feature excavations. Small, rare artifacts (e.g., glass beads, shell beads, uncommon animal and plant species remains) were also discovered in these two types of flotation samples.

Site Stratigraphy

44WM119 is situated on sandy loam soils with a modern pH range of 4.5 to 5.0. In the area of the 1976 test excavations, a surficial duff zone directly overlies the shell midden accumulation; a plowzone (Ap horizon) is present in the vicinity of the 1978 trench. Beneath the shell midden is a buried A horizon on sandy loam or silt loam 6 to 10 cm in depth, which gradually grades into a loamy yellow clay B_1 horizon. At a depth of 1 meter below the buried A horizon is a blue clay B_2 horizon (John C. Nicholson, USDA soil scientist, personal communication, October, 1978). The presence of the shell midden has drastically affected the underlying soil pH. The plowzone and midden pH ranges from 8.5 to 9.0, the B_1 horizon has a pH of 8.5, and the pH of the B_2 soil horizon is 7.5.

The midden consists of 122 distinguishable, stratified features, attributable to 22 discrete episodes of human occupation (producing an equivalent number of archaeological components). Four other components are represented only by artifacts found in disturbed contexts. Eighty-one features may be termed "extensive," insofar as they were produced when cultural debris was dumped or discarded in a particular area, creating heaps of irregular dimensions. As the site was reoccupied through time, these extensive features were deposited one above another. The remaining 41 features excavated at 44WM119 are "intrusive," including various sorts of pits and basins which were dug into earlier deposits by the Indian inhabitants. The precise nature of these features is considered in Chapter VI.

Cultural Components

This section summarizes the essential data available on each cultural component discovered at the White Oak Point site, including the age and spatial extent of each component, the number and types of associated features, and the number and types of associated artifacts. Component designations had to be assigned early in the analysis, so they are not arranged in strict chronological order, as later determined from radiocarbon dating and stylistic analysis of artifacts. Site cultural chronology and the various artifact types are discussed more fully in the following sections.

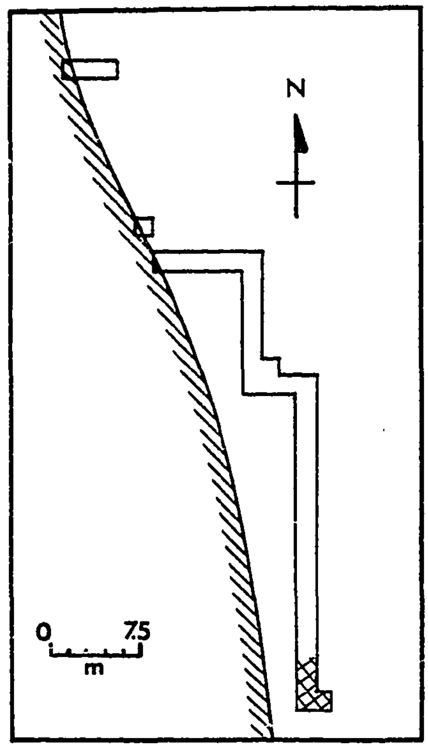
Late Archaic Component 1

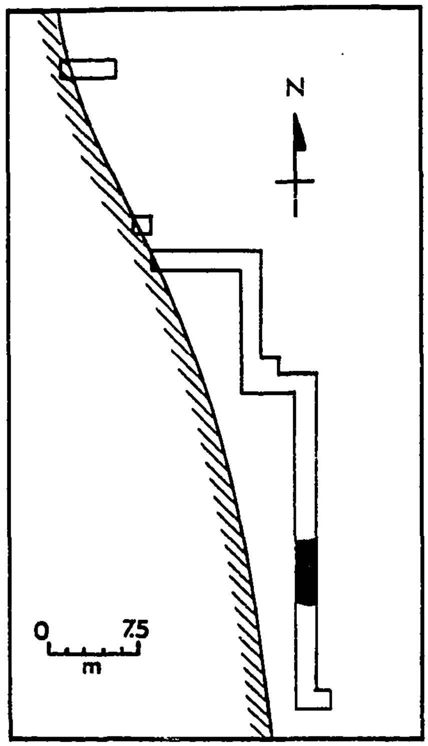
Age: c. 2000 B.C.

Spatial Extent: unknown

Features: none excavated; all artifacts were found redeposited in later contexts.

Artifacts:
- 1 quartzite stemmed projectile point (Table 53:1)
- 2 quartzite blade preforms, proximal ends
- 1 quartzite ovoid core, 285.6 g
- 1 steatite flake, 0.8 g





Late Archaic Component 2

Age: 1550 B.C.±75 (DIC-1771), corrected to 1950 B.C. ± 150

Spatial Extent: greatest linear dimension - 4.3 m, excavated midden volume - 1.21 m^3

Features (Extensive):
- #61 Midden (brown sandy loam and shells), Depth - 16 cm
- #62 Midden (light brown, clay loam and shells), Depth - 6 to 13 cm

Artifacts:
- 1 steatite vessel fragment with lug handle
- 5 quartzite stemmed projectile points (Table 53:2-6)
- 1 quartzite projectile point, distal fragment
- 1 micaceous schist bi-pitted hammerstone, 200.7 g
- 369 fire-cracked cobbles, 11.24 kg
- 1436 water-worn pebbles, 15.06 kg

Debitage:

	cores (g)	decortication flakes (g)	thinning flakes (g)
quartz	1 (55.6)	16 (188.4)	7 (17.4)
quartzite	1 (144.5)	11 (97.9)	24 (231.4)
shale			2 (8.3)
black chert		1 (0.8)	
red jasper		1 (6.7)	
rhyolite			1 (7.8)
basalt		1 (4.9)	
chlorite schist			3 (5.3)

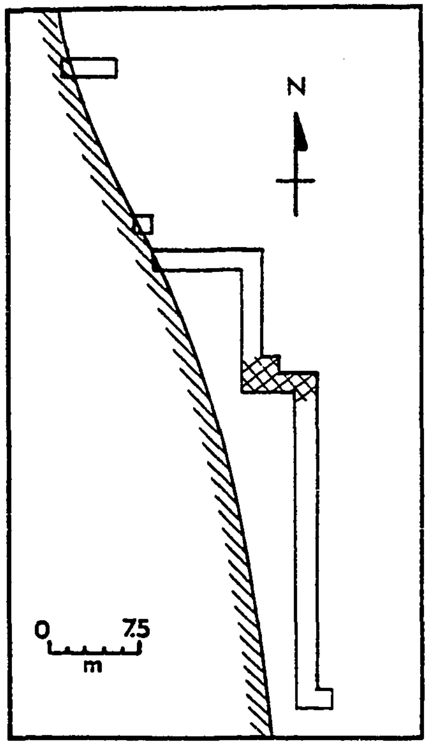
Late Archaic Component 3

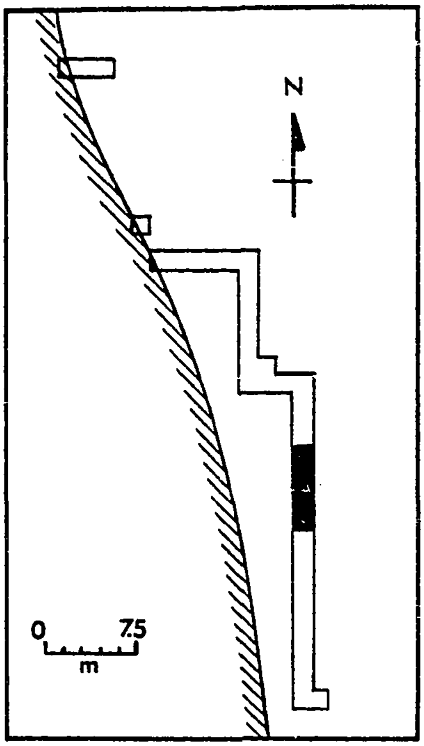
Age: c. 3000 B.C.

Spatial Extent: unknown

Features: none excavated; artifacts were found redeposited in later contexts.

Artifacts:
- 1 quartzite Savannah River projectile point (Table 53:7)
- 2 quartzite Savannah River projectile points, distal fragments
- 1 metarhyolite contracting stem projectile point, proximal fragment (Table 53:8)





Early Woodland Component 1

Age: 1110 B.C.±75 (SI-4375), corrected to 1370 B.C.±90

Spatial Extent: greatest linear dimension - 7.5 m, excavated midden volume - 1.27 m^3

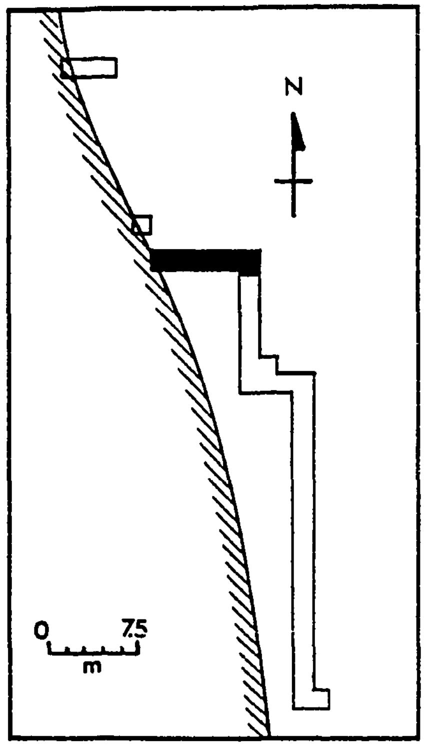
Features (Extensive):
- #63 Midden (brown loam and shell) Depth - 5 to 11 cm
- #66 Midden (light brown clay loam and shells) Depth - 8 cm
- #67 Midden (brown sandy loam and shells) Depth - 9 to 15 cm

Intrusive Natural Feature:
(Intrusive root hole, filled with ash, dark brown sandy loam and shells)
Diameter - 23 to 9 cm
Depth - 38 cm

Artifacts:
- 4 Bushnell Plain pottery vessels (Table 44:4,7,8,10)
- 3 quartz stemmed projectile points (Table 54:1-3)
- 1 quartzite lanceolate projectile point (Table 54:4)
- 1 quartzite blade, distal end
- 310 fire-cracked cobbles, 11.02 kg
- 1537 water-worn pebbles, 14.11 kg

Debitage:

	cores (g)	decortication flakes (g)	thinning flakes (g)
quartz		27 (49.5)	32 (55.0)
quartzite	2 (280.1)	6 (93.2)	9 (54.1)
green jasper		1 (4.8)	
yellow jasper		1 (1.2)	
chlorite schist			1 (1.2)
green siltstone			2 (0.4)



Early Woodland Component 2

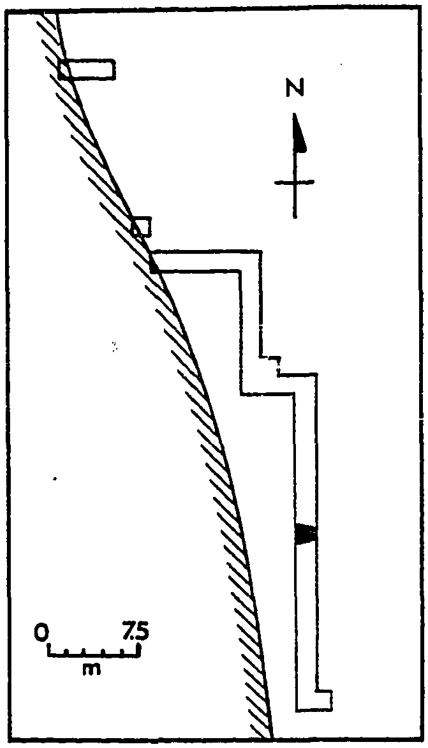
Age: 1160 B.C.±70 (SI-4377) and 1070 B.C.±70 (SI-4376), corrected to 1435 B.C.±90 and 1320 B.C.±90, respectively

Spatial Extent: greatest linear dimension - 9.0 m, excavated midden volume - 4.57 m^3

Features (Extensive):
- #30 Midden (shells and brown sandy loam)
  Diameter - 500 cm
  Depth - 60 cm
- #110 Midden (dark brown sandy loam and shells)
  Depth - 10 cm
- #111 Midden (shells and brown sandy loam)
  Depth - 11 cm
- #112 Midden (shells and brown sandy loam)
  Depth - 13 cm
- #115 Midden (shells and brown sandy loam)
  Depth - 11 cm
- #116 Midden (shells and brown sandy loam) Depth - 18 cm
- #117 Midden (yellow loamy clay and shells) Depth - 23 cm
- #118 Midden (light yellow clay and shells) Depth - 12 cm
- #123 Midden (brown sandy loam, ash and shells) Depth - 20 cm

Artifacts:
- 5 Bushnell Plain pottery vessels (Table 44:2,3,5,6,9)
- 1 polished white-tailed deer antler tine
- 1 mammal bone splinter awl, midsection, 12.9 mm wide, 9.2 mm thick
- 1 white-tailed deer metapodial splinter awl, complete, 73.9 mm long, 13.2 mm wide, 7.8 mm thick
- 1 quartz stemmed preform (Table 54:5)
- 1 quartzite projectile point, distal end
- 1 brown chert projectile point, distal end
- 1 quartz lanceolate projectile point, lateral fragment
- 2 quartzite blades, midsections
- 1 quartzite blade, distal end
- 1 quartz ovoid preform
- 1 black chert unifacial flake w/utilization retouch
- 1 piece of pecked and ground greenstone, fragment
- 1 sandstone hammerstone w/pecked margins, 143.5 g
- 1010 fire-cracked cobbles, 33.81 kg
- 4482 water-worn pebbles, 39.67 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	77 (857.2)	30 (68.0)
quartzite	9 (65.0)	6 (26.5)
black chert	1 (0.7)	2 (3.4)
green jasper	1 (3.1)	
red jasper	11 (76.2)	
yellow jasper	1 (1.5)	
chlorite schist	3 (103.5)	2 (1.8)



Early Woodland Component 3

Age: 900 B.C. - 400 B.C.

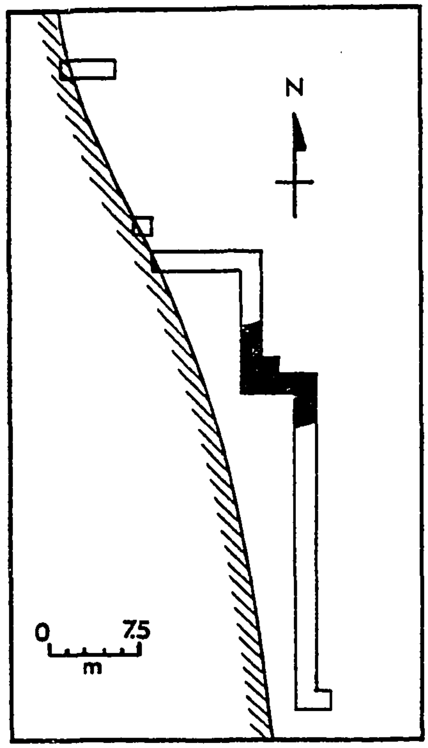
Spatial Extent: greatest linear dimension - 1.7 m, excavated midden volume - 0.23 m^3

Features (Extensive):
- #20 Midden (ash, shells and dark brown sandy loam) Depth - 17 cm

Artifacts:
- 1 Popes Creek Cord Marked pottery vessel (Table 45:24)
- 1 Popes Creek Net Impressed pottery vessel (Table 45:16)
- 4 quartz stemmed projectile points (Table 54:5,6,7,8)
- 2 quartz ovoid preforms
- 95 fire-cracked cobbles, 2.60 kg
- 329 water-worn pebbles, 3.80 kg

Debitage:

	decortication flakes (g)	thinning flakes (g)
quartz	2 (15.3)	2 (8.3)
quartzite	5 (97.4)	8 (65.0)
black chert	1 (0.6)	
basalt	1 (6.6)	



Early Woodland Component 4

Age: 900 B.C. - 400 B.C.

Spatial Extent: greatest linear dimension - 8.2 m, excavated midden volume - 1.03 m^3

Features (Extensive):

- #70 Midden (dark brown sandy loam and shells)
  Depth - 15 cm
- #71 Midden (light brown loamy clay and shells)
  Depth - 7 cm
- #93 Midden (light brown loamy clay and shells)
  Depth - 8 cm

Artifacts:

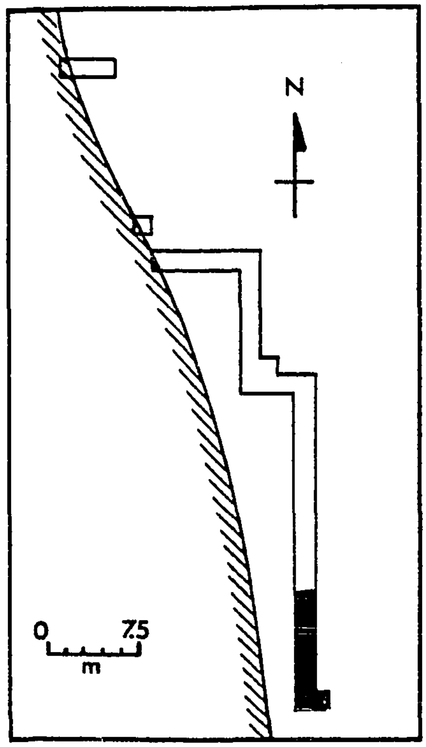
- 2 Popes Creek Net Impressed pottery vessels (Table 45:17,19)
- 2 Popes Creek Cord Marked pottery vessels (Table 45:21,22)
- 1 quartz stemmed projectile point (Table 54:9)
- 1 quartz stemmed projectile point (Table 54:10)
- 1 quartzite stemmed projectile point, proximal fragment
- 1 quartz ovoid preform
- 1 quartz spokeshave/endscraper
- 74 fire-cracked cobbles, 3.34 kg
- 270 water-worn pebbles, 1.66 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	12 (78.1)	1 (0.7)
quartzite	1 (9.2)	

Middle Woodland Component 1

Age: 400 B.C. - A.D. 300

Spatial Extent: greatest linear dimension - 10.5 m, excavated midden volume - 2.91 m^3



Features (Extensive):

#2 Midden (dark brown sandy loam, shells and ash)
Depth - 15 cm

#6 Midden (dark brown sandy loam, ash and shells)
Depth - 26 cm

#10 Midden (shells and dark brown sandy loam)
Depth - 38 cm

#11 Midden (shells, ash, and dark brown sandy loam)
Depth - 16 to 32 cm

#57 Midden (light brown loamy clay and shells)
Depth - 10 cm

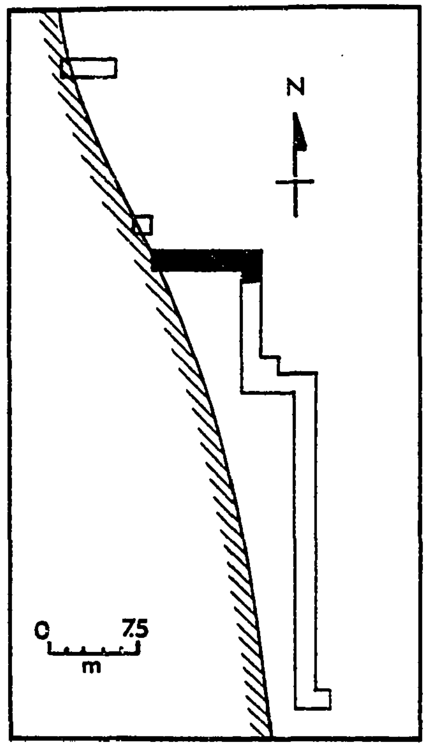
#58 Midden (dark brown sandy loam, shells and ash)
Depth - 8 to 17 cm

Artifacts:

1 Popes Creek Cord Marked pottery vessel (Table 45:23)
4 Popes Creek Net Impressed pottery vessels (Table 45:11,13, 15,20)
2 quartz Rossville projectile points (Table 55:1,2)
1 oyster pearl w/naturally occurring hole
2 quartz ovoid preforms
1 quartz unifacial flake w/utilization retouch
1 sandstone pitted hammerstone w/pecked margins, 145.6 g
1751 fire-cracked cobbles, 38.93 kg
2641 water-worn pebbles, 23.17 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	105 (838.4)	50 (137.4)
quartzite	8 (28.4)	23 (103.2)
black chert	1 (0.5)	1 (3.4)
green jasper	8 (51.4)	3 (2.0)
red jasper	2 (14.3)	
chlorite schist	2 (31.0)	1 (0.6)

Middle Woodland Component 2



Age: 400 B.C. - A.D. 300

Spatial Extent: greatest linear dimension - 9.3 m, excavated midden volume - 3.00 m^3

Features (Extensive):

#32 Midden (dark brown sandy loam and shells)
Depth - 44 cm

#36 Midden (brown sandy loam, shells and ash)
Depth - 20 cm

#107 Midden (light brown loamy clay and shells)
Depth - 13 cm

#113 Midden (brown sandy loam and shells)
Depth - 20 cm

#119 Midden (ash, shells and brown sandy loam)
Depth - 25 to 40 cm

#120 Midden (brown sandy loam and shells)
Depth - 32 to 38 cm

#121 Midden (brown sandy loam, ash and shells) Depth - 23 cm

#122 Midden (light brown loamy clay and shells) Depth - 8 cm

#124 Midden (ash, brown sandy loam and shells) Depth - 42 cm

#125 Midden (brown sandy loam, shells and ash) Depth - 16 cm

#135 Yellow Clay Cap (redeposited yellow clay subsoil dug from Feature #126) Thickness - 30 cm

Features (Intrusive):

#31 Basin (dark brown sandy loam, shells and ash)
Depth - 35 cm, Diameter - undetermined

#126 Deep Pit (filled w/shells and yellow loamy clay)
Depth - 60 cm, Diameter - undetermined

Artifacts:

2 Popes Creek Net Impressed pottery vessels (Table 45:12,14)
1 Popes Creek Cord Marked pottery vessel (Table 45:25)
1 Popes Creek pottery vessel w/smoothed rim (Table 45:27)
1 mammal long bone shaft, scored and snapped bead blank
1 quartz Rossville projectile point (Table 55:3)
3 quartz projectile points, distal fragments
1 quartzite projectile point, distal fragment
6 quartz ovoid preforms
1 quartzite ovoid preform
1 sandstone pitted hammerstone, 220.4 g

1 sandstone bi-pitted hammerstone w/pecked margins, 251.5 g
658 fire-cracked cobbles, 23.78 kg
3485 water-worn pebbles, 25.59 kg

Debitage:

	decortication flakes (g)	thinning flakes (g)
quartz	118 (524.9)	87 (132.2)
quartzite	10 (63.8)	17 (47.4)
black chert		8 (5.9)
tan chert	1 (0.7)	1 (3.2)
green jasper	4 (6.2)	1 (2.0)
white chert		1 (0.6)
red jasper		4 (2.0)
yellow jasper	1 (2.9)	15 (6.5)
rhyolite	1 (0.7)	
metarhyolite		2 (8.4)
argillite	2 (123.2)	

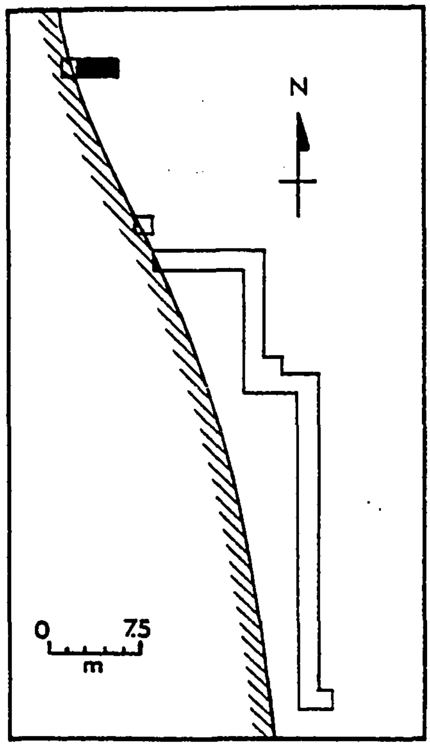
Middle Woodland Component 3

Age: 400 B.C. - A.D. 300

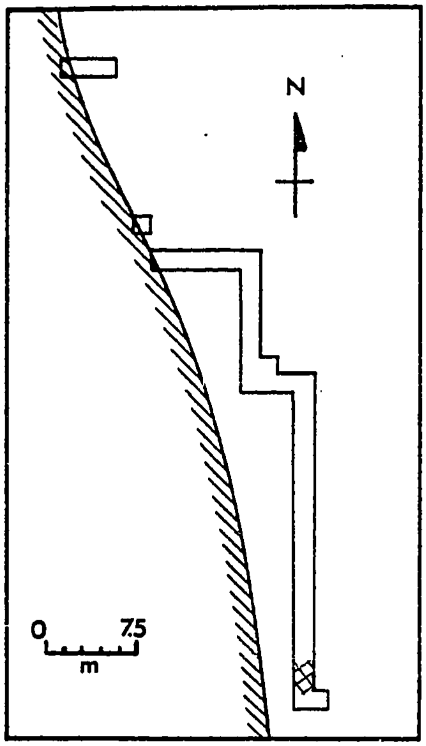
Spatial Extent: greatest linear dimension - 3.8 m, excavated midden volume - 1.30 m^3

Features (Extensive):
#134 Midden (brown sandy loam and shells)
Depth - 23 cm

Artifacts:
1 Popes Creek Net Impressed pottery vessel (Table 45:18)
1 Popes Creek Cord Marked pottery vessel (Table 45:26)
2 quartz Rossville projectile points (Table 55:4,5)
1 quartz hafted endscraper
1 quartz ovoid preform
1 sandstone hammerstone w/pecked margins, 105.7 g
464 fire-cracked cobbles, 11.08 kg
1796 water-worn pebbles, 15.25 kg



Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	37 (358.8)	18 (55.3)
quartzite	5 (141.3)	3 (13.9)
tan chert	1 (14.8)	
rhyolite		1 (0.3)
chlorite schist		1 (2.6)



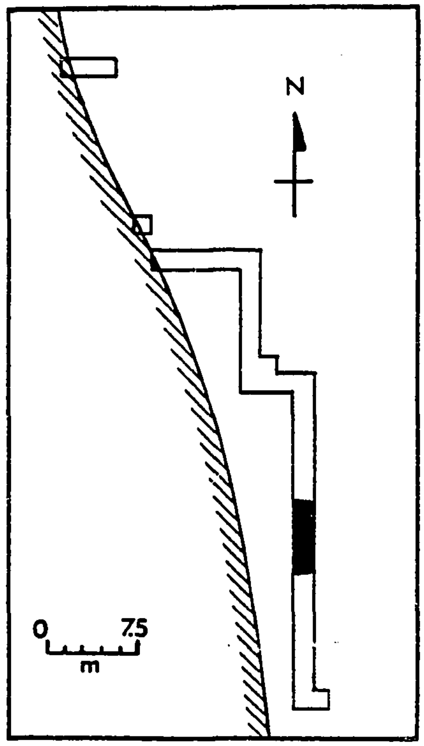
Late Woodland Component 1

Age: A.D. 700 - 900

Spatial Extent: unknown

Features: none excavated; artifacts were found redeposited in later contexts.

Artifacts:
- 1 Nomini Fabric Impressed pottery vessel (Table 47:58)
- 1 quartz Nomini projectile point (Table 56:1)
- 1 quartzite Nomini projectile point (Table 56:2)



Late Woodland Component 2

Age: A.D. 700 - 900

Spatial Extent: greatest linear dimension - 6.8 m, excavated midden volume - 0.58 m^3

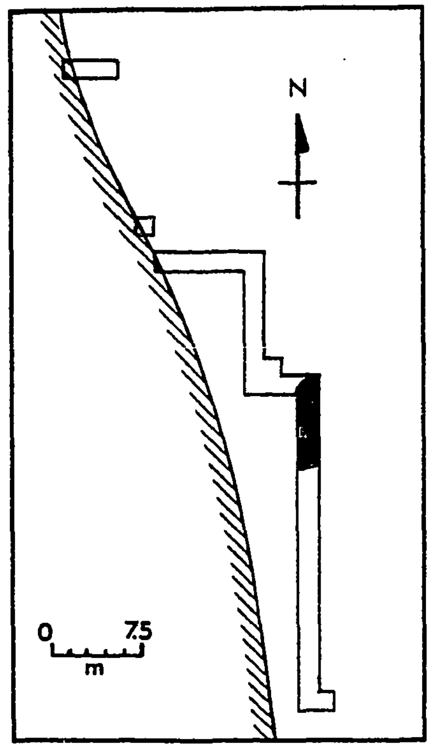
Features (Extensive):
- #24 Midden (ash, brown sandy loam and shells)
  Depth - 12 to 15 cm
- #60 Midden (dark brown sandy loam and shells)
  Depth - 9 cm
- #65 Midden (brown sandy loam, ash and shells)
  Depth - 8 to 13 cm

Features (Intrusive):
- #21 Basin (shells, dark brown sandy loam and ash)
  Diameter - 150+ cm
  Depth - 19 cm

Artifacts:
- 1 Nomini Fabric Impressed pottery vessel (Table 47:59)
- 1 Nomini Cord Marked pottery vessel (Table 47:66)
- 1 Mockley Net Impressed pottery vessel (Table 46:37)
- 2 Mockley Cord Marked pottery vessels (Table 46:32,34)
- 1 quartz Nomini projectile point (Table 56:3)
- 1 quartzite Nomini projectile point (Table 56:4)
- 1 quartz unifacial flake w/utilization retouch
- 146 fire-cracked cobbles, 3.83 kg
- 859 water-worn pebbles, 8.50 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	12 (139.1)	6 (9.4)
quartzite	4 (19.2)	7 (22.3)
black chert	1 (2.4)	
chlorite schist		1 (3.0)
red jasper	1 (2.8)	

Late Woodland Component 3



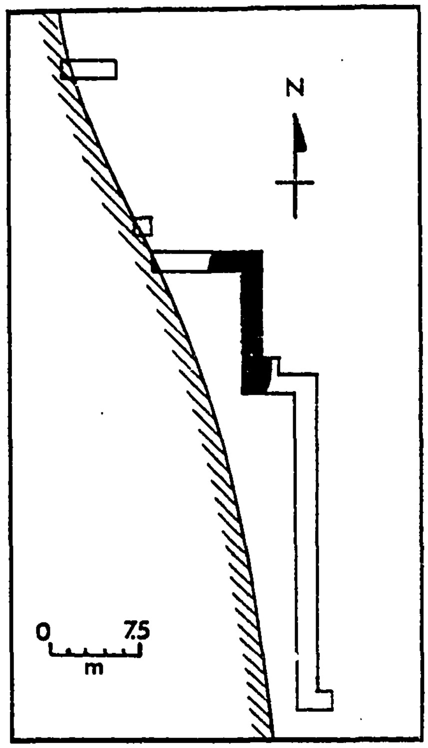
Age: A.D. 700 - 900

Spatial Extent: greatest linear dimension - 7.5 m, excavated midden volume - 0.77 m^3

Features (Extensive)
- #68 Midden (brown sandy loam and shells)
  Depth - 5 cm
- #69 Yellow Clay Cap (redeposited yellow clay subsoil dug from a pit in unit 24N3E)
  Diameter - 128 x 370 cm
  Thickness - 16 cm
- #72 Midden (dark brown sandy loam and shells)
  Depth - 18 cm

Artifacts:
- 1 Nomini Fabric Impressed pottery vessel (Table 47:61)
- 1 Nomini Cord Marked pottery vessel (Table 47:64)
- 2 Mockley Cord Marked pottery vessels (Table 46:29,30)
- 122 fire-cracked cobbles, 3.50 kg
- 795 water-worn pebbles, 5.03 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	4 (30.2)	3 (7.0)
quartzite	2 (11.0)	7 (20.9)
shale		1 (2.0)



Late Woodland Component 4

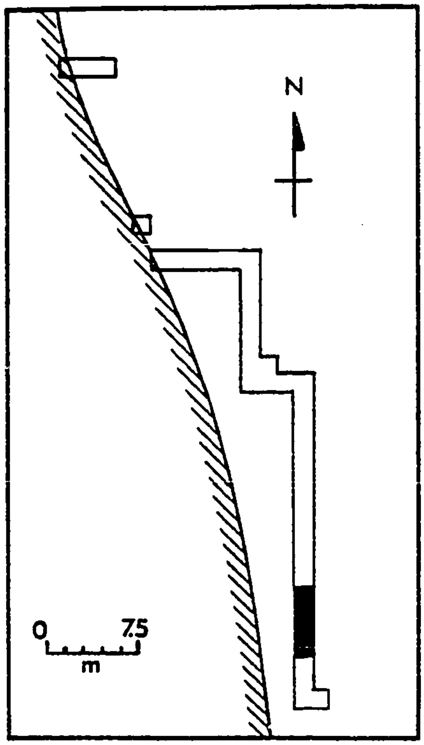
Age: A.D. 880±60 (DIC-1769), corrected to A.D. 895±80

Spatial Extent: greatest linear dimension - 12.2 m, excavated midden volume - 1.81 m^3

Features (Extensive):
- #45 Midden (ash, dark brown sandy loam and shells) Depth - 19 cm
- #80 Midden (ash and shells) Depth - 19 cm
- #81 Midden (light brown loamy clay and shells) Depth - 12 cm
- #82 Midden (brown sandy loam and shells) Depth - 4 cm
- #96 Midden (brown sandy loam and shells) Depth - 7 cm
- #97 Midden (light brown loamy sand and shells) Depth - 4 cm
- #101 Midden (shells and brown sandy loam) Depth - 20 cm
- #114 Midden (brown sandy loam, ash and shells) Depth - 10 cm

Artifacts:
- 3 Nomini Fabric Impressed pottery vessels (Table 47:60,62,63)
- 1 Nomini Cord Marked pottery vessel (Table 47:65)
- 5 Mockley Cord Marked pottery vessels (Table 46:1,28,31,33,35)
- 4 Mockley Net Impressed pottery vessels (Table 46:38,39,81,91)
- 1 white-tailed deer metapodial shaft fragment, stemmed projectile point, 30.0 mm long, 13.2 mm wide at shoulders, 11.1 mm long stem, 5.4 mm thick (Figure 18:C)
- 2 mammal bone awls, distal fragments (one charred)
- 1 chlorite schist miniature platform pipe, unfinished (Figure 18:A)
- 2 quartz Nomini projectile points (Table 56:5,6)
- 1 quartzite Nomini projectile point (Table 56:7)
- 1 green jasper Nomini projectile point (Table 56:8)
- 1 rhyolite Nomini projectile point (Table 56:9)
- 1 rhyolite ovoid biface
- 196 fire-cracked cobbles, 6.07 kg
- 1132 water-worn pebbles, 4.77 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	27 (139.1)	19 (44.8)
quartzite	2 (15.2)	4 (11.9)
black chert		2 (1.5)
red jasper	1 (4.3)	
yellow jasper		1 (0.2)
metarhyolite	1 (2.1)	1 (4.7)



Late Woodland Component 5

Age: A.D. 1100 - 1300

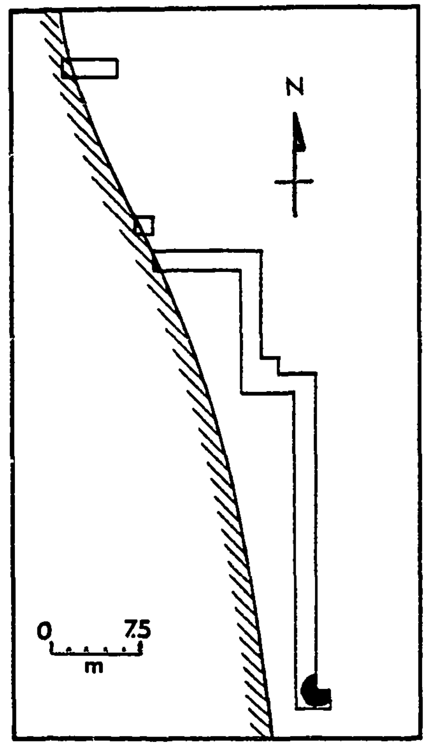
Spatial Extent: greatest linear dimension - 6.1 m, excavated midden volume - 1.46 m^3

Features (Extensive):
- #13 Midden (dark brown sandy loam and shells)
  Depth - 15 to 21 cm
- #59 Midden (dark brown sandy loam and shells)
  Depth - 5 to 12 cm

Features (Intrusive):
- #15 Basin (shells, ash and dark brown sandy loam)
  Depth - 25 cm
  Diameter - 80 x 95 cm
- #16 Basin (dark brown sandy loam, shells and charcoal)
  Depth - 36 cm
  Diameter - 140 cm

Artifacts:
- 3 Currioman Fabric Impressed pottery vessels (Table 48:68, 69,77)
- 1 quartz unifacial flake w/intentional retouch
- 1 quartz ovoid preform
- 1 rhyolite ovoid preform
- 508 fire-cracked cobbles, 14.65 kg
- 1707 water-worn pebbles, 17.40 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	44 (330.4)	24 (39.4)
quartzite	10 (81.0)	34 (119.2)
black chert	3 (3.1)	11 (3.7)
chlorite schist		1 (103.6)



Late Woodland Component 6

Age: A.D. 1310±50 (DIC-1764) and A.D. 1460±45 (DIC-1766), corrected to A.D. 1295±60 and A.D. 1430±60, respectively. The later date is probably more nearly correct.

Spatial Extent: greatest linear dimension - 1.8 m, excavated midden volume - 0.48 m^3

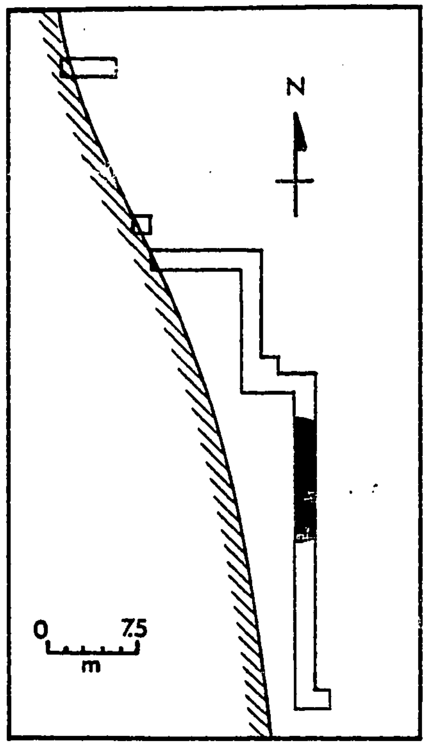
Features (Extensive):
#56 Midden (dark brown sandy loam and shells)
Depth - 8 to 12 cm

Features (Intrusive):
#4 Basin (ash and shell) with Pit in center (dark brown sandy loam and shells)
Basin Depth - 8 to 13 cm, Diameter - 132 cm
Pit Depth - 22 cm, Diameter - 56 cm

Artifacts:
2 Rappahannock Fabric Impressed pottery vessels (Table 49: 71,88)
2 Moyaone Cord Impressed pottery vessels (Table 50:94,95)
1 ceramic pipe bowl fragment w/incised lines perpendicular to the lip and scattered punctations
2 quartz unifacial flakes w/utilization retouch
1 quartzite unifacial flake w/utilization retouch
758 fire-cracked cobbles, 16.65 kg
485 water-worn pebbles, 2.33 kg

Debitage:

	decortication flakes (g)	thinning flakes (g)
quartz	29 (170.8)	29 (80.2)
quartzite	8 (69.9)	4 (8.0)
green jasper	2 (105.9)	
red jasper	1 (2.3)	
yellow jasper	1 (56.8)	
argillite	1 (2.1)	1 (2.1)



Late Woodland Component 7

Age: A.D. 1005±70 (SI-4374), corrected to A.D. 1015±80

Spatial Extent: greatest linear dimension - 10.0 m, excavated midden volume - 0.95 m^3

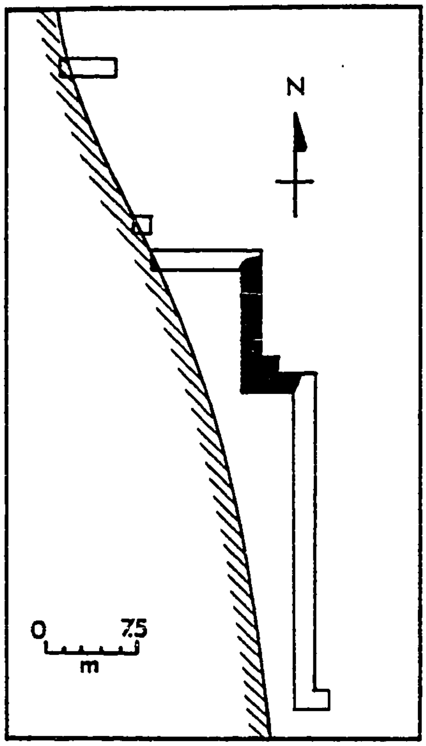
Features (Extensive):
- #23 Midden (brown sandy loam and shells)
  Depth - 8 to 17 cm
- #26 Midden (ash, dark brown sandy loam and shells)
  Depth - 12 cm
- #28 Midden (dark brown sandy loam and shells)
  Depth - 6 cm
- #50 Midden (brown sandy loam and shells)
  Depth - 20 cm
- #64 Midden (brown sandy loam and shells)
  Depth - 5 to 8 cm

Features (Intrusive):
- #22 Basin (ash, dark brown sandy loam and shells)
  Depth - 14 cm, Diameter - 140 cm
- #27 Basin (ash, dark brown sandy loam and shells)
  Depth - 6 cm, Diameter - 73 cm
- #48 Basin (ash, shells and dark brown sandy loam)
  Depth - 19 cm, Diameter - 116 cm
- #49 Basin (ash, dark brown sandy loam and shells)
  Depth - 11 cm, Diameter - 80 cm
- #54 Basin (ash, brown sandy loam and shells)
  Depth - 11 cm, Diameter - 150+ cm

Artifacts:
- 4 Rappahannock Fabric Impressed pottery vessels (Table 49:73,86,92,93)
- 3 Rappahannock Incised pottery vessels (Table 49:74,75,85)
- 1 fossil shark's tooth
- 1 Prunum apicinum shell bead, spire ground to form perforation
- 3 quartz triangular projectile points (Table 57:1,2,3)
- 1 black chert triangular projectile point (Table 57:4)
- 1 tan chert triangular projectile point, lateral fragment
- 1 red jasper biface, distal fragment
- 2 quartz triangular preforms
- 2 yellow jasper ovoid preforms
- 172 fire-cracked cobbles, 8.15 kg
- 600 water-worn pebbles, 4.33 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	28 (262.7)	13 (17.3)
quartzite	7 (83.0)	7 (9.4)
black chert		3 (2.2)
green jasper	3 (4.3)	
red jasper	2 (3.5)	
yellow jasper	1 (5.2)	

Late Woodland Component 8



Age: A.D. 1340±55 (DIC-1768), corrected to A.D. 1320±60

Spatial Extent: greatest linear dimension - 11.4 m, excavated midden volume - 2.54 m^3

Features (Extensive):

- #83 Midden (brown sandy loam and shells) Depth - 8 cm
- #84 Midden (brown sandy loam and shells) Depth - 20 cm
- #85 Midden (dark brown sandy loam and shells) Depth - 19 cm
- #87 Midden (shells and dark brown sandy loam) Depth - 26 cm
- #92 Midden (brown sandy loam and shells) Depth - 18 cm
- #94 Midden (shells, ash and dark brown sandy loam) Depth - 9 cm
- #95 Midden (shells and dark brown sandy loam) Depth - 8 cm
- #103 Midden (shells and brown sandy loam) Depth - 10 cm
- #104 Midden (brown sandy loam and shells) Depth - 4 cm

Features (Intrusive):

- #53 Basin (dark brown sandy loam and shells) Depth - 20 cm, Diameter - 150 cm
- #86 Basin (burned shells and dark brown sandy loam) Depth - 9 cm, Diameter - 104 cm
- #102 Basin (shells and dark brown sandy loam) Depth - 23 cm, Diameter - 96 cm
- #105 Basin (ash, shells and dark brown sandy loam) Depth - 6 cm, Diameter - 45 cm
- #106 Basin (dark brown sandy loam and shells) Depth - 34 cm, Diameter - 120 cm

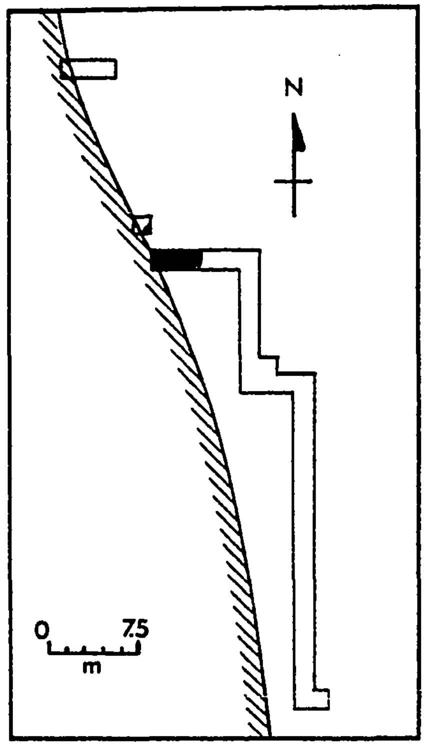
Artifacts:

- 2 Currioman Fabric Impressed pottery vessels (Table 48:67,82)
- 3 Rappahannock Fabric Impressed pottery vessels (Table 49:72,76,87)
- 2 ceramic pipe bowl fragments (1 undecorated, 1 w/punctations)
- 1 *Mercenaria mercenaria* disc bead, 2.8 mm in diameter, 1.2 mm thick, hole 1.0 mm in diameter (Figure 18:F)
- 1 white-tailed deer antler tine w/hollowed base, 76.4 mm long

1 white-tailed deer left ulna awl w/tip missing, 79.5 mm long
1 mammal bone fishhook, unfinished, incomplete, 17.1+ mm long, 9.8 mm wide, 2.7 mm thick
1 mammal bone spatula, distal fragment, 13.5 mm wide, 3.3 mm thick
1 mammal bone splinter awl, tip missing, proximal end rounded and polished, 57.5+ mm long, 10.4 mm wide, 5.0 mm thick
3 quartz triangular projectile points (Table 57:6,7,8)
1 tan chert triangular projectile point (Table 57:9)
1 yellow jasper triangular projectile point (Table 57:10)
2 quartz ovoid preforms
1 quartz biface, lateral fragment
1 quartzite flake w/bifacial retouch along one margin
1 sandstone hammerstone w/marginal pecking, 328.5 g
310 fire-cracked cobbles, 10.68 kg
2768 water-worn pebbles, 8.51 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	64 (508.2)	38 (65.9)
quartzite	7 (18.2)	17 (50.6)
black chert	2 (3.8)	2 (1.1)
green jasper	1 (8.3)	
red jasper	5 (15.0)	1 (0.3)
yellow jasper	2 (3.2)	2 (0.8)
rhyolite		1 (0.7)
chlorite schist	2 (10.4)	
basalt		1 (0.4)

Late Woodland Component 9



Age: A.D. 1300 - 1450

Spatial Extent: greatest linear dimension - 4.8 m, excavated midden volume - 1.12 m^3

Features (Extensive):
- #33 Midden (brown sandy loam and shells)
  Depth - 27 cm
- #34 Midden (brown sandy loam and shells)
  Depth - 15 cm

Features (Intrusive):
- #29 Basin (shells and brown sandy loam)
  Depth - 18 cm
  Diameter - unknown
- #35 Basin (shells and brown sandy loam)
  Depth - 30 cm
  Diameter - 160 cm
- #40 Basin (dark brown sandy loam, ash and shells) Depth - 23 cm, Diameter - 140 cm
- #42 Basin (shells, ash and brown sandy loam)
  Depth - 41 cm, Diameter - 120 cm

Artifacts:
- 4 Rappahannock Fabric Impressed pottery vessels (Table 49:78,79,84,89)
- 1 Currioman Fabric Impressed pottery vessel (Table 48:70)
- 1 Moyaone Plain pottery vessel (Table 50:96)
- 2 bowl fragments of a ceramic pipe, w/punctations below the lip
- 1 mammal bone splinter awl, complete, 52.8 mm long, 9.3 mm wide, 5.2 mm thick; w/tapered and polished tip, 20 mm long
- 1 bird split long bone awl, tip missing, 83.0+ mm long, 7.6 mm wide, 2.7 mm thick
- 2 mammal bone fishhooks, incomplete (1 unfinished, 1 finished), 10.7+ mm and 19.8+ mm long, 11.1 mm and 8.4 mm wide, 3.8 mm and 3.2 mm thick, respectively (Figure 18:D)
- 1 white-tailed deer antler tine, scored twice and snapped, 19.4 mm long, 6.8 mm in diameter; otherwise unaltered
- 1 Mercenaria mercenaria disc bead, charred, 3.0 mm in diameter, 1.0 mm thick, hole 1.1 mm in diameter
- 1 Prunum apicinum bead, w/spire ground off to form perforation (Figure 18:G)
- 3 Dentalium occidentale beads, complete (Figure 18:H)
- 1 quartz triangular projectile point (Table 57:10)

1 quartzite hammerstone w/marginal pecking, 198.1 g
1 sandstone pitted hammerstone w/marginal pecking, 442.4 g
158 fire-cracked cobbles, 7.04 kg
458 water-worn pebbles, 6.66 kg

Debitage:

	decortication flakes (g)	thinning flakes (g)
quartz	47 (356.9)	17 (17.4)
quartzite	3 (4.0)	
black chert	1 (1.2)	
tan chert	2 (6.3)	
white chert	1 (3.5)	1 (0.4)
red jasper		2 (0.3)
yellow jasper	1 (0.3)	8 (3.0)
basalt	2 (183.7)	

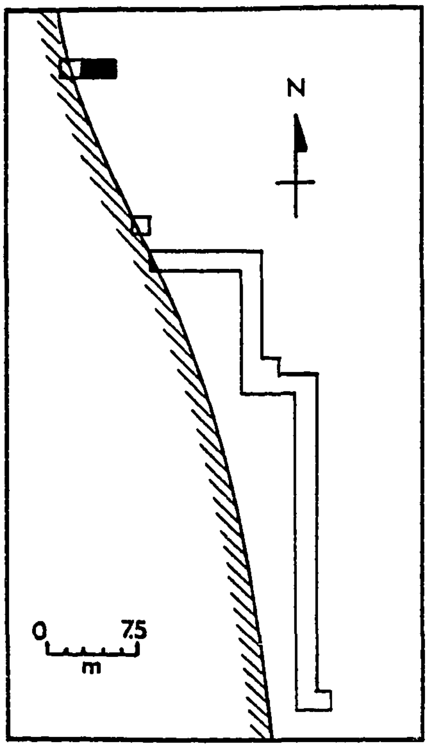
Late Woodland Component 10

Age: A.D. 860±60 (DIC-1763), corrected to A.D. 875±80

Spatial Extent: greatest linear dimension - 3.1 m, excavated midden volume - 1.39 m^3

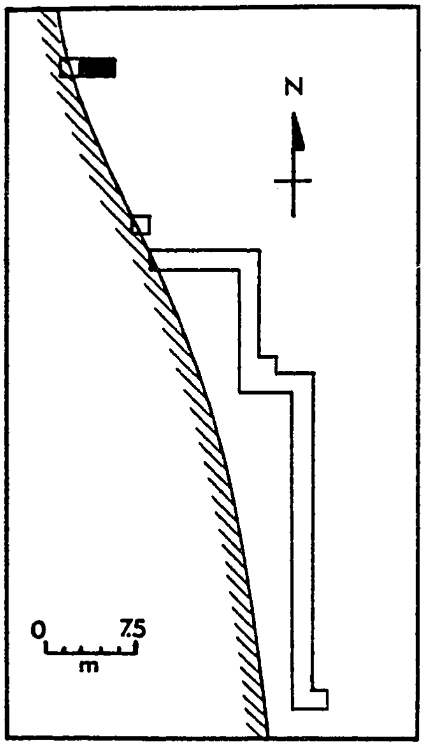
Features (Extensive):
 #132 Midden (dark brown sandy loam and shells)
 Depth - 17 cm

Features (Intrusive):
 #133 Basin (dark brown sandy loam and shells)
 Depth - 14 cm
 Diameter - 70 cm



Artifacts:
- 1 Mockley Net Impressed pottery vessel (Table 46:36)
- 1 Nomini Fabric Impressed pottery vessel (Table 47:57)
- 1 *Castor canadensis* left lower incisor, cut and sharpened into chisel form
- 1 fossil shark's tooth
- 1 quartz projectile point, distal fragment
- 1 quartz ovoid preform
- 443 fire-cracked cobbles, 10.69 kg
- 1777 water-worn pebbles, 16.23 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	29 (217.4)	12 (19.5)
quartzite	5 (69.1)	7 (13.4)
green jasper		1 (0.7)
red jasper		1 (1.8)
chlorite schist		2 (1.3)



Late Woodland Component 11

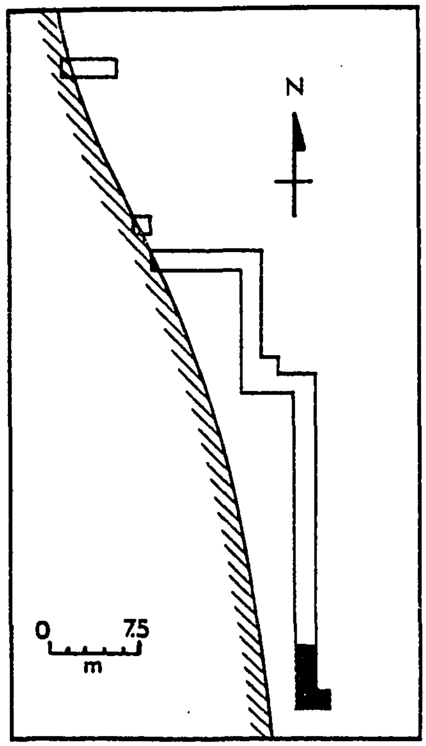
Age: A.D. 1400 - 1500

Spatial Extent: greatest linear dimension - 3.5 m, excavated midden volume - 1.06 m^3

Features (Extensive):
#130 Midden (dark brown sandy loam and shells)
Depth - 25 cm

Artifacts:
- 3 Rappahannock Fabric Impressed pottery vessels (Table 49: 80,83,90)
- 1 mammal bone splinter awl, complete, 76.0 mm long, 12.7 mm wide, 9.6 mm thick
- 1 mammal bone splinter awl, distal fragment, 36.5+ mm long, 9.0 mm wide, 4.1 mm thick
- 1 fragment of white-tailed deer antler shaft; scored, snapped and socketed
- 1 *Busycon canaliculatum* rectangular cut-out, 115 x 130 mm, 1.7 mm thick, ground surfaces (Figure 18:J)
- 66 fire-cracked cobbles, 3.36 kg
- 71 water-worn pebbles, 1.93 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	12 (79.4)	4 (15.8)
quartzite	1 (24.4)	1 (3.1)
black chert	2 (2.2)	
green jasper		1 (1.5)
yellow jasper		1 (0.4)



Protohistoric/Early Historic
Component 1

Age: A.D. 1500 - 1640

Spatial Extent: greatest linear dimension - 6.8 m, excavated midden volume - 0.84 m^3

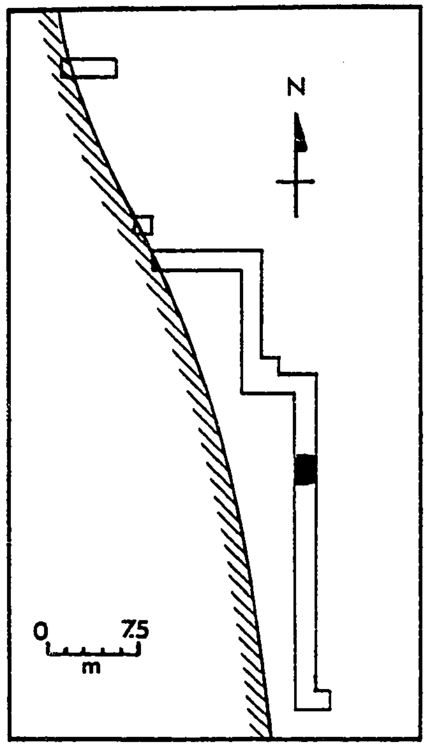
Features (Extensive):
- #3 Midden (dark brown sandy loam, shells and ash)
  Depth - 6 to 12 cm
- #55 Midden (dark brown sandy loam and shells)
  Depth - 10 cm

Features (Intrusive):
- #1 Basin (crushed shells and ash)
  Depth - 4 cm
  Diameter - 52 x 68 cm
- #5 Basin (shells, dark brown sandy loam and ash)
  Depth - 8 cm
  Diameter - 56 x 63 cm
- #7 Basin (dark brown sandy loam, ash and shells)
  Depth - 7 cm, Diameter - 116 cm

Artifacts:
- 3 Yeocomico Plain pottery vessels (Table 51:50,52,53)
- 1 Yeocomico Scraped pottery vessel (Table 51:49)
- 2 ceramic pipe bowl fragments, plain
- 1 ceramic pipe stem fragment, plain
- 1 elk mandibular canine pendant; tooth ground and perforated, drilled hole diameter - 2.3 mm (Figure 18:E)
- 1 white-tailed deer metapodial shaft awl, complete w/rounded, polished shaft, 88.3 mm long, 9.6 mm wide, 10.0 mm thick, tapered tip 15.0 mm long
- 1 fossil shark's tooth
- 1 Dentalium occidentale bead, complete
- 1 quartz triangular projectile point (Table 57:1)
- 2 quartz triangular projectile points, lateral fragments (Table 58:2,3)
- 2 quartz projectile points, blade midsection fragments
- 2 quartz ovoid preforms
- 1 black chert unifacial flake w/intentional marginal retouch
- 1 yellow jasper unifacial flake w/marginal utilization retouch
- 921 fire-cracked cobbles, 14.96 kg
- 1099 water-worn pebbles, 9.55 kg

Debitage:

	decortication flakes (g)	thinning flakes (g)
quartz	149 (701.2)	65 (141.9)
quartzite	12 (237.6)	14 (47.7)
black chert	1 (10.2)	
green jasper		1 (3.4)
red jasper	5 (11.6)	
yellow jasper		3 (1.9)
mica schist		1 (3.1)



Protohistoric/Early Historic
Component 2

Age: A.D. 1500 - 1640

Spatial Extent: greatest linear dimension - 2.7 m, excavated midden volume - 0.09 m^3

Features (Intrusive):

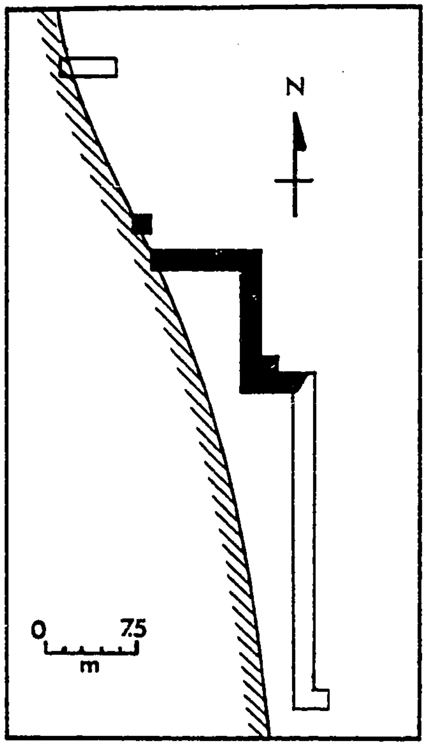
#25 Deep Pit (ash, brown sandy loam and shells)
Depth - 35 cm
Diameter - 60 cm

#47 Basin (dark brown sandy loam and shells)
Depth - 11 cm
Diameter - 70 cm

Artifacts:

2 Yeocomico Plain pottery vessels (Table 51:44,51)
1 Yeocomico Scraped pottery vessel (Table 51:40)
1 quartz triangular projectile point (Table 58:4)
25 fire-cracked cobbles, 0.92 kg
67 water-worn pebbles, 0.21 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	5 (66.4)	5 (4.3)
quartzite	1 (6.8)	
black chert	1 (0.7)	



Protohistoric/Early Historic
Component 3

Age: A.D. 1510±75 (DIC-1765), corrected to A.D. 1480±90; A.D. 1540±55 (DIC-1770), corrected to A.D. 1500±65; A.D. 1630±55 (DIC-1767) and A.D. 1690±55 (DIC-1762)

Spatial Extent: greatest linear dimension - 19.6 m, excavated midden volume - 3.55 m^3

Features (Extensive):
- #51 Midden (dark brown sandy loam and shells) Depth - 24 cm
- #73 Midden (dark brown sandy loam and shells) Depth - 14 cm
- #74 Midden (burned shells and dark brown sandy loam) Depth - 13 cm
- #75 Midden (ash, dark brown sandy loam and shells) Depth - 17 cm
- #79 Midden (brown sandy loam and shells) Depth - 10 cm
- #88 Midden (ash, dark brown sandy loam and shells) Depth - 26 cm
- #99 Midden (brown sandy loam and shells) Depth - 9 cm

Features (Intrusive):
- #44 Basin (ash, shells and brown sandy loam) Depth - 33 cm, Diameter - 135 cm
- #52 Basin (shells and dark brown sandy loam) Depth - 22 cm, Diameter - 107 cm
- #76 Basin (dark brown sandy loam and broken shells) Depth - 20 cm, Diameter - 160 cm
- #77 Basin (brown sandy loam and shells) Depth - 19 cm, Diameter - 42 cm
- #78 Basin (ash, shells, and brown sandy loam) Depth - 25 cm, Diameter - 68 cm
- #89 Basin (ash, dark brown sandy loam and shells) Depth - 10 cm, Diameter - 80 cm
- #90 Basin (dark brown sandy loam and shells) Depth - 8 cm, Diameter - 165 cm
- #91 Basin (ash, dark brown sandy loam and shells) Depth - 4 cm, Diameter - 37 cm
- #98 Basin (shells and brown sandy loam) Depth - 20 cm, Diameter - 90 cm

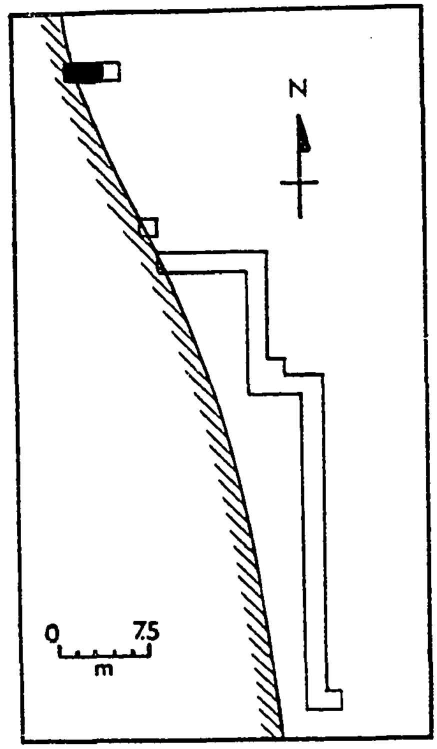
#100 Basin (ash, dark brown sandy loam and shells)
Depth - 33 cm, Diameter - 105 cm
#108 Basin (ash, dark brown sandy loam and shells)
Depth - 3 cm, Diameter - 53 cm
#109 Basin (ash, shells and brown sandy loam)
Depth - 7 cm, Diameter - 60 cm
#127 Burial Pit (brown sandy loam and shells)
Depth - 23 cm, Diameter - unknown

Artifacts:

8 Yeocomico Plain pottery vessels (Table 51:43,45,46,47,48, 54,55,56)
2 Yeocomico Cord Marked pottery vessels (Table 51:41,42)
1 ceramic elbow pipe, complete (Figure 18:B)
1 ceramic pipe stem, triangular in cross section
3 bowl fragments from a single plain pipe
3 bowl fragments from a single rocker stamped dentate decorated pipe
2 bird bone beads, complete, 21.0 mm and 38.9 mm long, 2.8 mm and 3.9 mm in diameter; scored, snapped and polished
1 white-tailed deer antler tine w/tip scored and snapped off, 88.1 mm long, 17.3 mm in diameter
1 white-tailed deer antler projectile point, one half complete, split longitudinally; proximal end was scored, snapped and hollowed to a depth of 18 mm; 32.9 mm long, 12.0 mm in diameter
1 mammal bone pin, complete, rounded and polished; 56.2 mm long, 5.9 mm wide, 4.5 mm thick
2 midsection fragments of a bird bone awl; bone had been split longitudinally, charred and highly polished, 8.2 mm wide, 2.4 mm thick
1 mammal bone awl midsection, partially charred, polished, 7.1 mm wide, 3.7 mm thick
2 complete mammal bone splinter awls, rounded and polished, 53.0 mm and 40.1 mm long, 8.5 mm and 7.0 mm wide, 5.1 mm and 2.9 mm thick, respectively
2 distal fragments of mammal bone awls
1 oyster pearl with a natural perforation
1 *Aequipecten irradians concentricus* disc bead, 3.6 mm in diameter, hole 1.2 mm in diameter, 1.0 mm thick (Figure 18:I)
1 white glass disc bead, 2.6 mm in diameter, hole 1.1 mm in diameter, 1.5 mm thick
1 Human burial, portions of a skull and the 1st cervical vertebra
1 quartz triangular projectile point (Table 58:5)
1 rhyolite biface, distal fragment
5 quartz ovoid preforms
1 sandstone pitted hammerstone w/marginal pecking, 363.4 g
492 fire-cracked cobbles, 23.50 kg
5117 water-worn pebbles, 13.13 kg

Debitage:	decortication flakes (g)	thinning flakes (g)
quartz	179 (1454.1)	85 (116.7)
quartzite	11 (86.5)	12 (20.7)
black chert		10 (4.1)
red jasper	6 (8.5)	2 (0.7)
yellow jasper	1 (0.8)	2 (1.5)
green jasper		4 (2.5)
metarhyolite		1 (4.7)

Protohistoric/Early Historic
Component 4



Age: A.D. 1640 - 1700

Spatial Extent: greatest linear dimension - 2.9 m, excavated midden volume - 0.23 m^3

Features (Extensive):
- #128 Midden (surface duff, dark brown sandy loam and shells)
  Depth - 3 cm

Features (Intrusive);
- #129 Pit (dark brown sandy loam and crushed shells)
  Depth - 40 cm
  Diameter - 50 cm
- #131 Burial Pit (dark brown sandy loam and shells)
  Depth - 15 to 20 cm
  Diameter - 120+ cm

Artifacts:
- 1 Camden Plain pottery vessel (Table 50:97)
- 1 mammal bone splinter awl, distal fragment
- 1 Human burial
- 11 fire-cracked cobbles, 0.82 kg
- 32 water-worn pebbles, 0.10 kg

Debitage:

	decortication flakes (g)
quartz	2 (13.0)
black chert	1 (1.0)

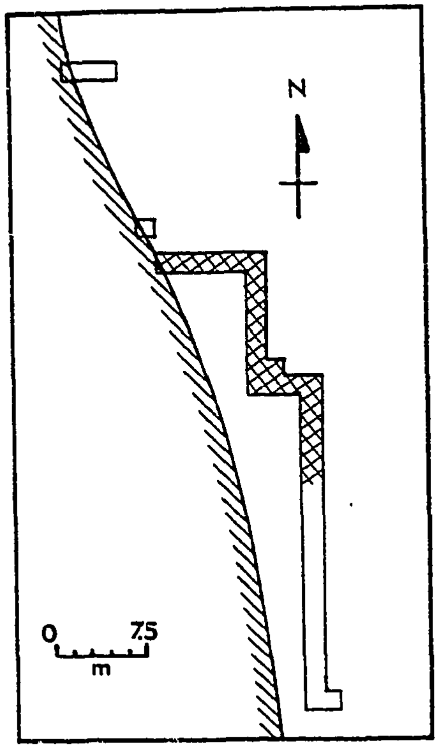
Historic Euramerican Component 1

Age: A.D. 1700 - 1800

Spatial Extent: unknown

Features: none excavated, artifacts were found in disturbed context (i.e., plowzone)

Artifacts:
- 1 blond flint gun spall fragment
- 1 handforged nail, 70 mm long, w/heavily battered head and flattened tip, burned
- 1 handforged nail, tip fragment, w/slightly flattened tip



Discussion of Cultural Chronology and Artifact Assemblages

The 26 archaeological components partially excavated at 44WM119, the White Oak Point site, span a period of more than 4500 years, from Late Archaic times to the recent colonial past. Because of the obvious importance of this long sequence for resolving problems in regional culture history, a total of 14 radiocarbon dates were obtained on charcoal and shell samples from the midden (Table 42). One of the primary advantages of the White Oak Point radiocarbon series is the fact that this constitutes the largest number of dates obtained from a single site in the region, thus obviating some interpretive problems inevitably encountered when relying upon dates from distant sites. For ease of comparison, all other known radiocarbon dates relevant to lower Potomac Valley chronology have been assembled in Table 43.

The White Oak Point sequence begins with three Late Archaic components. The oldest of these (Late Archaic Component 3, LA3) is represented by only four fragmentary Savannah River Contracting-Stemmed variant projectile points (Claflin 1931:33-39) which were all found mixed in later component features. This point type has never been directly dated, but is thought to date to circa 3000 B.C.

In the Chesapeake Tidewater, the small variant of Savannah River Stemmed has been found recently in situ at 44NB128 associated with Holmes points, where they were radiocarbon dated 2155 B.C. ± 85 and 1955 B.C. ± 95 (corrected to 2733 ± 130 and 2475 B.C. ± 130, respectively) (Stephen R. Potter, personal communication, 1982). This corresponds well with a date of 1944 B.C. ± 350 (corrected to 2460 B.C. ± 360) obtained at the Gaston site in North Carolina on the Savannah River Stemmed small variant (Coe 1964:55, 98, 110). Quartzite Holmes

Table 42. Radiocarbon Dates from the White Oak Point Site, 44WM119.

Associated Ceramic Ware	Uncorrected Date	Corrected Date (after Damon et al. 1974)	Laboratory Number	Charcoal or Shell
pre-ceramic (steatite bowls)	1550 B.C. (3500 ± 75)	1950 B.C. ± 150	DIC-1771	S
Bushnell	1160 B.C. (3110 ± 70)	1435 B.C. ± 90	SI-4377	S
	1110 B.C. (3060 ± 75)	1370 B.C. ± 90	SI-4375	S
	1070 B.C. (3020 ± 70)	1320 B.C. ± 90	SI-4376	C
Mockley and Nomini	A.D. 860 (1090 ± 60)	A.D. 875 ± 80	DIC-1763	C
	A.D. 880 (1070 ± 60)	A.D. 895 ± 80	DIC-1769	C
Townsend	A.D. 1005 (945 ± 70)	A.D. 1015 ± 80	SI-4374	C
Townsend and Moyaone	A.D. 1310 (640 ± 50)	A.D. 1295 ± 60	DIC-1764	C
Townsend and Currioman	A.D. 1340 (610 ± 55)	A.D. 1320 ± 60	DIC-1768	C
Townsend and Moyaone	A.D. 1460 (490 ± 45)	A.D. 1430 ± 60	DIC-1766	C
Yeocomico	A.D. 1510 (440 ± 75)	A.D. 1480 ± 90	DIC-1765	C
	A.D. 1540 (410 ± 55)	A.D. 1500 ± 65	DIC-1770	C
	A.D. 1630 (320 ± 55)	not applicable	DIC-1767	C
	A.D. 1690 (260 ± 55)	not applicable	DIC-1762	C

Table 43. Radiocarbon Dates from Sites in the Chesapeake Bay Coastal Plain.

Associated Ceramic Ware	Uncorrected Date	Corrected Date	Laboratory No.	State*	Reference**
pre-ceramic (Late Archaic)	2155 B.C. (4105 ± 85)	2733 B.C. ± 130	SI-4228	V	4
	1955 B.C. (3905 ± 95)	2475 B.C. ± 130	SI-4229	V	4
Marcey Creek	950 B.C. (2900 ± 95)	1165 B.C. ± 100	I-5091	M	3
Popes Creek and Accokeek	545 B.C. (2495 ± 95)	655 B.C. ± 140	I-5090	M	3
	490 B.C. (2440 ± 95)	590 B.C. ± 140	I-5247	M	3
	A.D. 80 (1870 ± 125)	A.D. 75 ± 130	M-1605	M	5
Mockley	A.D. 200 (1750 ± 90)	A.D. 205 ± 95	I-5817	D	1
	A.D. 300 (1650 ± 110)	A.D. 315 ± 110	I-6060	D	1
	A.D. 325 (1625 ± 160)	A.D. 340 ± 160	UGa-1273b	D	1
	A.D. 330 (1620 ± 65)	A.D. 345 ± 70	UGa-1273a	D	1
	A.D. 460 (1490 ± 120)	A.D. 480 ± 120	Gx-2266	V	2
	A.D. 580 (1370 ± 120)	A.D. 605 ± 120	M-1608	M	5
	A.D. 815 (1135 ± 95)	A.D. 835 ± 110	I-5246	M	3
	A.D. 875 (1075 ± 90)	A.D. 890 ± 110	Gx-2263	V	2

Table 43. (cont.)

Associated Ceramic Ware	Uncorrected Date	Corrected Date	Laboratory No.	State*	Reference**
Townsend	A.D. 1085 (865 ± 75)	A.D. 1090 ± 80	UGa-923	D	1
	A.D. 1100 (850 ± 55)	A.D. 1100 ± 60	UGa-1440	D	1
	A.D. 1125 (825 ± 65)	A.D. 1125 ± 70	SI-4230	V	4
	A.D. 1225 (725 ± 75)	A.D. 1215 ± 80	SI-4232	V	4
	A.D. 1285 (665 ± 75)	A.D. 1270 ± 80	UGa-925	D	1
	A.D. 1370 (580 ± 60)	A.D. 1350 ± 70	UGa-924	D	1
Yeocomico	A.D. 1605 (345 ± 70)	A.D. 1560 ± 80	SI-4231	V	4
	A.D. 1645 (305 ± 70)	not applicable	SI-4372	V	4

*State Key: D - Delaware, M - Maryland, V - Virginia

**References: 1 - Artusy 1976:9; 2 - Barka and McCary 1977:17; 3 - Gardner and McNett 1971:43,45; 4 - Stephen R. Potter 1982:121-123; 5 - Wright 1973:29.

points (defined by Handsman and McNett 1974, McNett and Gardner 1975) were associated with the two remaining Late Archaic components at 44WM119, and a date of 1550 B.C. ± 75 (corrected to 1950 B.C. ± 150) was obtained from oyster shells in Feature #62. To ascertain whether leaching had affected the reliability of the date, other shells from the feature were analyzed for O-18 and C-13 isotope content and were found to be normal (delta O-18, -4.85; delta C-13, -3.33; Irene C. Stehli, Dicarb Radioisotope, personal communication, 1982; Mangerud 1972). A portion of a steatite bowl was also recovered from Component LA2.

5,207 potsherds were found during excavation of the Woodland and Protohistoric/Early Historic components and during later laboratory sorting of flotation samples. Discounting 983 sherds which were either too small or too eroded to any longer determine the manner of exterior surface treatment, the remaining 4,224 sherds were intensely analyzed and 97 individual pottery vessels were distinguished, the minimum number of vessels represented by those sherds. This procedure involved matching and mending hundreds of old breaks and resulted in the reconstruction of sizable vessel segments and several nearly whole vessels. The figure of 97 vessels was conservatively estimated and is thought to be very nearly correct.

Qualitative and quantitative data on each vessel is presented in Tables 44 through 51, and additional information on the size and capacity of the reconstructable vessels may be found in Table 52. Seven new pottery types have been mentioned in this discussion, so formal type descriptions are also presented in the final section of this appendix.

Table 44. Bushnell Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Temper (in order of abundance)	Body Thickness (mm)	Appendages	Decoration and Basal Treatment
2	EW 2	13	Body, Base	?	Grog, Hornblende Schist	8-11	-	Base impressions - a single S-twist cord, 3.2 mm diameter, crosses numerous parallel-arranged fibers.
3	EW 2	83	Body, Base	20%	Muscovite Schist	9-12	Riveted Lug	Base impressions - numerous parallel fibers, 1 mm in diameter.
4	EW 1	1	Body	?	Grog, Fiber, Muscovite Schist	11		-
5	EW 2	23	Rim, Body	?	Muscovite Schist, Grog	11-12	Riveted Lug	-
6	EW 2	19	Rim, Body	?	Muscovite Schist, Grog, Bone, Fiber	8	-	-
7	EW 1	26	Rim, Body, Base	30%	Grog, Shell, Fiber, Muscovite Schist	8-11	Riveted Lug	Lip - individual notches made obliquely on top of lip with an S-twist cord, 1.5 mm diameter, with 7.3 twists/cm.
8	EW 1	112	Rim, Body	58%	Muscovite Schist, Hornblende Schist, Steatite, Grog, Fiber	8-10	Riveted Lug	
9	EW 2	72	Rim, Body, Base	62%	Muscovite Schist, Grog, Fiber	8-11	Riveted Lug	Lip - individual notches made obliquely on top of lip with an S-twist cord, 1.0 mm diameter, with 15 twists/cm. Base - impressions of fibers arranged in parallel bundles.
10	EW 1	11	Body	?	Grog, Fiber, Hornblende Schist	8-10	-	-

Table 45. Popes Creek Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Interior Surface Treatment	Decoration	Exterior Surface Treatment
11	MW 1	66	Rim, Body, Base	30%	11-14	scraped near lip, smoothed inside base	shallow finger-trailed line (11.5 mm wide) just below lip	Knotted Net Impressed - S-twist 0.8 mm diameter cords, spaced 10 x 13 mm apart, knots 2.0 mm in diameter
12	MW 2	112	Rim, Body, Base	35%	7-11	smoothed	none	Knotted Net Impressed - S- twist 1.0 mm diameter cords with 10 turns/cm, spaced 5x5 mm apart, knots 1.8 mm in diameter
13	MW 1	167	Rim, Body, Base	40%	7-9	smoothed	none	Knotted Net Impressed- S-twist 1.0 mm diameter cords, spaced 9x9 mm apart, knots 1.0 mm in diameter
14	MW 2	13	Rim, Body, Base	?	7-12	scraped parallel to lip	none	Knotted Net Impressed - eroded surface
15	MW 1	74	Rim, Body, Base	25%	7-8	partially scraped near lip, smoothed elsewhere	none	Knotted Net Impressed - S-twist 1.0 mm diameter cords, spaced 5x11 mm apart, knots 2.5 mm in diameter
16	EW 3	2	Body	?	12-14	smoothed	none	Knotted Net Impressed - 1.0 mm diameter cords, spaced 10x13 mm apart, knots 2.8 mm in diam
17	EW 4	8	Body	?	6-8	smoothed	none	Knotted Net Impressed - eroded surface
18	MW 3	12	Body	?	9-11	smoothed	none	Knotted Net Impressed - eroded surface
19	EW 4	6	Body	?	7-9	smoothed	none	Knotted Net Impressed - eroded surface

Table 45. (cont.)

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Interior Surface Treatment	Decoration	Exterior Surface Treatment
20	MW 1	9	Body	?	8-12	scraped near lip, smoothed elsewhere	none	Knotted Net Impressed - 0.8 mm diameter cords, spaced 8x11 mm apart, knots 1.0 mm in diameter
21	EW 4	16	Rim, Body, Base	?	7	smoothed	shallow finger-trailed strip below lip	Cord Marked - cord wrapped paddle with 1.2 mm diameter cords
22	EW 4	70	Rim, Body, Base	22%	10-13	scraped parallel to lip	shallow finger-trailed strip (5.9 mm wide), 6.5 mm below lip	Cord Marked - cord wrapped paddle with double strand, S-twist, 2.0 mm diameter cords with 2 turns/cm
23	MW 1	1	Body	?	9-11	scraped near lip	none	Cord Marked - cord wrapped paddle, eroded impressions
24	EW 3	2	Rim, Body	?	11-13	scraped near lip	2 shallow finger-trailed strips (7.8 mm & 8.0 mm wide), 10.0 mm & 32.8 mm below lip, respectively	Cord Marked - cord wrapped paddle with double strand, S-twist, 2.5 mm diameter cords with 2 turns/cm
25	MW 2	11	Rim, Body	?	11-13	smoothed	shallow finger-trailed strip (5.5 mm wide), 10.0 mm below lip	Cord Marked - cord wrapped paddle with double strand, Z-twist, 1.8 mm diameter cords with 3 turns/cm
26	MW 3	4	Body	?	10-12	smoothed	none	Cord Marked - cord wrapped paddle with double strand, S-twist, 2.5 mm diameter cords with 2 turns/cm
27	MW 2	1	Rim	?	7-8	smoothed	notched lip; deep punctations just below lip	Cord Marked - notches across top of lip, made with a single S-twist, 0.5 mm diameter cord with 20 turns/cm

Table 46. Mockley Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment
1	LW 4	9	Rim, Body	5%	8-9	Cord Marked - cord wrapped paddle with double strand, S-twist, 1.5 mm diameter cords with 1.5 turns/cm; impressions at 45° to lip
28	LW 4	11	Rim, Body	?	7-10	Cord Marked - cord wrapped paddle with Z-twist, 0.8 mm diameter cords with 7.5 turns/cm; impressions perpendicular to lip
29	LW 3	3	Body	?	7-9	Cord Marked - cord wrapped paddle with Z-twist, 1.5 mm diameter cords with 4 turns/cm
30	LW 3	6	Body	?	6-9	Cord Marked - cord wrapped paddle with S-twist, 0.8 mm diameter cords with 9 turns/cm
31	LW 4	4	Body	?	6-8	Cord Marked - cord wrapped paddle with S-twist, 1.2 mm diameter cords
32	LW 2	4	Body	?	9	Cord Marked - cord wrapped paddle with S-twist, 0.5 mm diameter cords
33	LW 4	43	Body, Base	?	8-11	Cord Marked - cord wrapped paddle with double strand, Z-twist, 1.0 mm diameter cords with 6 turns/cm
34	LW 2	2	Body	?	6-7	Cord Marked - cord wrapped paddle; eroded impression
35	LW 4	21	Rim, Body	?	6-8	Cord Marked - cord wrapped paddle with double strand, Z-twist, 0.8 mm diameter cords with 6 turns/cm
36	LW 10	147	Rim, Body, Base	45%	7-10	Looped Net Impressed - 0.5 mm diameter weft cords and 1.0 mm diameter, paired warp cords (all S-twist), spaced 4.5 x 4.5 mm apart
37	LW 2	10	Rim, Body	?	9-12	Knotted Net Impressed - S-twist, 0.5 mm diameter cords, spaced 6 x 6 mm apart
38	LW 4	1	Body	?	8-9	Knotted Net Impressed - Z-twist, 0.5 mm diameter cords, spaced 5.5 x 5.5 mm apart
39	LW 4	13	Body, Base	?	6-7	Knotted Net Impressed - S-twist, 0.5 mm diameter cords, spaced 11 x 15 mm apart (overlapping, criss-crossed impressions)
81	LW 4	2	Body	?	6-8	Knotted Net Impressed - eroded impression
91	LW 4	9	Body	?	5-7	Knotted Net Impressed - 1.2 mm diameter cords, spaced 6.5 x 6.5 mm apart

Table 47. Nomini Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment
57	LW 10	44	Rim, Body, Base	15%	5-7	Fabric Impressed - spaced weft-twining with two and three strand, S-twist, 0.8 mm diameter cords with 3 turns/cm, spaced 2.5 x 2.5 mm apart
58	LW 1	22	Rim, Body	10%	6-9	Fabric Impressed - spaced weft-twining with two strand, S-twist, 1.0 mm diameter cords with 3 turns/cm, spaced 9 x 9 mm apart
59	LW 2	8	Body	?	7-9	Fabric Impressed - spaced weft-twining with S-twist, 0.8 mm diameter cords, spaced 6.5 x 6.5 mm apart
60	LW 4	11	Body, Base	?	6-7	Fabric Impressed - spaced weft-twining with S-twist, 2.3 mm diameter cords with 5 turns/cm, spaced 3.5 x 3.5 mm apart
61	LW 3	1	Body	?	6	Fabric Impressed - spaced weft-twining with S-twist, 2.2 mm diameter cords with 4 turns/cm, spaced 2.8 x 2.8 mm apart
62	LW 4	1	Body	?	6-7	Fabric Impressed - spaced weft-twining with S-twist, 0.5 mm diameter cords, spaced 3 x 3 mm apart
63	LW 4	1	Body	?	5-7	Fabric Impressed - spaced weft-twining with two and three strand, S-twist, 0.8 mm diameter cords, with 5 turns/cm, spaced 4 x 4 mm apart
64	LW 3	33	Rim, Body	18%	5-7	Cord Marked - cord wrapped paddle with double strand, S-twist, 1.2 mm diameter cords with 5 turns/cm
65	LW 4	8	Rim, Body, Base	?	5-9	Cord Marked - cord wrapped paddle with S-twist, 1.0 mm diameter cords with 2.5 turns/cm
66	LW 2	21	Body, Base	?	5-9	Cord Marked - cord wrapped paddle with S-twist, 1.0 mm diameter cords with 2.5 turns/cm

Table 48. Currioman Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Temper (in order of abundance)	Body Thickness (mm)	Vessel Form	Exterior Surface Treatment
67	LW 8	127	Rim, Body, Base	40%	Rounded Quartz, Oyster Shell, Fine Sand	5-7	Round-based Jar with unrestricted orifice	Fabric Impressed - a twined weave, with a 5.5 mm wide rigid warp and S-twist, 1.0 mm weft cords with 7 turns/cm
68	LW 5	2	Body	?	Oyster Shell, Rounded Quartz	6-7	Round-based Jar with unrestricted orifice	Fabric Impressed - a twined weave, with a 6 mm wide rigid warp and Z-twist, 1.2 mm weft cords with 8 turns/cm
69	LW 5	12	Rim, Body, Base	?	Rounded Quartz, Oyster Shell, Fine Sand	5-7	Round-based Jar with unrestricted orifice	Fabric Impressed - a twined weave, with a 4.5 mm wide rigid warp and S-twist, 1.3 mm weft cords with 6 turns/cm
70	LW 9	27	Rim, Body	?	Rounded Quartz, Oyster Shell	6-7	Round-based Jar with unrestricted orifice	Fabric Impressed - a twined weave, with a 6 mm wide rigid warp and S-twist, 1.5 mm weft cords with 4 turns/cm
77	LW 5	379	Rim, Body, Base	80%	Rounded Quartz, Oyster Shell	6-8	Semi-conical Jar with unrestricted orifice	Fabric Impressed - a twined weave with a 3.5 mm wide rigid warp and S-twist, 1.2 mm weft cords with 6 turns/cm
82	LW 8	35	Rim, Body, Base	25%	Oyster Shell, Rounded Quartz, Fine Sand	6-7	Shallow Bowl	Fabric Impressed - a twined weave, with a 6 mm wide rigid warp and S-twist, 1.5 mm weft cords

Table 49. Townsend Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
71	LW 6	12	Body	?	5-7	Fabric Impressed - a twined weave, with rigid warp and fine weft; eroded impression	none
72	LW 8	73	Rim, Body, Base	80%	6-8	Fabric Impressed - a twined weave, with a 4.5 mm rigid warp and S-twist, 1.7 mm weft cords (5/cm)	none
73	LW 7	360	Rim, Body, Base	50%	6-7	Fabric Impressed - a twined weave, with a 3.5 mm rigid warp and S-twist, 1.0 mm weft cords (4/cm) with 7 turns/cm	none
74	LW 7	19	Rim, Body, Base	?	5-7	Fabric Impressed - a twined weave, with a 4.2 mm rigid warp and S-twist, 1.0 mm weft cords (6/cm)	Incised - four nested squares with corner triangles (47x49 mm for entire motif) incised below lip; motifs separated by 20 to 44 mm
75	LW 7	40	Rim, Body	?	6-9	Fabric Impressed - a twined weave, with a 3.5 mm rigid warp and S-twist, 2.0 mm weft cords (4/cm)	Incised - alternating zones of 5 horizontal, 4 oblique, and 10 vertical incised lines in a band just below the lip, with a horizontal row of punctations below
76	LW 8	21	Body	?	5-8	Fabric Impressed - a twined weave, with a 4.5 mm rigid warp and Z-twist, 1.2 mm weft cords (4/cm) with 8 turns/cm	none

Table 49. (cont.)

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
78	LW 9	188	Rim, Body, Base	30%	7-8	Fabric Impressed - a twined weave, with a 5.3 mm rigid warp and S-twist, 2.0 mm weft cords (3/cm)	none
79	LW 9	52	Body, Base	?	6-8	Fabric Impressed - a twined weave, with rigid warp and fine weft; eroded impression	none
80	LW 11	128	Rim, Body, Base	35%	6-8	Fabric Impressed - a twined weave, with a 3.0 mm rigid warp and S-twist, 1.0 mm weft cords (5/cm)	none
83	LW 11	70	Rim, Body, Base	20%	6-7	Fabric Impressed - a twined weave, with a 5.5 mm rigid warp and S-twist, 1.6 mm weft cords (6/cm) with 4 turns/cm	none
84	LW 9	1	Body	?	7-9	Fabric Impressed - a twined weave, with a 1.0 mm rigid warp and S-twist, 1.0 mm weft cords (5/cm) with 5 turns/cm	none
85	LW 7	1	Rim	?	5-6	Fabric Impressed - a twined weave, with a rigid warp and fine weft; eroded impression	Incised - two 2.0 mm wide incised horizontal lines below lip in a zone 9 mm wide
86	LW 7	43	Body	15%	5-7	Fabric Impressed - a twined weave, with a 5.0 mm rigid warp and S-twist, 1.0 mm weft cords (4.5/cm)	none

Table 49. (cont.)

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
87	LW 8	41	Body	10%	5-9	Fabric Impressed - a twined weave, with a 6.0 mm rigid warp and S-twist, 1.0 mm weft cords (5/cm) with 3 turns/cm	Punctations - 2 hollow cane impressions, 2.5 mm in diameter
88	LW 6	26	Rim, Body	?	6-8	Fabric Impressed - a twined weave, with a 3.0 mm rigid warp and Z-twist, 0.7 mm weft cords (7/cm) with 10 turns/cm	none
89	LW 9	2	Body	?	7-8	Fabric Impressed - a twined weave, with a rigid warp and fine weft; eroded impression	none
90	LW 11	17	Rim, Body, Base	?	5-9	Fabric Impressed - a twined weave, with a 5.0 mm rigid warp and Z-twist, 1.0 mm weft cords (5/cm) with 8 turns/cm	none
92	LW 7	17	Body	?	4-6	Fabric Impressed - a twined weave, with a rigid warp and fine weft; eroded impression	none
93	LW 7	15	Body	?	5-8	Fabric Impressed - a twined weave, with a 5.0 mm rigid warp and S-twist, 1.0 mm weft cords (4/cm) with 7 turns/cm	none

Table 50. Moyaone and Camden Wares vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
94	LW 6	4	Rim, Body	?	5-7	Cord Marked (Partially Smoothed) - obscured impressions	Cord Wrapped Stick Impressions - zoned horizontally, vertically, & obliquely placed impressions from the lip to 56 mm below (Hurley #219, spaced, 5.0 mm diameter stick with Z-twist, 0.8 mm cords with 12 turns/cm)*
95	LW 6	8	Rim, Body	?	5	Cord Marked (Partially Smoothed) - obscured impressions	Cord Wrapped Stick Impressions - oblique impressions below lip in a 10 mm wide zone, with a single horizontal impression below (similar to Hurley #220, spaced, with a 4.0 mm stick diameter, three Z-twist strands, S-twist, 0.4 mm cords with 3 turns/cm)*
96	LW 9	13	Rim, Body	?	7-8	Plain	none
97	P/EH 4	4	Rim, Body	10%	5-8	Burnished	none

*Hurley 1979

Table 51. Yeocomico Ware vessel attributes.

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
40	P/EH 2	135	Rim, Body, Base	50%	5-6	Scraped	none
41	P/EH 3	69	Rim, Body	?	6-8	Cord Marked - cord wrapped paddle w/two strand, S-twist, 0.8 mm diameter cords w/10 turns/cm	Cord Wrapped Stick Impressions - 5 placed horizontally in 24 mm below lip, with a 12 mm wide zone of oblique impressions below; individual cord impressions across lip. (Hurley #222, non-spaced)*
42	P/EH 3	4	Rim, Body	?	4-6	Cord Marked - cord wrapped paddle w/S-twist, 1.0 mm diameter cords	Cord Wrapped Stick Impressions - 7 placed horizontally in a 31 mm wide zone below lip, with a 12 mm wide zone of oblique impressions below. (Hurley #218, non-spaced)*
43	P/EH 3	36	Body	?	7-9	Plain	none
44	P/EH 2	26	Body	?	4-6	Plain	none
45	P/EH 3	7	Body	?	5-6	Plain	none
46	P/EH 3	25	Rim, Body	?	5-7	Plain	none
47	P/EH 3	339	Rim, Body, Base	60%	5-8	Plain	Punctations - vertical and slightly oblique paired rows of round punctations, 5 to 10/row, extending from the lip to 51 mm below.

Table 51. (cont.)

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
48	P/EH 3	35	Rim, Body, Base	30%	7-9	Plain	Punctations - vertical rows of jabbed punctations, 9 to 10/row, extending from the lip to 7 3 mm below (= vessel shoulder); rows are 12, 20, and 30 mm apart.
49	P/EH 1	1	Body	?	6-7	Scraped	none
50	P/EH 1	137	Rim, Body, Base	15%	5-7	Plain	Cord Wrapped Stick Impressions - at least 3 placed horizontally below lip, with oblique impressions below (similar to Hurley's #263, with a multiple stick foundation, 4.2 mm in diameter, and S-twist cords, 1.2 mm in diameter)*
51	P/EH 2	47	Body	?	6-7	Plain	Cord Wrapped Stick Impressions - at least 6 placed horizontally below lip (Hurley #219, spaced with a 4 mm stick diameter, and Z-twist, 1.2 mm cords with 9 turns/cm)*
52	P/EH 1	1	Rim	?	5	Plain	Cord Wrapped Stick Impressions - at least 2 placed horizontally below lip (Hurley #219, spaced with a 4.5 mm stick diameter, and Z-twist, 1.8 mm cords with 5 turns/cm)*

Table 51. (cont.)

Vessel #	Associated Component	Number of Sherds	Vessel Portions	% of Whole Vessel	Body Thickness (mm)	Exterior Surface Treatment	Decoration
53	P/EH 1	141	Rim, Body, Base	20%	6-7	Plain	Cord Wrapped Stick Impressions - 4 placed horizontally in a 19 mm wide zone below lip, with a 12 mm wide zone of oblique impressions below (Hurley #217, non-spaced, with a 4.2 mm stick diameter, and Z-twist, 0.9 mm cords with 12 turns/cm)*
54	P/EH 3	86	Rim, Body	?	4-6	Plain	Cord Impressions - 6 placed horizontally in 33 mm zone below lip, with a 10 mm wide zone of oblique impressions below (Hurley #1, with a single, two strand, Z-twist, 1.0 mm cord with 5 turns/cm)*
55	P/EH 3	23	Body	?	5-7	Plain	Cord Wrapped Stick Impressions - at least 4 placed horizontally below lip (Hurley #219, spaced, with a 2.5 mm stick diameter, and S-twist, 1.5 mm cord)*
56	P/EH 3	6	Body	?	5-6	Plain	Cord Wrapped Stick Impressions - at least 8 placed horizontally below lip (Hurley #219)*

*Hurley 1979

Table 52. Steatite Bowl and Ceramic Vessel Sizes and Capacities.

Vessel #	Type Designation	Component	Vessel Height (mm)	Vessel Orifice Diameter (mm)	Vessel Capacity (ml)
Steatite Bowl	-	LA 2	85	126 (width)	
5	Bushnell Plain	EW 2	88	104 (width)	
9	Bushnell Plain	EW 2	86		1200
11	Popes Creek Net Impressed	EW 3	330	280	16,000
1	Mockley Cord Marked	LW 4		210	
36	Mockley Net Impressed	LW 10		320	
67	Currioman Fabric Impressed	LW 8	240	300	9000
82	Currioman Fabric Impressed	LW 8	100	220	3200
72	Rappahannock Fabric Impressed	LW 8	110	120	800
73	Rappahannock Fabric Impressed	LW 7	190	310	6500
74	Rappahannock Fabric Impressed	LW 7		210	
78	Rappahannock Fabric Impressed	LW 9		340	
80	Rappahannock Fabric Impressed	LW 11	240	290	7000
83	Rappahannock Fabric Impressed	LW 11		300	
40	Yeocomico Scraped	P/EH 2	160	185	4000
47	Yeocomico Plain	P/EH 3		150	
48	Yeocomico Plain	P/EH 3		160	
54	Yeocomico Plain	P/EH 3		230	
97	Camden Plain	P/EH 4	80		

Table 53. Late Archaic Stemmed Projectile Point attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Stem Form	Total Height (mm)	Stem Height (mm)	Blade Width (mm)	Stem Width (mm)	Blade Thickness (mm)	Comments
1	LA 1	quartzite	Holmes	converging sides, concave base	56.7	12.2	28.5	19.7	10.9	Opposing left edges steeply beveled
2	LA 2	quartzite	Holmes	straight sides, straight base	47.2	12.4	(c.27)	(c.20)	9.3	Opposing right edges steeply beveled
3	LA 2	quartzite	Holmes	straight sides, convex base	-	10.5	-	19.8	8.7	
4	LA 2	quartzite	Holmes	converging sides, straight base	(60+)	15.7	34.8	23.1	13.1	
5	LA 2	quartzite	Holmes	converging sides, straight base	58.6	11.8	24.5	18.8	10.5	Opposing left edges steeply beveled
6	LA 2	quartzite	Holmes	converging sides, concave base	49.8	13.1	29.3	19.9	12.0	
7	LA 3	quartzite	Savannah River, contracting-stem variant	converging sides, convex base	-	12.1	46.7	15.3	10.8	
8	LA 3	meta-rhyolite	Savannah River, contracting stem variant	converging sides, convex base	-	16.2	(c.43)	26.2	10.5	

Table 54. Early Woodland Stemmed and Lanceolate Projectile Point attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Total Height (mm)	Stem Height (mm)	Blade Width (mm)	Stem Width (mm)	Blade Thickness (mm)	Comments
1	EW 1	quartz	Calvert	43.1	11.3	18.2	15.3	10.5	Opposing right edges steeply beveled
2	EW 1	quartz	Calvert	47.1	19.4	24.8	18.5	10.1	Corticated striking platform remnant on base
3	EW 1	quartz	Calvert	45.8	14.1	25.0	18.4	9.8	Concave base; one right edge steeply beveled
4	EW 1	quartzite	unnamed lanceolate	(c.44)	-	25.3	-	8.1	
5	EW 3	quartz	Calvert	-	15.6	-	20.6	8.4	
6	EW 3	quartz	Calvert	32.5	13.1	20.5	13.8	11.3	Opposing right edges steeply beveled
7	EW 3	quartz	Calvert	(c.42)	13.4	23.4	16.3	7.5	Opposing left edges steeply beveled
8	EW 3	quartz	Calvert	40.8	14.7	20.9	17.1	10.9	One right edge steeply beveled
9	EW 4	quartz	Calvert	-	15.9	24.7	15.7	11.7	Opposing right edges steeply beveled
10	EW 4	quartz	Calvert	45.8	11.0	23.3	16.4	9.0	

Table 55. Middle Woodland Contracting Stemmed Projectile Point Attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Total Height (mm)	Stem Height (mm)	Blade Width (mm)	Blade Thickness (mm)
1	MW1	quartz	Rossville	(c.36)	6.9	14.8	7.7
2	MW1	quartz	Rossville	(c.27)	-	14.6	5.6
3	MW2	quartz	Rossville	37.8	10.9	15.5	7.8
4	MW3	quartz	Rossville	31.9	10.7	15.6	7.0
5	MW3	quartz	Rossville	(c.42)	-	20.3	9.0
6	unknown (plowzone)	quartz	Rossville	(c.43)	5.2	17.7	7.8
7	unknown (plowzone)	quartz	Rossville	43.4	11.7	19.5	10.8

Table 56 . Late Woodland Side-Notched Projectile Point attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Total Height (mm)	Hafting Element Ht. (mm)	Blade Width (mm)	Width at Notches (mm)	Basal Width (mm)	Blade Thickness (mm)	Comments
1	LW 1	quartz	Nomini	(c.30)	9.2	18.5	15.9	18.5	5.6	
2	LW 1	quartzite	Nomini	-	11.9	24.3	22.3	23.4	6.6	
3	LW 2	quartz	Nomini	(c.31)	10.6	18.0	14.5	16.2	6.4	
4	LW 2	quartzite	Nomini	(c.34)	10.4	16.9	15.9	19.4	7.1	Ground notches and base
5	LW 4	quartz	Nomini	26.6	8.7	18.0	16.4	18.1	5.7	
6	LW 4	quartz	Nomini	-	10.3	22.6	16.3	(c.19)	6.1	
7	LW 4	quartzite	Nomini	37.9	9.3	20.8	16.1	19.8	7.4	
8	LW 4	green jasper	Nomini	21.6	13.7	18.1	17.7	10.9	4.6	Resharpened just above shoulders
9	LW 4	rhyolite	Nomini	41.3	7.1	23.4	-	15.9	10.8	Apparently unfinished - thick, unnotched
10	general surface collection	quartz	Nomini	32.2	11.4	20.4	17.0	18.9	8.3	

Table 57. Late Woodland Triangular Projectile Point attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Point Shape	Total Height (mm)	Basal Width (mm)	Blade Thickness (mm)	Depth of Basal Concavity (mm)
1	LW 7	quartz	Levanna	Isosceles triangle with straight sides and concave base	(c.34)	(c.28)	7.2	4.5
2	LW 7	quartz	Levanna	Isosceles triangle with incurvate sides and concave base	-	21.7	7.7	1.0
3	LW 7	quartz	Levanna	Isosceles triangle with straight sides and straight base	-	24.7	6.3	-
4	LW 7	black chert	Levanna	Isosceles triangle with incurvate sides and concave base	-	25.6	5.0	2.7
5	LW 7	tan chert	Levanna	Isosceles triangle with incurvate sides and concave base	21.5	(c.21)	4.3	1.3
6	LW 8	quartz	Levanna	Isosceles triangle with incurvate sides and concave base	35.6	(c.30)	6.9	3.0
7	LW 8	quartz	Levanna	Isosceles triangle with straight sides and straight base	-	(c.32)	10.2	-
8	LW 8	quartz	Levanna	Isosceles triangle with incurvate sides and concave base	34.6	29.0	7.1	3.1
9	LW 8	tan chert	Levanna	Isosceles triangle with incurvate sides and concave base	25.8	(c.21)	5.0	(c.2.5)
10	LW 8	yellow jasper	Levanna	Isosceles triangle with straight sides and concave base	26.4	24.7	6.5	2.8
11	LW 9	quartz	Levanna	Isosceles triangle with straight sides and concave base	-	25.9	5.8	1.5

Table 58. Protohistoric/Early Historic Triangular Projectile Point Attributes.

Projectile Point #	Associated Component	Raw Material	Type Designation	Point Shape	Total Height (mm)	Basal Width (mm)	Blade Thickness (mm)	Depth of Basal Concavity (mm)
1*	P/EH1	quartz	Potomac	Isosceles triangle with excurvate sides & concave base	23.4	19.6	5.8	1.8
2	P/EH1	quartz	Potomac	Isosceles triangle with straight sides	(c.25)	(c.25)	5.9	?
3	P/EH1	quartz	Potomac	Isosceles triangle with straight sides	(c.28)	(c.25)	6.9	?
4	P/EH2	quartz	Potomac	Isosceles triangle with straight sides & concave base	(c.22)	16.7	5.1	2.0
5*	P/EH3	quartz	Potomac	Isosceles triangle with straight sides & concave base	(c.25)	16.7	6.0	2.5

*Points with serrated edges

The majority of artifacts recovered from 44WM119 were stone tools or other lithic objects. From the entire excavated area (excluding the plowzone) 9,059 fire-cracked cobbles (weighing 260.62 kg), 32,943 water-worn pebbles (236.99 kg), 2,131 pieces of debitage (12.26 kg), and 134 stone tools and tool fragments were found. This last figure includes 53 measurable projectile points; the qualitative and quantitative data about these are presented in Tables 53 through 58. One new projectile point type, the Nomini point, is also described.

The earliest pottery type in the Middle Atlantic has been generally thought to be steatite tempered Marcey Creek Plain (Manson 1948). Recently, however, several similar types have been recognized which differ only in temper and are probably contemporaneous with or perhaps even older than Marcey Creek Plain, which has been dated at 950 B.C. ± 95 (corrected to 1165 B.C. ± 100) (Gardner and McNett 1971:43). Dames Quarter Black Stone Tempered Plain, reported from Delaware and eastern Maryland, is tempered with what is thought to be hornblende of Piedmont origin (Artusy 1976:2). Croaker Landing Plain is distinguished by its grog temper, or occasionally grog and steatite temper (Egloff 1981:9). At White Oak Point, vessel fragments of yet another type, Bushnell Plain, were found in stratigraphic association with wood charcoal and oyster shells used for dating. Three radiocarbon determination yield an average date of 1110 B.C. ± 60 (corrected to 1370 B.C. ± 70). Bushnell Plain is characterized by temper consisting predominantly of muscovite schist or hornblende schist with some grog, fiber, steatite and a few minute particles of shell and bone. Apparently this ware was first found by David I. Bushnell at a site he called Nantaughtacund in Caroline County, Virginia (Bushnell 1937). In Bushnell's collections are two body sherds of this ceramic type, catalogued as lot USNM-398815 at the Smithsonian Institution (Stephen R. Potter, personal communication, 1981). Other diagnostic vessel attributes for these four types are nearly identical. All are shallow, straight-walled vessels with lug handles, protruding basal heels and elongated oval, flat bases often bearing impressions of matting or other fabric.

The existence of these four similar, nearly contemporaneous types in the Middle Atlantic Coastal Plain indicates a period of active experimentation in pottery manufacture during the Early Woodland. All of the lithic temper varieties (or, conceivably, the pots themselves) were transported from the Piedmont, thereby perpetuating the same resource procurement network by which steatite bowls were formerly acquired. The inclusion of both ground steatite and ceramic sherds in newly formed pots modeled after steatite bowls may reflect the potters' perceived need to maintain physical continuity between old and new. The presence of fiber in at least six of the Bushnell Plain vessels poses the intriguing possibility that the inspiration for the technological innovation of pottery manufacture had a southern origin and was not a strictly local development.

Projectile points associated with Bushnell ceramics are of the Calvert type (Stephenson and Ferguson 1963:143-144). These points are the latest in a series of stemmed projectile points which became progressively shorter throughout the Late Archaic and Early Woodland. At White Oak Point they also occur with Popes Creek Cord Marked and

Popes Creek Net Impressed pottery, during a period lasting from approximately 900 B.C. to 400 B.C. (Early Woodland Components EW3 and EW4). This period has previously been designated the Accokeek Phase (Wright 1973:20), and has generally been defined on the basis of the presence of Accokeek Cord Marked pottery. This type was originally established by Robert Stephenson, who described the temper as "a coarse to medium-fine sand often combined with lesser amounts of angular, crushed quartz" (Stephenson and Ferguson 1963:97). Later writers have emphasized the presence of crushed quartz as the diagnostic attribute (Wright 1973:10; Steponaitis 1980:28).

At White Oak Point, only Vessel #14 contains a small quantity of crushed quartz temper; all the others are tempered entirely with sand or with a mixture of sand and larger rounded quartz particles. Based on the large proportion of sand temper in the paste and the prevalence of scraped interiors, the vessels from 44WM119 are all classified as Popes Creek Ware, which includes Popes Creek Net Impressed and Popes Creek Cord Marked (Holmes 1903:254; Stephenson and Ferguson 1963: 92-96). Although no radiocarbon dates were obtained, the five components with Popes Creek Ware were divided into Early Woodland and Middle Woodland on the basis of associated projectile point types, specifically, Early Woodland Calvert points and Middle Woodland Rossville points. Conventional doctrine in the Middle Atlantic region maintains that cordmarking at first predominated, but was gradually superceded by net impressed pottery during this transitional period. These trends do not occur at the White Oak Point site. The Middle Woodland Popes Creek Phase is thought to have lasted about 700 years, from 400 B.C. to A.D. 300. Unfortunately, the beginning and end of this phase have never been radiometrically dated at this or any other site.

The subsequent Middle Woodland Selby Bay Phase (A.D. 300-700) is defined by the presence of shell tempered Mockley Cord Marked and Mockley Net Impressed pottery types, and Selby Bay Lanceolate, Stemmed and Side-Notched projectile points, most commonly made of rhyolite (Wright 1973:21-22; Stephenson and Ferguson 1963:103-108; Opperman 1980). None of the excavated components was attributable to the Selby Bay Phase, although diagnostic projectile points were found on the surface of the plowed, inland portion of the site.

Both types of Mockley pottery continued in use for at least another 200 years in association with another previously undescribed ware and a different projectile point type. Late Woodland Components LW1-LW4 and LW10 were all occupied between A.D. 700 and A.D. 900. Radiocarbon dates were obtained from two of these components, with extremely close results (A.D. 860 ± 60, corrected to A.D. 875 ± 80, and A.D. 880 ± 60, corrected to A.D. 895 ± 80). The associated projectile point type is here defined as the Nomini point, a broad based, shallowly side-notched type made of quartz, quartzite, or occasionally of rhyolite and green jasper. The minority lithic types indicate a continuation of Selby Bay Phase trading contacts with the upper Susquehanna River region. Nomini Cord Marked is very similar to its Mockley counterpart in vessel form and surface treatment, but differs in the replacement of the characteristically coarse oyster shell Mockley tempering with finely graded, rounded quartz pebbles. Nomini Fabric Impressed has a paste identical to Nomini Cord Marked, with surface impressions made by the careful application of an open weave, weft-twined fabric. The impressions superficially resemble those created by a knotted net on Mockley Net Impressed vessels, but careful inspection reveals an absence of knots and a pattern of tightly twisted warps, and loosely twisted, bulkier wefts (see Hurley 1979:111, Fabric Number 6).

An unusual artifact found in Component LW4 is an unfinished, miniature platform pipe made of chlorite schist (Figure 18:A). The pipe measures 30.1 mm long, 14.8 mm wide and 22.0 mm high, and all surfaces are covered with cutting and scraping marks left from the preliminary shaping. The bowl had been drilled to a depth of 5 mm; there is no trace of a stem hole. Similar platform pipes dating to A.D. 700 to A.D. 1000 have been reported from western Maryland (Stearns 1943:Plate IV-3), central Delaware (Thomas and Warren 1970), and central Pennsylvania (Smith 1979:14-15; also see Turnbaugh and Keifer 1979:34-37).

Like the development of the Selby Bay Phase, the sudden expansion of Townsend series ceramics from an as yet unknown source was a pan-Chesapeake Tidewater occurrence. The Townsend ceramics stylistic sequence has been determined for southern Delaware by Daniel Griffith (1977, 1980) who has ascertained that complex incised motifs occur earliest, and simple geometric incised motifs continue in use for several hundred years with simple geometric cord impressed and cord-wrapped stick impressed motifs gradually becoming predominant at some late sites. One of the White Oak Point components dates from the beginning of this sequence, as evidenced by the ceramics and a radiocarbon date. Component LW7 contained three Rappahannock Incised vessels with rim decorations corresponding to Griffith's varieties

RI6 and RI7. These are complex combinations of incised squares, horizontal, vertical and oblique lines which he maintains are early varieties of Rappahannock Incised (Griffith 1980:30-31). A C-14 date on wood charcoal from Feature #22 is A.D. 1005 ± 70 (corrected to A.D. 1015 ± 80). Rappahannock Fabric Impressed is the only Townsend ware type present in later components, but unfortunately, it is not a temporally sensitive type.

Another previously undescribed ceramic type, defined here as Currioman Fabric Impressed, was found in three components, with Rappahannock Fabric Impressed in Components LW5 and LW8, and both with Moyaone Plain in Component LW9. This new type is somewhat of an enigma, since there is apparently not even the vaguest reference to such a type elsewhere in the region. Surface treatment and vessel form are identical to Rappahannock Fabric Impressed, the two types differing primarily in temper (oyster shell in Rappahannock vs. fine rounded quartz, oyster shell and, occasionally, very fine sand in Currioman) and lip treatment (untreated lip vs. untreated, flattened and fabric impressed, or flattened and deeply notched with a basket edge). Component LW8 has been dated A.D. 1340 ± 55 (corrected to A.D. 1320 ± 60). Components LW6 and LW9 contain Moyaone ware vessels and the former component is dated A.D. 1310 ± 50 and A.D. 1460 ± 45 (corrected to A.D. 1295 ± 60 and A.D. 1430 ± 60). Both of the dated charcoal samples came from the same deep pit, and the later date is thought to be the more accurate of the two. Component LW11 contained only Rappahannock Fabric Impressed ceramics. Levanna triangular projectile points are associated with all of the Late Woodland components.

These late Late Woodland components have a more diverse artifact assemblage than the components previously discussed. For instance, three quite different types of shells were altered for beads: circular, flat disc beads were made from the quahog (Mercenaria mercenaria); the spires of common marginellas (Prunum apicinum) were ground so that these small, sturdy shells could be sewn on garments (Bushnell 1907: 38-40); and naturally hollow ribbed tusk shells (Dentalium occidentale) were broken into 5 mm to 10 mm segments and the ends ground smooth (Figure 18:F, G, H). A large section of a channeled whelk (Busycon canaliculatum) body whorl had been cut into roughly rectangular shape and the outer surface ground smooth, before being discarded in the midden of Component LW11. The object was probably a blank for the sort of rare effigy masks found near the mouth of Potomac Creek, in Stafford County, Virginia, in the mid-nineteenth century (Snow 1978:62, Figure 3).

A third previously undescribed ceramic ware was discovered at White Oak Point and was determined to be, on the basis of stratigraphic superposition and radiocarbon dating, the only specifically Protohistoric/Early Historic ware found in the lower Potomac Valley. This newly recognized Yeocomico ware has three types (Yeocomico Scraped, Yeocomico Plain, and Yeocomico Cord Marked) all with very finely crushed oyster shell tempering. Yeocomico Plain and Yeocomico Cord Marked vessels often have horizontal and oblique cord wrapped stick impressions or direct cord impressions just below the lip. Two Yeocomico Plain vessels have vertical or slightly oblique rows of punctation extending from vessel lip to shoulder. Four radiocarbon dates from Component P/EH3 yield a mean date of A.D. 1590 ± 80.

A white glass seed bead was found with a partial burial (Feature #127) associated with this component, confirming the Protohistoric/Early Historic attribution. These three Yeocomico types resemble the previously described types Potts Scraped, Potts Cord-Wrapped Dowel Impressed (Evans 1955:48), and an unnamed Sullivan Cove Phase cord marked pottery with cord-wrapped stick impressions (Wright 1973:16-17, 22-23). However, the temporal placement of these previous types either has never been established or, in the case of the Sullivan Cove Phase variety, is debatable (Potter 1982:132-133).

Two additional bead types are documented from these components, a disc bead made from a southern scallop (<u>Aequipecten irradians concentricus</u>) and a pendant produced from an elk (<u>Cervus canadensis</u>) mandibular canine. The only other elk tooth pendant found in the Tidewater came from the Maycock's Point shell midden in Prince George County, Virginia, where it was associated with Mockley ware ceramics (Barber 1981:14). Presumably these isolated artifacts were traded from the Piedmont, where elk bones have been recovered as food refuse from Late Woodland and Protohistoric contexts (Clark 1980:15).

A complete ceramic elbow pipe was found in Component P/EH3 midden. The pipe is tempered with small amounts of sand and finely crushed shell, and the bowl is set at a 165° angle from the stem. Potomac triangular projectile points, which are smaller than the Late Woodland Levanna points and frequently serrated, were found in all three components.

The latest aboriginal component excavated at 44WM119, P/EH4, is represented by an awl and four sherds of a Camden Plain bowl (MacCord 1969) found in the unplowed surface duff near the bluff edge, and a poorly preserved human burial placed in a shallow pit (Feature #131).

The most recent artifacts from the site are a few handwrought nails and a gunspall found in the plowzone. These few eighteenth century items derive from the colonial period white and black residents, masters and slaves, who intensively farmed Bushfield Plantation, established on the right bank of Nomini Creek in 1665.

Pottery and Projectile Point Type Descriptions

Bushnell Plain (Figure 13, Table 14)

Summary: A coiled pottery with smoothed surfaces, made of buff colored, poorly compacted paste with micaceous schist or hornblende schist temper (and small proportions of grog, fiber, steatite, bone and shell inclusions). Vessel form is ovoid or rectangular with rounded corners; bases are flat with irregularities and are impressed with bundled fibers. Lugs were riveted to vessel walls at the narrow ends of vessels. Decoration is limited to notches or single cord impressions across lips and on lug handles.

Method of Manufacture: Coiled vessels, occasionally broken along poorly welded coil lines; coil widths are 20 mm to 28 mm; bases and lugs seem to have been modeled by hand.

Paste: Temper is composed of crushed muscovite schist and hornblende schist, with occasional grog, fiber, steatite, bone and shell inclusions in some vessels. Particle size varies tremendously, with very fine flecks in some vessels and coarse particles up to 8 mm in diameter in others. The temper comprises 5 to 40% of the paste.
Plastic is a fine-grained clay w/few extraneous inclusions.
Hardness is generally 1.5 on the Mohs scale, with a few compact vessels as hard as 2.5.
Texture varies from fine, compact and smooth to very coarse, crumbly and uneven in consistency. This range corresponds to the size of temper inclusions, with fine temper particles occurring in the most compact paste. Most Bushnell sherds have a friable paste and are difficult to excavate intact.

Color: Exterior surface color ranges from very pale brown (Munsell 10YR 8/3) to light brown (7.5YR 6/4) and light reddish brown (5YR 6/4). Interior surfaces and the core are similar, but sometimes more gray.

Firing: Low temperature in an oxidizing atmosphere with the vessel upright.

Surface Treatment: Smoothed by hand on interior and exterior, often unevenly, with large temper particles protruding from the surfaces. Bases bear impressions of bundled fibers.

Vessel Form: Lips are tapered and rounded; about half are notched obliquely with a cord.
Rims are straight.
Bodies are ovoid or rectangular with rounded corners.
Bases are flat with heel protrusions at the intersection with the vessel wall, extending 3 mm to 9 mm.
Thickness of walls range from 6 mm to 11 mm; bases from 9 mm to 12 mm.
Lugs are flattened hemispheres attached through holes in the vessel walls by clay rivets. The lugs range from 24 mm to 32 mm wide and one is decorated with vertical notches around the edge.

Decoration: Simple, oblique cord notching of the lip and nicking of a lug.

Vessel Size: Small vessels with heights of 85 mm to 88 mm and two measurable widths of 104 mm and 126 mm.

Sample Size: 360 sherds from 9 vessels.

Temporal Position: Early Woodland; a mean radiocarbon date of 1110 B.C. ± 60 was obtained at 44WM119.

<u>Nomini Fabric Impressed</u> (Figure 14, Table 47)

Summary: A coiled pottery with impressions made with a spaced weft-twined fabric on the exterior surfaces, smoothed interior surfaces, and a compact reddish brown to black paste tempered with pieces of rounded quartz. Vessels are large with slightly thickened rounded bases and direct rims with flattened lips and no decoration.

Method of Manufacture: Coiled and paddled malleated vessels, rarely broken along coil lines; coil widths range from 14 mm to 18 mm.

Paste: Temper is rounded quartz pebbles ranging in size from 1 mm to 8 mm with most being about 2 mm in diameter, and comprising 10 to 20% of the paste. The temper may be sieved, size-graded sand or crushed sandstone. A few pieces of limonite are probably unintentional inclusions.
The plastic is a compact, fine-grained clay.
Hardness ranges from 2.0 to 2.5 according to the Mohs scale.
Texture is clayey and smooth to the touch.

Color: Exterior surfaces range from reddish brown to black; interior surfaces are generally gray or black, as are the cores.

Firing: Moderately low temperatures in a poorly controlled oxidizing atmosphere, producing smudge marks on the exteriors. Vessels were apparently fired in an inverted position, creating a reducing atmosphere inside the pots.

Surface Treatment: Exterior surfaces are paddled with distinct impressions of a spaced weft-twined fabric, which superficially resembles Mockley Net Impressed surface treatment. Distance between warp elements ranges from 2.5 mm to 6 mm. Basal sherds have smeared or incomplete impressions. Interior surfaces are smoothed.

Vessel Form: Lips were flattened with the fabric wrapped paddle but the impressions are sometimes smoothed over. Rims are direct. Bodies are probably rounded, although the excavated vessel portions are too incomplete to derive information on vessel shape and size. Bases are apparently rounded. Thickness of the walls range from 4 mm to 7 mm with bases from 8 mm to 12 mm.

Decoration: none.

Vessel Size: Unknown, but probably large, based on rim curvatures.

Sample Size: 88 sherds from 7 vessels.

Temporal Position: Late Woodland; radiocarbon dated at A.D. 860 $\pm$ 60 and A.D. 880 $\pm$ 60.

<u>Nomini Cord Marked</u> (Figure 14, Table 47)

Summary: A coiled pottery with cord-wrapped paddle impressions on the exterior surfaces, smoothed interior surfaces, and a compact, reddish brown to black paste tempered with pieces of rounded quartz. Vessels are large with slightly thickened rounded bases and direct rims with flattened lips and no decoration.

Nomini Cord Marked vessels have identical attributes as Nomini Fabric Impressed vessels, with the following exceptions:

Surface Treatment: Exterior surfaces are paddled with S-twist cords. The impressions were applied vertically or slightly diagonally to the lip.

Sample Size: 62 sherds from 3 vessels.

Currioman Fabric Impressed (Figure 14, Table 48)

Summary: A coiled pottery with exterior surfaces impressed with a rigid warp fabric or basket, smoothed interior surfaces, and buff to black paste with rounded quartz and crushed oyster shell temper. Vessels are generally large jars or small bowls with rounded bases, direct or very slightly everted rims, and undecorated except for basket edge impressions across the lip.

Method of Manufacture: Coiled with paddle malleated exterior surfaces, rarely demonstrating coil fractures. Coil width ranges from 18 mm to 23 mm.

Paste: Temper is a combination of finely crushed oyster shell and rounded quartz particles, ranging from fine sand 0.1 mm in diameter to large pieces up to 4 mm in size. Temper constitutes 30 to 50% of the paste. The plastic is compact, fine-grained clay. Hardness ranges from 1.5 to 2.0 on the Mohs scale. Texture is moderately compact, sandy to the touch, and rather crumbly due to the large amounts of temper in some vessels. The crushed oyster shell produces a lamellar past structure.

Color: Exterior surfaces range from reddish buff to black, interiors have the same range but tend to be more gray or black, as do the cores.

Firing: Moderately low temperature and a poorly controlled oxidizing atmosphere producing smudge marks on the vessels.

Surface Treatment: Exterior surfaces are impressed with a twined fabric with a wide, rigid warp (perhaps a basket). The warp elements are oriented parallel to the rim. Basal sherds have smeared and incomplete fabric impressions. Interiors are evenly smoothed.

Vessel Form: Lips are thinned and either rounded or flattened with the paddle. Rims are direct or slightly everted. Bodies and bases are rounded. Thickness ranges from 5 mm to 8 mm; bases are slightly thicker, from 8 mm to 10 mm.

Decoration: None, except for the deep basket edge notched across the lip.

Vessel Size: Large, open mouthed jars and shallow bowls are the only types represented at 44WM119.

Sample Size: 582 sherds from 6 vessels.

Temporal Position: Late Woodland; radiocarbon dated to A.D. 1340 ± 55.

Yeocomico Plain (Figure 16, Table 51)

Summary: A coiled pottery with smoothed exterior and interior surfaces, light reddish tan to gray-brown paste with coarsely to finely crushed oyster shell temper, and a moderately compact, silty clay texture. Vessels are of medium size, usually quite thin walled, with rounded or semiconical bases, direct or everted rims and neck constrictions, and undecorated, punctated, cord impressed or cord-wrapped stick impressed rims.

Method of Manufacture: Coiled with paddle malleated exterior surfaces. Breaks occasionally occur on coil lines; coil widths range from 12 mm to 20 mm.

Paste: Temper is crushed particles of oyster shells, varying greatly in size between vessels, from finely crushed pieces to fragments 7 mm in diameter; most are 1 mm to 2 mm in size. A few sand grains are visible in the paste of all the pots and are probably unintentional inclusions, as is the deciduous leaf which left an impression in the paste of one vessel. Temper comprises 15 to 20% of the paste.
The plastic is moderately compact silty clay with a lamellar structure due to the oyster shell temper which has frequently leached away.

Hardness ranges from 2.0 to 2.5 on the Mohs scale. Texture is moderately coarse and generally compact.

Color: Exterior surfaces are light reddish tan to gray-brown. Interior surfaces range from bright orange to buff and are frequently smudge blackened. The core color is usually the same as the exterior, but is sometimes more gray.

Firing: Medium temperature in a poorly controlled oxidizing atmosphere.

Surface Treatment: Exterior surfaces are smoothed over paddle malleating, although shell temper particles were frequently left on or are just beneath the surface. The leaching of this surficial temper has left the exterior surfaces pitted and uneven. Interior surfaces are evenly smoothed.

Vessel Form: Lips are slightly thinned and usually rounded, but sometimes flattened. Rims are direct or everted with neck constrictions. Bodies are rounded. Bases are rounded or semiconical. Thickness ranges from 4 mm to 7 mm and is generally thin except for the shoulders of vessels with everted rims (7mm to 8 mm) and bases (8 mm to 12 mm).

Decoration: Vessels have two distinct types of decoration, vertical or slightly oblique lines of punctations, and horizontal and oblique cord-wrapped stick impressions (or, rarely, single direct cord impressions). Both types are restricted to the upper rim. One of the punctated vessels has a neck constriction, and in this case the punctation extends from lip to shoulder. A few undecorated vessels are known.

Vessel Size: Medium, with vessel orifice diameter ranging from 150 mm to 230 mm, with similar vessel heights.

Sample Size: 909 sherds from 13 vessels.

Temporal Position: Protohistoric/Early Historic. A mean radiocarbon date of A.D. 1590 ± 80 was obtained at 44WM119, and similar dates have been determined at the nearby site of 44NB149 (Stephen R. Potter, personal communication). This ceramic type has also been found at several other Protohistoric/Early Historic aboriginal sites in Virginia's Northern Neck.

Yeocomico Cord Marked (Figure 16, Table 51)

Summary: A coiled pottery with cord marked exterior surfaces, smoothed interior surfaces and reddish tan to gray paste with coarsely to finely crushed oyster shell, and a moderately compact, silty clay texture. Vessels are of medium size, probably with rounded or semiconical bases, direct rims, and cord-wrapped stick impressed decorations.

Attributes of this type are identical to those described for Yeocomico Plain, with the following exceptions:

Surface Treatment: Exterior surfaces were malleated with a cord-wrapped paddle.

Decoration: Vessels have horizontal and oblique cord-wrapped stick impressions in a band just below the lip.

Sample Size: 73 sherds from 2 vessels.

Temporal Position: Protohistoric/Early Historic (c. 1500-1650 A.D.)

Yeocomico Scraped (Figure 16, Table 51)

Summary: A coiled pottery with scraped interior surfaces (grooves and scratches from some curved object being dragged over the surface), smoothed interior surfaces, and light buff to gray paste with coarsely to finely crushed oyster shell, and a moderately compact, silty clay texture. Vessels are of medium size, with semiconical bases, direct rims, and are undecorated.

Attributes of this type are identical to those described for Yeocomico Plain, with the following exceptions:

Surface Treatment: Exterior surfaces were scraped with a curved object (perhaps a gourd fragment or piece of wood), creating curving grooves and scratches across the surface.

Decoration: undecorated.

Sample Size: 136 sherds from 2 vessels.

Temporal Position: Protohistoric/Early Historic (c. 1500-1650 A.D.).

Nomini Side-Notched (Figure 17, Table 56)

Summary: A small, broad blade with shallow side notches and a straight or slightly concave base.

Form, Blade: A broad, moderately thick blade with straight edges.

Base: Generally concave, or occasionally straight base, which was ground in one case.

Side-notches: Very shallow, usually forming a slight concavity in the edges.

Size, Height: Range, 21 mm - 41 mm; average, 32 mm.

Blade Width: Range, 17 mm to 24 mm; average, 20 mm.

Thickness: Range, 4 mm to 11 mm; average, 7 mm.

Material: Half of the White Oak Point specimens were made from white vein quartz and others were made from quartzite, both raw materials available as river transported gravels; one each was made from imported rhyolite and green jasper.

Technique of Manufacture: These points were apparently made from split cobbles or ovoid blanks produced by direct percussion, which were thinned and shaped by pressure flaking. Much of the secondary flaking is limited to the blade edges, leaving somewhat rough blade faces with numerous irregular ridges.

Comment: This point has been found at White Oak Point, associated with Mockley and Nomini ceramic wares in components radiocarbon dated A.D. 860 ± 60 and A.D. 880 ± 60. Quartz points of similar manufacture have also been found in adjacent Northumberland County, in surface collections from sites with major Mockley ware components (Stephen R. Potter, personal communication, 1982).

Figure 13. Early Woodland and Middle Woodland Ceramic Vessels.

A - Bushnell Plain (Table 44:7), side view

A' - front view

B - Bushnell Plain (Table 44:9)

C - Popes Creek Net Impressed (Table 45:11)

D - Popes Creek Cord Marked (Table 45:22)

E - Popes Creek Cord Marked (Table 45:24)

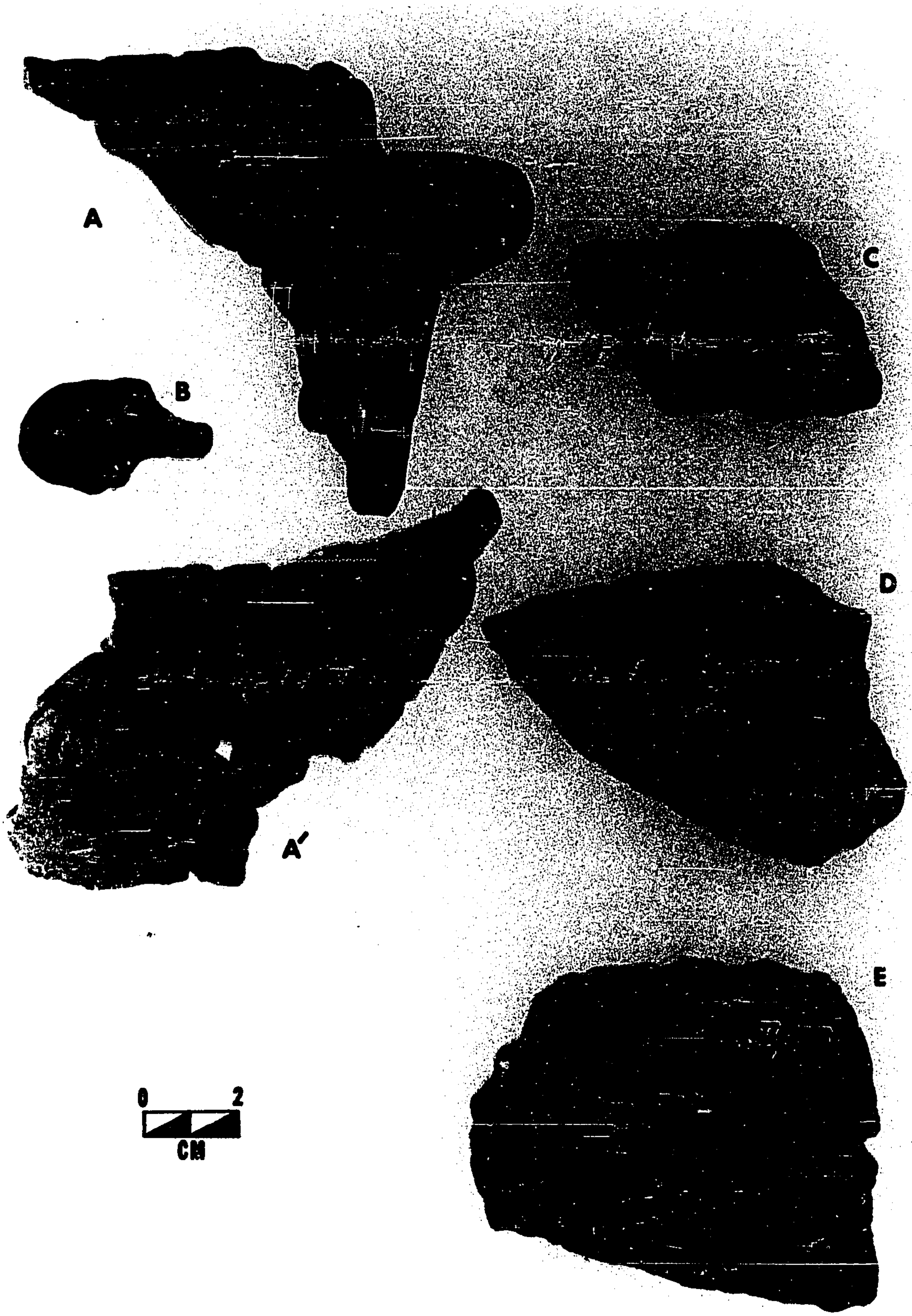

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Figure 14. Late Woodland Ceramic Vessels.

A - Nomini Net Impressed (Table 47:57)

B - Nomini Cord Marked (Table 47:64)

C - Mockley Net Impressed (Table 46:36)

D - Currioman Fabric Impressed (Table 48:67)

A B

C

D

Figure 15. Late Woodland Ceramic Vessels.

A - Rappahannock Incised (Table 49:74)

B - Moyaone Cord Impressed (Table 50:94)

C - Rappahannock Fabric Impressed (Table 49:80)

D - Rappahannock Fabric Impressed (Table 49:78)

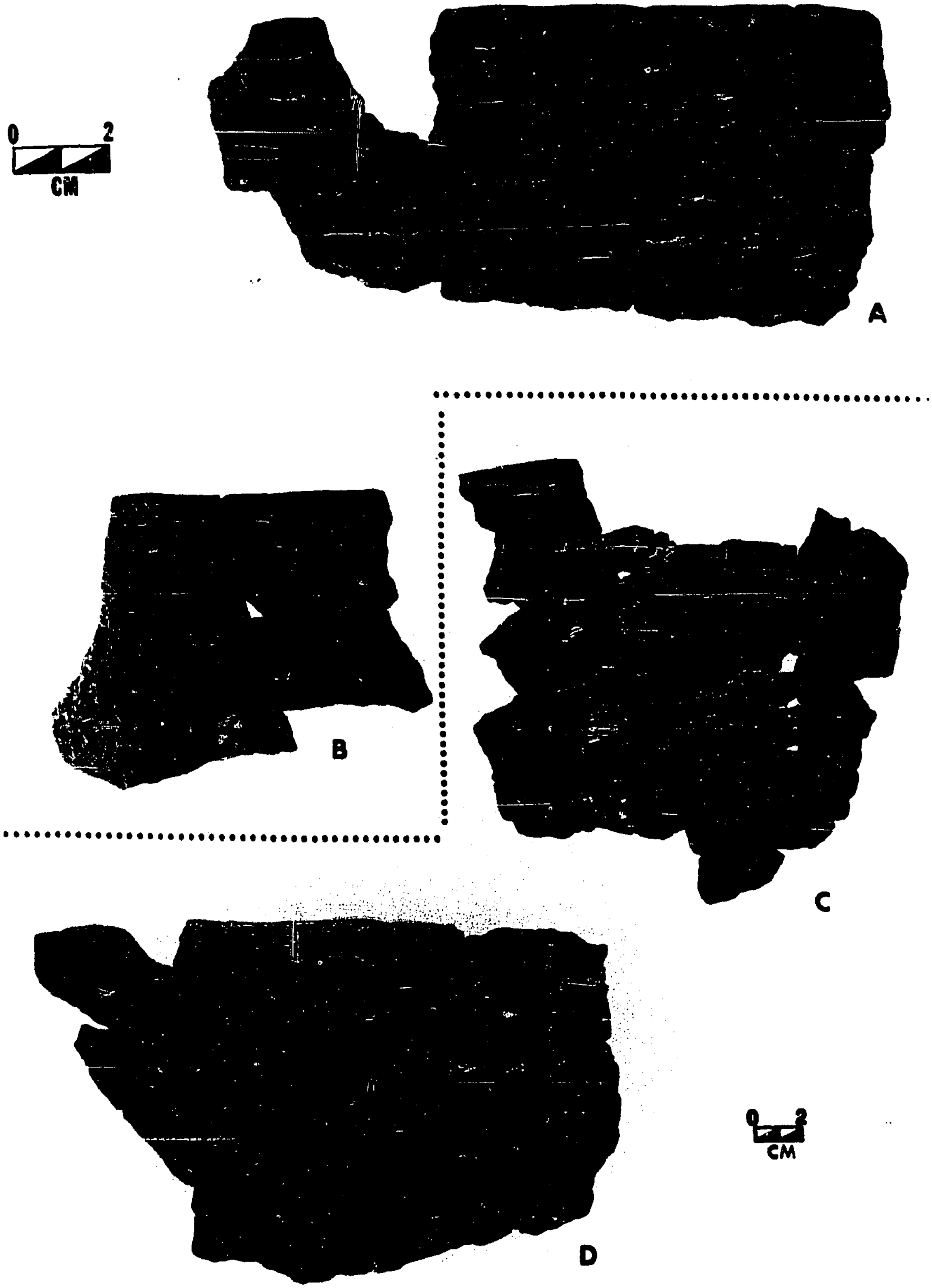
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Figure 16. Protohistoric/Early Historic Ceramic Vessels.

A - Yeocomico Plain (Table 51:48)

B - Yeocomico Plain (Table 51:47)

C - Yeocomico Plain (Table 51:42)

D - Camden Plain (Table 50:97)

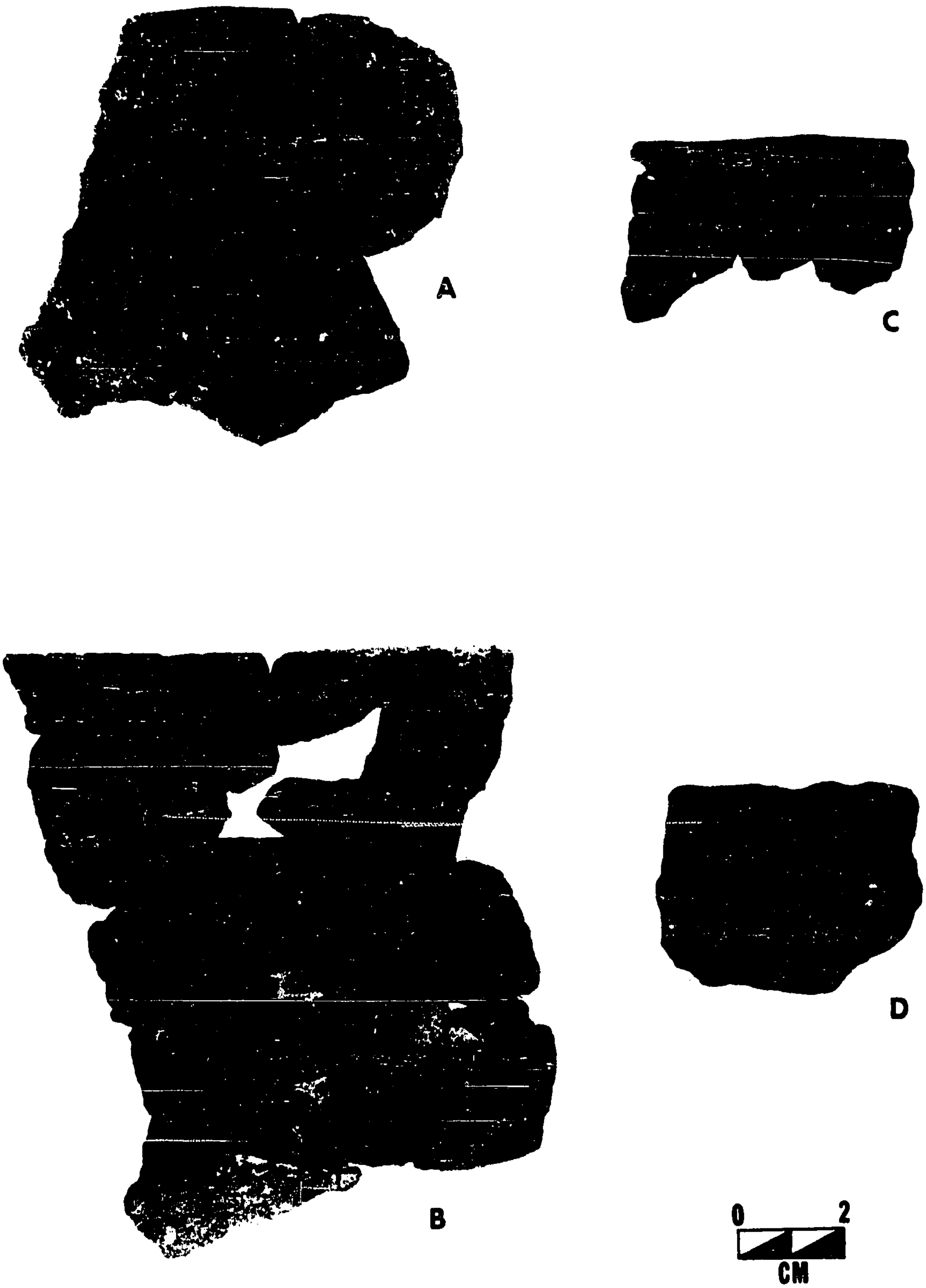
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Figure 17. Projectile Points.

A - Bare Island (Table 53:1)

B - Bare Island (Table 53:5)

C - Calvert (Table 54:3)

D - Calvert (Table 54:6)

E - Calvert (Table 54:8)

F - Calvert (Table 54:10)

G - Rossville (Table 55:3)

H - Rossville (Table 55:4)

I - Nomini (Table 56:1)

J - Nomini (Table 56:4)

K - Nomini (Table 56:7)

L - Levanna (Table 57:5)

M - Levanna (Table 57:8)

N - Levanna (Table 57:10)

O - Potomac (Table 58:1)

P - Potomac (Table 58:5)

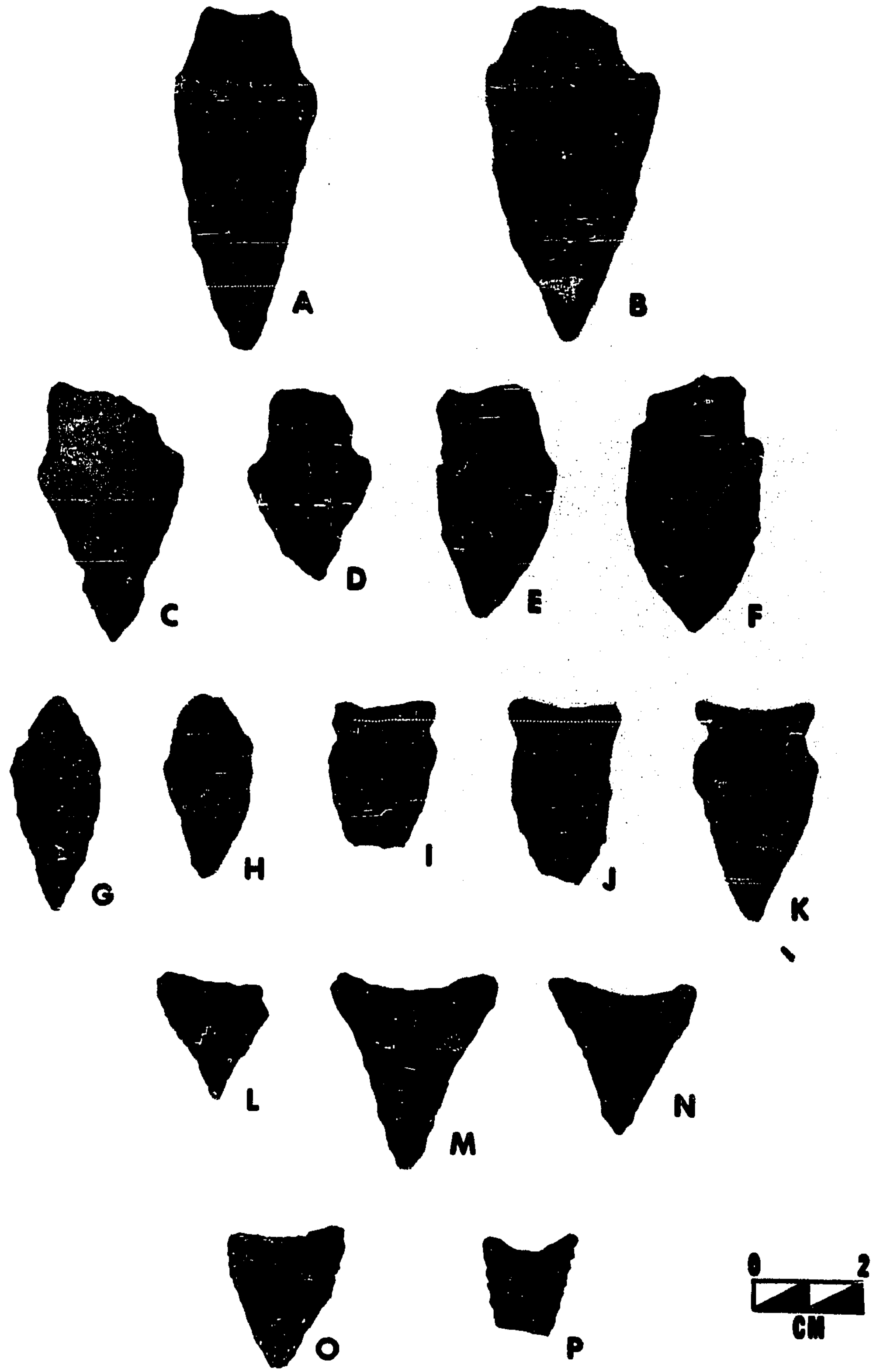
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Figure 18. Lithic, Ceramic, Bone and Shell Artifacts from 44WM119.

A - Chlorite Schist Pipe (LW4)

B - Ceramic Pipe (P/EH3)

C - Bone Projectile Point (LW4)

D - Bone Fishhook (LW9)

E - Elk Tooth Pendant (P/EH1)

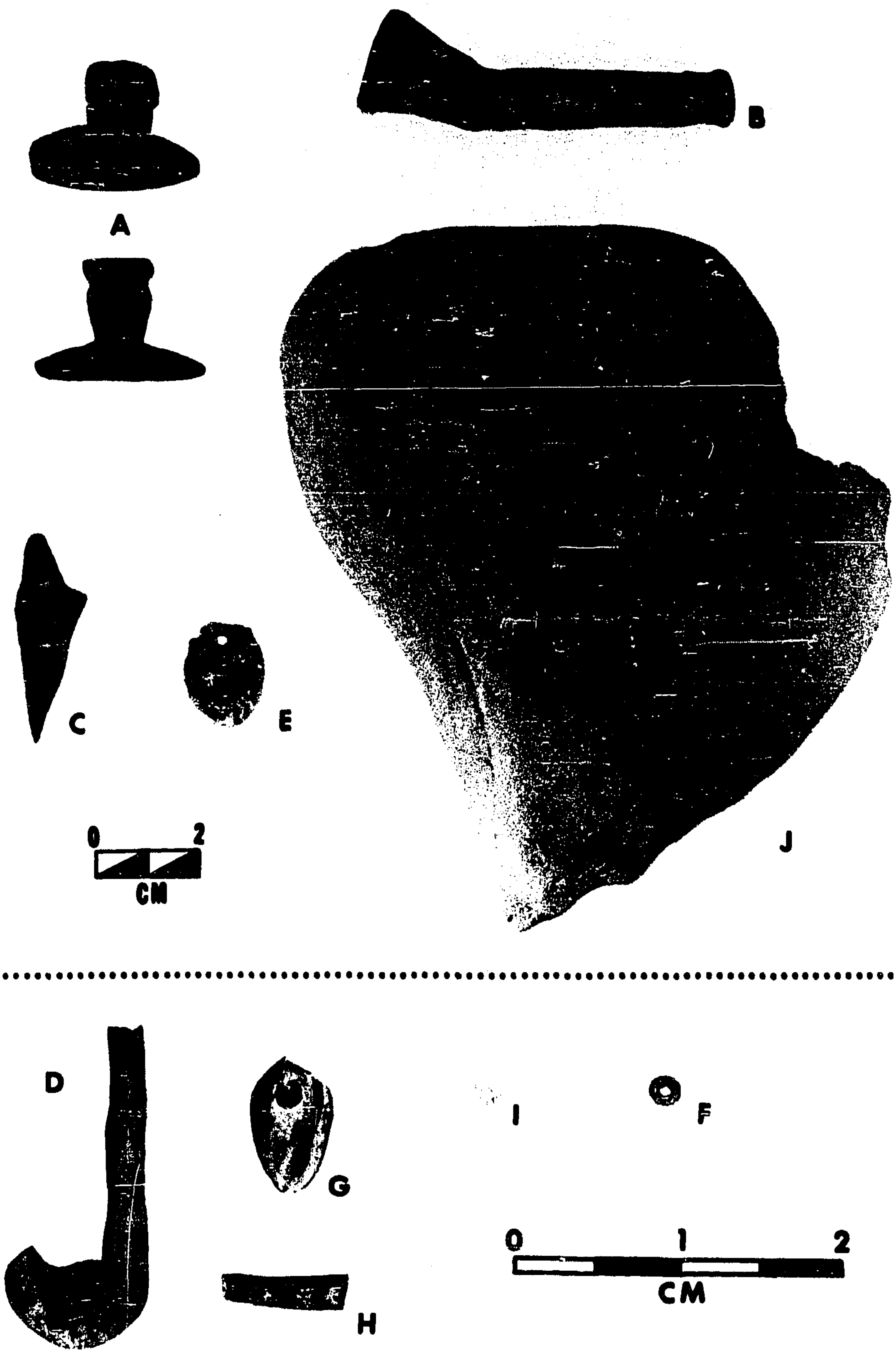
F - *Mercenaria mercenaria* bead (LW8)

G - *Prunum apicinum* bead (LW9)

H - *Dentalium occidentale* bead (LW9)

I - *Aequipecten irradians* bead (P/EH3)

J - *Busycon canaliculatum* blank (LW11)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Human Skeletal Remains

Two fragmentary human skeletons were found at 44WM119. Dr. T. Dale Stewart, of the Smithsonian Institution, kindly agreed to examine the skeletal remains and offered the following interpretations. A calvarium and first cervical vertebra were found eroding from the bluff edge and were attributed to Component P/EH3 (Feature #127). The individual was an adult, probably a female, with a skull tending toward brachiocranic, which occurs infrequently at other late prehistoric sites in the Virginia and Maryland Coastal Plain.

Numerous post-cranial elements, most of which were badly crushed and fragmented, of another adult of unknown sex were found in Component P/EH4 (Feature #131). From field observations and laboratory analysis of field notes and the skeletal remains, it was ascertained that the skeleton was buried on its left side with legs, and probably the arms, drawn up in a flexed position. The skull was missing and had apparently been lost to bluff erosion. There is no reason to think that the two groups of skeletal remains might belong to the same individual. A considerable distance separated the two finds and both comprised *in situ* features affected to varying degree by bluff erosion.

Appendix B

PLANT REMAINS FROM 44WM119

Dr. Gary W. Crawford, at the Department of Anthropology, University of Toronto, has identified some of the plant remains recovered by flotation at White Oak Point. Table 59 presents the data available at this time. Analysis of other samples and of unidentified seeds is ongoing.

Corn (Zea mays) is present in small quantities from several late Late Woodland components which postdate A.D. 1100. A single bearsfoot (Polymnia uvedalia) seed was found in each of three components, dating to Late Woodland through Early Historic times. In addition, grape (Vitis sp.), sumac (Rhus sp.) and cleavers (Galium sp.) seeds were also found in small quantities. Most of the recovered plant remains are hickory, acorn and walnut nutshell fragments. Wood charcoal was also recovered from numerous samples.

Table 59. Plant Remains Identified from the White Oak Point Site.

Components		Plant Remains
Late Archaic	2	acorn
Early Woodland	1	hickory
	2	hickory
Middle Woodland	1	acorn, hickory, 1 grape seed (?)
	2	hickory, acorn, 1 sumac seed (?)
Late Woodland (early)	2	hickory
	4	hickory, walnut (?), 3 <u>Galium</u> seeds, 2 bearsfoot seeds, 1 grape seed, acorn
Late Woodland (late)	5	acorn, hickory, corn kernel fragment (?)
	6	acorn, 1 corn kernel, 1 corn cupule, 1 corn embryo, hickory
	7	hickory
	8	1 sumac seed, 1 bearsfoot seed, 2.59 g hickory
	9	1 corn kernel fragment (?), hickory
	11	1 bearsfoot seed
Protohistoric/Early Historic	3	hickory, walnut, 1 bearsfoot seed

REFERENCES CITED

Abert, S.T.

1885 Improvement of Nomini Creek, Virginia. U.S. Army, Annual Report of the Chief of Engineers for 1885:966-968 and map.

1889 Improvement of Nomini Creek, Virginia. U.S. Army, Annual Report of the Chief of Engineers for 1889:1003-1006 and map.

Allen, Glover M.

1920 Dogs of the American Aborigines. Harvard University, Museum of Comparative Zoology, Bulletin 63:429-517.

Allen, J.

1972 Nebira 4: An Early Austronesian Site in Central Papua. Archaeology and Physical Anthropology of Oceania 7(2): 81-124.

Allison, Roland

1964 Shell Heaps around Deer Isle. Maine Archaeological Society, Bulletin 2:3-5.

1972 More about the Shell Heaps. Maine Archaeological Society, Bulletin 12(2):1-3.

Allo, Jan

1970 Analysis of Midden from Two Sites on Motutapu Island, New Zealand. Records of the Auckland Institute and Museum 7:83-91.

1972 The Whangamata Wharf Site (N49/2): Excavations on a Coromandel Coastal Midden. Records of the Auckland Institute and Museum 9:61-79.

Ambrose, J.

1863 A Few Observations on a Beach Mound, or Kitchen Midden, near French Village. Proceedings and Transactions of the Nova Scotian Institute of Science 2:34-45.

Ambrose, W.R.

1963 Shell Dump Sampling. New Zealand Archaeological Association Newsletter 6(3):155-159.

1967 Archaeology and Shell Middens. Archaeology and Physical Anthropology in Oceania 2:169-187.

Anderson, Atholl J.
1973a A Critical Evaluation of the Methodology of Midden Sampling. New Zealand Archaeological Association Newsletter 16(3): 119-127.

1973b The Conchiolin Dating Method. New Zealand Journal of Science 16(2):553-558.

1979 Prehistoric Exploitation of Marine Resources at Black Rocks Point, Palliser Bay. In "Prehistoric Man in Palliser Bay," edited by B.F. Leach and H.M. Leach, pp. 49-65. National Museum of New Zealand, Bulletin 21.

1981 A Model of Prehistoric Collecting on the Rocky Shore. Journal of Archaeological Science 8(2):109-120.

Andretta, Margarida Davina, and Maria Jose Menezes
1968 Nota Previa Sobre O Sambaqui "B" Do Guaraguacu. Revista do Centro de Ensino e Pesquisas Arquelogicas 1:25-30.

Andrews, E. Wyllys, IV
1969 The Archaeological Use and Distribution of Mollusca in the Maya Lowlands. Tulane University, Middle American Research Institute, Publication 34.

______, Michael P. Simmons, Elizabeth S. Wing, E. Wyllys Andrews V
1974 Excavation of an Early Shell Midden on Isla Cancun, Quintana Roo, Mexico. Tulane University, Middle American Research Institute, Publication 31:147-197.

Andreyev, G.I.
1964 Certain Problems Relating to the Shell Mound Culture. In "The Archaeology and Geomorphology of Northern Asia," H.N. Michael, editor, pp. 249-264. Arctic Institute of North America, Anthropology of the North: Translations from Russian Sources 5.

Anonymous
1907 Narrative of a Voyage to Maryland, 1705-1706. American Histcrical Review 12(2):327-340.

Arber, Edward, editor
1910 Travels and Works of Captain John Smith, two volumes. John Grant, Edinburgh.

Artusy, Richard E., Jr.
1976 An Overview of the Proposed Ceramic Sequence in Southern Delaware. Maryland Archeology 12(2):1-15.

Ascher, Robert
1959 A Prehistoric Population Estimate Using Midden Analysis and Two Population Models. Southwestern Journal of Anthropology 15(2):168-178.

1962 Ethnography for Archaeology: A Case from the Seri Indians. Ethnology 1:360-369.

Aschmann, Homer
1975 Culturally Determined Recognition of Food Resources in the Coastal Zone. Geoscience and Man 12:43-47.

Aten, Lawrence E.
1979 Appendix B: Determination of Seasonality on Rangia cuneata. Archaeological Frameworks for the Upper Texas Coast: Circa 1500 B.C. to the Historic Period. Ph.D. dissertation, Department of Anthropology, University of Texas at Austin, University Microfilms International 80-09,824.

Atwater, Caleb
1820 Description of the Antiquities Discovered in the State of Ohio and Other Western States. Transactions and Collections of the American Antiquarian Society 1.

Avery, Graham
1974 Open Station Shell Midden Sites and Associated Features from the Pearly Beach Area, South-Western Cape. South African Archaeological Bulletin 29(3-4):104-114.

Bailey, Geoffrey N.
1975a The Role of Molluscs in Coastal Economies: The Results of Midden Analysis in Australia. Journal of Archaeological Science 2(1):45-62.

1975b The Role of Shell Middens in Prehistoric Economies. Ph.D. thesis, Cambridge University.

1977 Shell Mounds, Shell Middens, and Raised Beaches in the Cape York Peninsula. Mankind 11(2):132-143.

1978 Shell Middens as Indicators of Postglacial Economies: A Territorial Perspective. In The Early Postglacial Settlement of Northern Europe, edited by Paul Mellars, pp. 37-63. University of Pittsburgh Press, Pittsburgh.

1981 Concepts of Resource Exploitation: Continuity and Discontinuity in Paleoeconomy. World Archaeology 13(1):1-15.

Baird, S.F.
1881 Notes on Certain Aboriginal Shell Mounds on the Coast of New Brunswick and New England. Proceedings of the United States National Museum 4:292-297.

Barber, Michael B.
1981 The Vertebrate Faunal Utilization Pattern of the Middle Woodland Mockley Ceramic Users: The Maycock's Point Shell Midden Site, Prince George County, Virginia. Unpublished manuscript.

Barbour, Philip L., editor
1969 The Jamestown Voyages. Hakluyt Society, 2nd Series, 87(1-2).

Barka, Norman F., and Ben C. McCary
1977 Early Shell Tempered Pottery in the James River Valley, Virginia. Eastern States Archeological Federation, Bulletin 35/36:17.

Baumhoff, Martin A.
1978 Environmental Background. In Handbook of North American Indians, volume 8: California, edited by R.F. Heizer, pp. 16-24. Smithsonian Institution, Washington, D.C.

Baylor, J.B.
1894 Complete Survey of the Natural Oyster Beds, Rocks, and Shoals of Virginia. Report to the Governor of Virginia, 1895. Superintendent of Public Documents, Richmond.

Beaglehole, John C., editor
1955 Journals of Captain James Cook on His Voyages of Discovery, Volume 1: The Voyage of the Endeavor, 1768-1771. Hakluyt Society, Extra Series XXXIV.

1961 Journals of Captain James Cook on His Voyages of Discovery, Volume 2: The Voyage of the Resolution and Adventure, 1772-1775. Hakluyt Society, Extra Series XXXV.

1962 The Endeavor Journal of Joseph Banks, 1768-1771, two volumes. Angus and Robertson, Sydney.

1967 Journals of Captain James Cook on His Voyages of Discovery, Volume 3: The Voyage of the Resolution and Discovery, 1776-1780. Hakluyt Society, Cambridge.

Beaton, John
1973 The Nature of Aboriginal Exploitation of Mollusc Populations in Southern California. Master's thesis, Department of Anthropology, University of California, Los Angeles.

Behrensmeyer, Anna K., and Andrew P. Hill, editors
1980 Fossils in the Making. University of Chicago Press, Chicago.

Behrensmeyer, Anna K., David Western, and Dorothy E. Dechant Boaz
1979 New Perspectives in Vertebrate Paleoecology from a Recent Bone Assemblage. Paleobiology 5(1):12-21.

Bennett, M.K.
1955 The Food Economy of the New England Indians, 1605-1675. Journal of Political Economy 63(5):369-397.

Berry, George S.
1898-1899 The Great Shell Mounds of Damariscotta. _New England Magazine_ n.s. 19:178-188.

Best, Elsdon
1924 _The Maori_, two volumes. H.H. Tombs, Wellington. HRAF OZ 4, two volumes.

Bettinger, Robert L.
1980 Explanatory/Predictive Models of Hunter-Gatherer Adaptation. _Advances in Archaeological Method and Theory_ 3:189-255.

Beyer, George E.
1899 Investigations of Some Shell-Mounds in Calcasieu Parish. _Louisiana Historical Society, Publications_ 2(2) for 1898: 16-23.

Bigalke, E.H.
1973 The Exploitation of Shellfish by Coastal Tribesmen of the Transkei. _Annual of the Cape Province Museum (Natural History)_ 9:159-175.

Binford, Lewis R.
1964 _Archaeological and Ethnohistorical Investigations of Cultural Diversity and Progressive Development Among Aboriginal Cultures of Coastal Virginia and North Carolina_. Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor. University Microfilms International 65-5,877.

1978 _Nunamiut Ethnoarchaeology_. Academic Press, New York.

1981 Behavioral Archaeology and the "Pompeii Premise." _Journal of Anthropological Research_ 37(3):195-208.

_______, and Jack B. Bertram
1977 Bone Frequencies - And Attritional Processes. In _For Theory Building in Archaeology_, edited by L.R. Binford, pp. 77-153. Academic Press, New York.

Bird, Junius
1938 Antiquity and Migrations of the Early Inhabitants of Patagonia. _Geographical Review_ 28(2):250-275.

1946 The Alacaluf. In "Handbook of South American Indians," edited by J.H. Steward. _Smithsonian Institution, Bureau of American Ethnology_ 143(1):55-80.

Bishop, A.H.
1913 An Oransay Shell-Mound: A Scottish Pre-Neolithic Site. _Proceedings of the Society of Antiquarians of Scotland_ 48:52-108.

Blatchley, W.S.
1912 An Indiana Shell Mound. Proceedings of the Indiana Academy of Sciences for 1911, pp. 61-63.

Boissevain, Ethel
1943 Observations on a Group of Shell Heaps on Cape Cod. Massachusetts Archaeological Society, Bulletin 5(1):6-11.

Bonnichsen, Robson, and David Sanger
1977 Integrating Faunal Analysis. Canadian Journal of Archaeology 1:109-133.

Boone, Yvonne
1976 Le Ramassage des Coquillages. In La Prehistoire Francaise, two volumes, edited by Henry de Lumley, pp. (I):703-707. CNRS, Paris.

Borgogno, I., and O.F. Linares de Sapir
1980 Molluskan Fauna from Both Sides of the Isthmus. In "Adaptive Radiation in Prehistoric Panama," edited by O.F. Linares de Sapir and A.J. Ranere, pp. 216-222. Harvard University, Peabody Museum of Archaeology and Ethnology, Monograph 5.

Borgstrom, Georg
1962 Shellfish Protein - Nutritive Aspects. Fish as Food II: 115-147. Academic Press, New York.

Boriskovskii, P.I.
1970 The Early Neolithic Shell Mound at Quynh-Van. Soviet Anthropology and Archaeology 7(4):355-366.

Botkin, Steven
1975 Aboriginal Exploitation of Shellfish at Malibu: Effects of Human Predation Upon Shellfish Populations. Master's thesis, Department of Anthropology, University of California, Los Angeles.

1980 Effects of Human Exploitation on Shellfish Populations at Malibu Creek, California. In Modeling Change in Prehistoric Subsistence Economies, edited by T.K. Earle and A.L. Christenson, pp. 121-139. Academic Press, New York.

Bowdler, Sandra
1976 Hook, Line and Dillybag: An Interpretation of an Australian Coastal Shell Midden. Mankind 10:248-258.

Bradford, Charles
1969 Damariscotta Oyster Shell Heaps. Maine Archaeological Society, Bulletin 9(1):8-9.

Brain, C.K.
1976 Some Principles in the Interpretation of Bone Accumulations Associated with Man. In Human Origins, edited by G. Isaac and E. McCown, pp. 96-116. W.A. Benjamin, Menlo Park, California.

Braun, David P.
1974 Explanatory Models for the Evolution of Coastal Adaptation in Prehistoric New England. American Antiquity 39(4): 582-596.

Brennan, Louis A.
1962a A Beginning in Chronology for the Croton River Area. Pennsylvania Archaeologist 32(3-4):138-156.

1962b The Q Tradition and the GO Horizon. New York State Archaeological Association Bulletin 24:11-16.

1963 A 6000 Yr. Old Midden of Virginia Oyster Shell at Croton Point, Lower Mid Hudson. New York State Archaeological Association Bulletin 29:14-18.

1968 The Twombly Landing Site. New York State Archaeological Association Bulletin 42:11-28.

1971 The Implications of Two New C-14 Dates From Montrose Point, Lower Hudson, N.Y. Proceedings of the Middle Atlantic Archeology Conference, edited by Charles W. McNett, Jr., and William M. Gardner, pp. 9-20.

1974 The Lower Hudson: A Decade of Shell Middens. Archaeology of Eastern North America 2(1):81-93.

1976 Coastal Adaptation in Prehistoric New England. American Antiquity 41(1):112-113.

1977 The Midden is the Message. Archaeology of Eastern North America 5:122-137.

Brewer, Andra J.
1973 Analysis of Floral Remains from the Higgs Site (40LO45). In "Excavation of the Higgs and Doughty Sites," by M.C.R. McCollough and C.H. Faulkner, pp. 141-144. Tennessee Archaeological Society, Miscellaneous Paper 12.

Brinch Petersen, E.
1973 A Survey of the Late Palaeolithic and Mesolithic of Denmark. In The Mesolithic in Europe, edited by S.K. Kozlowski, pp. 77-127. Warsaw University Press, Warsaw.

Brinton, Daniel G.
1872 Artificial Shell Deposits of the United States. Smithsonian Institution, Annual Report for 1866:356-358.

Brown, Clair A.
1936 The Vegetation of Indian Mounds, Middens and Marshes in Plaquemines and St. Bernard Parishes. Department of Conservation, Louisiana Geological Survey, Geological Bulletin 8:423-440.

Bruce, Walter G.
1965 Long Cave: A Maine Shell Deposit Site. Maine Archaeological Society, Bulletin 27:8-12.

Buchanan, W.F., S.L. Hall, J. Henderson, A. Olivier, J.M. Pettigrew, J.E. Parkington and P.T. Robertshaw
1978 Coastal Shell Middens in the Paternoster Area, South-Western Cape. South African Archaeological Bulletin 33(127):89-93.

Buchanan, William T., Jr.
1976a The Hallowes Site, Westmoreland County, Virginia. Archeological Society of Virginia, Quarterly Bulletin 30(4):194-199.

1976b The Mount Airy Shellfield Site, Westmoreland County, Virginia. Archeological Society of Virginia, Quarterly Bulletin 30(4):200-210.

Buck, P.
1952 The Coming of the Maori. Whitcombe and Tombs, Wellington.

Bullbrook, J.A.
1953 On the Excavation of a Shell-Mound at Palo Seco, Trinidad, B.W.I. Yale University, Publications in Anthropology 50.

Bullen, Ripley P.
1949 Excavations in Northeastern Massachusetts. Peabody Foundation for Archaeology, Papers 1(3).

______, Adelaide K. Bullen, and William J. Bryant
1967 Archaeological Investigations at the Ross Hammock Site, Florida. William J. Bryant Foundation, American Studies, Report 7.

______, and F.W. Sleight
1959 Archaeological Investigation of the Castle Windy Midden, Florida. William J. Bryant Foundation, American Studies, Report 1.

1960 Archaeological Investigations of Green Mound, Florida. William J. Bryant Foundation, American Studies, Report 2.

Bunyan, D.E.
1976 Shell Content as Determined by Solubility in Acid. In "The Glenrose Cannery Site," edited by R.G. Matson, pp. 79-81. National Museum of Man, Mercury Series, Archaeological Survey of Canada, Paper 52.

Bushnell, David I., Jr.
1937 Indian Sites Below the Falls of the Rappahannock, Virginia. Smithsonian Institution, Miscellaneous Collections 96(4).

Butler, Amos W.
1917 Observations on Some Shellmounds of the Eastern Coast of Florida. Proceedings of the 19th International Congress of Americanists: 104-107. Washington, D.C.

Buttes, Henry
1599 Dyets Dry Dinner. Thomas Creede and William Wood, London.

Butzer, Karl W.
1978 Toward an Integrated, Contextual Approach in Archaeology: A Personal View. Journal of Archaeological Science 5(3): 191-193.

Byers, Douglas S.
1941 A Further Note on the Squibnocket Cliff Shell Heap. American Antiquity 7(1):68.

1979 The Nevin Shellheap: Burials and Observations. Papers of the Robert S. Peabody Foundation for Archaeology 9.

______, and Frederick Johnson
1939 Some Methods Used in Excavating Eastern Shell Heaps. American Antiquity 4(2):189-212.

1940 Two Sites on Martha's Vineyard. Peabody Foundation for Archaeology, Papers 1 (1).

Byrd, Kathleen Mary
1974 Tchefuncte Subsistence: Information Obtained from the Excavation of the Morton Shell Mound, Iberia Parish, Louisiana. Southeastern Archaeological Conference, Bulletin 19:70-75.

Cabeza de Vaca, Alvar Nunez
1961 Adventures in the Unknown Interior of America, translated and edited by Cyclone Covey. Crowell, New York.

Cahen, D., and J. Moeyersons
1977 Subsurface Movements of Stone Artefacts and Their Implications for the Prehistory of Central Africa. Nature 266:812-815.

Callan, Dennis
1973 Some Dietary Preferences of a Hawaiian Population: A Statistical Study of Covariation of Shell Middens. In University of Hawaii, Social Science Research Institute, Asian and Pacific Archaeology Series 5:115-126.

Campbell, Valerie
1972 Some Radiocarbon Dates for Aboriginal Shell Middens in the Lower Macleay River, New South Wales. Mankind 8:283-286.

Carlson, David L.
1979 Hunter-Gatherer Mobility Strategies: An Example from the Koster Site in the Lower Illinois Valley. Ph.D. dissertation, Northwestern University, University Microfilms International 79-27313.

Carriker, M.R., R.E. Palmer, and R.S. Prezant
1980 Functional Ultramorphology of the Dissoconch Valves of the Oyster Crassostrea virginica. National Shellfisheries Association, Proceedings 70(2):139-183.

Carter, G.F.
1941 Archaeological Notes on a Midden at Point Sal. American Antiquity 6:214-226.

Case, Gerard R., and Wilkes A. Owens
1966 The Mound Builders of the St. Johns River Valley, Central Florida. Chesopiean 4 (1).

Cassels, Richard
1972 Human Ecology in the Prehistoric Waikato. Polynesian Society, Journal 81(2):196-247.

Casteel, Richard W.
1976 Comparison of Column and Whole Unit Samples for Recovering Fish Remains. World Archaeology 8(2):192-196.

1977 Characterization of Faunal Assemblages and the Minimum Number of Individuals Determined from Paired Elements. Journal of Archaeological Science 4(2):125-134.

Ceci, Lynn
1977 The Effect of European Contact and Trade on the Settlement Pattern of Indians in Coastal New York: 1524-1665. Ph.D. dissertation, Department of Anthropology, City University of New York. University Microfilms International 77-13,655.

Chadbourne, H.P.
1859 Oyster Shell Deposit in Damariscotta. Maine Historical Society, Collections 6:345-351.

Champlain, Samuel de
1613 Le Voyages du Sieur de Champlain. Paris.

Chaplin, Raymond E.
1971 The Study of Animal Bones from Archaeological Sites. Seminar Press, London.

Chapman, J. Jefferson
1977 Archaic Period Research in the Lower Little Tennessee River Valley. University of Tennessee, Department of Anthropology, Report of Investigations 18.

Cherry, John F.
1978 Questions of Efficiency and Integration in Assemblage Sampling. In "Sampling in Contemporary British Archaeology," edited by J.F. Cherry, C. Gamble, and S. Shennon, pp. 293-320. British Archaeological Reports, British Series 50.

Chesapeake Bay Research Council
1973 The Effects of Hurricane Agnes on the Environment and Organisms of Chesapeake Bay. Virginia Institute of Marine Science, Special Report 29.

Chomko, Stephen A., and Gary W. Crawford
1978 Plant Husbandry in Prehistoric Eastern North America: New Evidence for its Development. American Antiquity 43(3): 405-408.

Churchill, D.M., and J.J. Wymer
1965 The Kitchen-Midden Site at Westward Ho!, Devon, England. Proceedings of the Prehistoric Society 31:74-84.

Cipriani, Licho
1955 Excavations in Andamanese Kitchen-Middens. Actes du IV Congres International Scientifique, Anthropologique et Ethnologique 2:250-253.

1966 The Andaman Islanders, edited and translated by D. Taylor Cox and Linda Cole. Praeger, New York.

Claflin, William H., Jr.
1931 The Stalling's Island Mound, Columbia County, Georgia. Peabody Museum of American Archaeology and Ethnology, Papers 14(1):1-47.

Clark, A.H., Jr.
1963 Supplementary Note on Pre-Columbian Littorina littorea in Nova Scotia. Nautilus 77(1):8-11.

______, and J.S. Erskine
1961 Pre-Columbian Littorina-Littorea in Nova Scotia. Science 134:393-394.

Clark, Geoffrey
1971 The Asturian of Cantabria: Subsistence Base and the Evidence for Post-Pleistocene Climatic Shifts. American Anthropologist 73:1245-1257.

1981 On Preagricultural Coastal Adaptations. Current Anthropology 22(4):444-445.

______, and Shereen Lerner
1980 Prehistoric Resource Utilization in Early Holocene Cantabrian Spain. Anthropology UCLA 10 (1&2):53-96.

Clark, George R., II
1968 Mollusk Shell: Daily Growth Lines. Science 161:800-802.

1979 Seasonal Growth Variations in the Shells of Recent and Prehistoric Specimens of *Mercenaria mercenaria* from St. Catherines Island, Georgia. In "The Anthropology of St. Catherines Island, 2: The Refuge-Deptford Mortuary Complex," by D.H. Thomas and C.S. Larsen. American Museum of Natural History, Anthropological Papers 56(1):161-179.

Clark, Grahame
1975 The Earlier Stone Age Settlement of Scandinavia. Cambridge University Press, Cambridge.

1977 World Prehistory, 3rd edition. Cambridge University Press, Cambridge.

Clark, Wayne E.
1980 The Origins of the Piscataway and Related Indian Cultures. Maryland Historical Magazine 75(1):8-22.

Clarke, D.V.
1976 The Neolithic Village of Skara Brae, Orkney: 1972-73 Excavations. Department of the Environment, Her Majesty's Stationery Office, Edinburgh.

Coe, Joffre L.
1964 The Formative Cultures of the Carolina Piedmont. American Philosophical Society, Transactions, New Series 54(5).

Cohen, Mark N.
1977 The Food Crisis in Prehistory. Yale University Press, New Haven.

Coles, J.M.
1971 The Early Settlement of Scotland: Excavations at Morton, Fife. Proceedings of the Prehistoric Society 37:284-366.

Cook, Sherburne F.
1946 A Reconsideration of Shell Mounds with Respect to Population and Nutrition. American Antiquity 12(1):50-53.

______, and R.F. Heizer
1952 The Physical Analysis of Nine Indian Mounds of the Lower Sacramento Valley. University of California, Publications in American Archaeology and Ethnology 40(7):281-312.

______, and A.E. Treganza
1947 The Quantitative Investigation of Aboriginal Sites: Comparitive Physical and Chemical Analysis of Two California Indian Mounds. American Antiquity 13(2):135-141.

1950 Quantitative Investigation of Indian Mounds. University of California, Publications in American Archaeology and Ethnology 40(5):223-261.

Coutts, Peter J.F.
1969a Analysis of Archaeological Material from Eroding Midden Sites. New Zealand Archaeological Association Newsletter 12(2):82-91.

1969b The State of Preservation of Shell Material in Midden Sites. Transactions of the Royal Society of New Zealand 2(9): 135-137.

1970a The Archaeology of Wilson's Promontory. Australian Institute of Aboriginal Studies, Australian Aboriginal Studies 28, Prehistory and Material Cultures Series 7.

1970b Bivalve-Growth Patterning as a Method for Seasonal Dating in Archaeology. Nature 226:874.

1971a Archaeological Studies at Martin's Bay. Polynesian Society, Journal 80(2):170-203.

1971b Recent Techniques of Midden Analysis and Studies of Modern Shellfish Populations in New Zealand. Transactions of the Royal Society of New Zealand, General 2(11):143-156.

1972a An Approach to Excavating and Analysing Large Quantities of Archaeological Data. New Zealand Archaeological Association Newsletter 15(3):81-88.

1972b Interpretation of Archaeological Material Eroded from Coastal Dune Sites. Journal of the Royal Society of New Zealand 2(3):407-412.

1975 The Seasonal Perspective of Marine-Oriented Prehistoric Hunter-Gatherers. In Growth Rhythms and History of the Earth's Rotation, edited by G.D. Rosenberg and S.K. Runcorn, pp. 243-252. Willey, London.

______, and C.F.W. Higham
1971 The Seasonal Factor in Prehistoric New Zealand. World Archaeology 2:266-277.

Crabtree, David M., Conrad D. Clausen, and Ariel A. Roth
1980 Consistency in Growth Line Counts in Bivalve Specimens. Palaeogeography, Palaeoclimatology, Palaeoecology 29(3-4): 323-340.

Craig, Alan K., and Norbert P. Psuty
1971 Paleoecology of Shell Mounds at Otuma, Peru. Geographical Review 56(1):125-132.

Crawford, Gary W., W.H. Hurley, and M. Yoshizaki
1978 Implications of Plant Remains from the Early Jomon Hamanasuno Site. Asian Perspectives 19(1):145-155.

Crusoe, Donald L., and Chester B. DePratter
1976 A New Look at the Georgia Coastal Shell Mound Archaic. Florida Anthropologist 29(1):1-23.

Cumbaa, Stephen L.
1976 A Reconsideration of Freshwater Shellfish Exploitation in the Florida Archaic. Florida Anthropologist 29:49-59.

Dall, W.H.
1877 On Succession in the Shell-Heaps of the Aleutian Islands. U.S. Geological and Geographical Survey, Contributions to North American Ethnology I:41-91.

Dalton, Joseph F.
1971 Test Excavation of the McCrea Site. Archeological Society of Virginia, Quarterly Bulletin 26(1):46-49.

Dame, Richard F.
1972 Comparisons of Various Allometric Relationships in Intertidal and Subtidal American Oysters. U.S. Department of Commerce, Fishery Bulletin 70(4):1121-1126.

Damon, P.E., C.W. Ferguson, A. Long, and E.I. Wallick
1974 Dendrochronologic Calibration of the Radiocarbon Time Scale. American Antiquity 39(2):350-366.

Damp, Jonathan E., Deborah M. Pearsall, and Lawrence T. Kaplan
1981 Beans for Valdivia. Science 212:811-812.

Darwin, Charles
1972 The Voyage of the Beagle. Bantam, New York.

Davidson, D.A.
1973 Particle Size and Phosphate Analysis: Evidence for the Evolution of a Tell. Archaeometry 15:143-152.

1976 Processes of Tell Formation and Erosion. In Geoarchaeology: Earth Science and the Past, edited by D.A. Davidson and M.L. Schackley, pp. 255-266. Westview Press, Boulder, Colorado.

Davidson, Janet M.
1967 Midden Analysis and the Economic Approach in New Zealand Archaeology. Records of the Auckland Institute and Museum 6(3):203-228.

Davis, Dave D.
1972 Human Ecology and the Shell Midden. Anthropology UCLA 4(2):17-26.

Day, Paul R.
1965 Particle Fractionation and Particle-Size Analysis. In Methods of Soil Analysis, Part 1, edited by C.A. Black. American Society of Agronomy, Madison, Wisconsin.

Deacon, H.J.
1970 Two Shell Midden Occurrences in the Tsitsikama National Park, Cape Province: A Contribution to the Study of the Ecology of the Strandloopers. Koedoe 13:37-49.

Delaney, Patrick J.V.
1963 Geology and Geomorphology of the Coastal Plain of Rio Grande de Sul, Brazil and Northern Uruguay, Appendix C: Archeological Sites. Louisiana State University, Coastal Studies Series 15:57-58.

Dennell, R.W.
1976 The Economic Importance of Plant Resources Represented on Archaeological Sites. Journal of Archaeological Science 3:229-247.

1979 Prehistoric Diet and Nutrition: Some Food for Thought. World Archaeology 11(2):121-135.

DeWitt, Ridge, and Stewart Ware
1979 Upland Hardwood Forests of the Central Coastal Plain of Virginia. Castanea 44(3):163-174.

Dillehay, Tom D.
1975 Prehistoric Subsistence Exploitation in the Lower Trinity River Delta, Texas. Texas Archeological Survey, Research Report 51.

Dillon, John F., and George R. Clark II
1980 Growth-Line Analysis as a Test for Contemporaneity in Populations. In Skeletal Growth of Aquatic Organisms, edited by D.C. Rhoads and R.A. Lutz, pp. 395-415. Plenum Press, New York.

Douglas, A.E.
1885 Some Characteristics of the Indian Earth and Shell Mounds on the Atlantic Coast of Florida. American Antiquarian and Oriental Journal 7(2):74-82, 140-147.

Dow, Robert L.
1971 Some Characteristics of Maine Coastal Kitchen Middens. Maine Archaeological Society Bulletin 2(1).

Dreisch, Angela von den
1976 A Guide to the Measurement of Animal Bones from Archaeological Sites. Harvard University, Peabody Museum Bulletin 1.

Driscoll, E.G.
1970 Selective Bivalve Shell Destruction in Marine Environments, A Field Study. Journal of Sedimentary Petrology 40:898-905.

Drover, Christopher E.
1974 Seasonal Exploitation of Chione Clams on the Southern California Coast. Journal of California Anthropology 1(2):224-233.

Drucker, Philip
1951 The Northern and Central Nootkan Tribes. Smithsonian Institution, Bureau of American Ethnology, Bulletin 144.

Dye, David H.
1980 Primary Forest Efficiency in the Western Middle Tennessee Valley. Ph.D. dissertation, Department of Anthropology, Washington University. University Microfilms International 81-03675.

Earle, Timothy K.
1980 A Model of Subsistence Change. In Modeling Change in Prehistoric Subsistence Economies, edited by T.K. Earle and A.L. Christenson, pp. 1-29. Academic Press, New York.

Eaton, G.F.
1898 The Prehistoric Fauna of Block Island as Indicated by its Ancient Shell-Heaps. American Journal of Science, series 4, 6:137-159.

Eaton, Jack D., and Joseph W. Ball
1978 Studies in the Archaeology of Coastal Yucatan and Campeche, Mexico. Tulane University, Middle American Research Institute, Publication 46.

Egloff, Keith
1981 Spheres of Cultural Interaction Across the Coastal Plain of Virginia in the Woodland Period. Unpublished manuscript.

Elouard, P.
1969 L'Homme du Nouakchottien. Notes Africaines, Dakar 121:8-10.

Emerson, Thomas E.
1978 A New Method for Calculating the Live Weight of the Northern White-tailed Deer from Osteoarchaeological Material. Midcontinental Journal of Archaeology 3(1):35-44.

Emery, K.O., and R.L. Edwards
1966 Archaeological Potential of the Atlantic Coast Shelf. American Antiquity 31(5):733-737.

Engel, Frederic
1957 Early Sites on the Peruvian Coast. Southwestern Journal of Anthropology 13:54-68.

1973 New Facts About Pre-Columbian Life in the Andean Lomas. Current Anthropology 14(3):271-280.

Erskine, John S.
1960 Shell Heap Archaeology of Southwestern Nova Scotia. Proceedings of the Nova Scotia Institute of Science 24(4): 339-375.

Evans, Clifford
1955 A Ceramic Study of Virginia Archeology. Smithsonian Institution, Bureau of American Ethnology, Bulletin 160.

Evans, J.W.
1972 Tidal Growth Increments in the Cockle Clinocardium nuttali. Science 176:416-417.

Fairbridge, Rhodes W.
1976 Shellfish-Eating Preceramic Indians in Coastal Brazil. Science 191:353-359.

FAO/WHO
1973 Amino Acid Content of Food and Biological Data on Proteins. United Nations, Rome.

Fewkes, J.W.
1896 A Prehistoric Shell Heap on Prince Edward Island. American Antiquarian 18:30-33.

1904 The Aborigines of Puerto Rico. Smithsonian Institution, Bureau of American Ethnology, Annual Report 25.

Firth, Raymond
1959 Economies of the New Zealand Maori. New Zealand Government Printer.

Foster, J.W.
1975 Shell Middens, Paleoecology, and Prehistory: The Case from Estero Morua, Sonora, Mexico. The Kiva 41:185-194.

Fowler, Rev. J.
1870 On Shell Heaps in New Brunswick. Smithsonian Institution, Annual Report 25:389.

Fowler, William S.
1979 An Inquiry Into Shellfish Eating. Narragansett Archaeological Society of Rhode Island, Report for 1979.

Fraser, F.C., and J.E. King
1954 Faunal Remains. In Excavations at Star Carr, by J.G.D. Clark, pp. 70-95. Cambridge University Press, Cambridge.

Frey, David G.
1946 Oyster Bars of the Potomac River. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report 32.

Gagliano, Sherwood M.
1967 Occupation Sequence at Avery Island. Louisiana State University, Coastal Studies Series 22.

Gaines, A.S., and K.M. Cunningham
1878 Shell-heaps on Mobile River. Smithsonian Institution, Annual Report for 1877:290-291.

Galtsoff, Paul S.
1964 The American Oyster. United States Department of the Interior, Fish and Wildlife Division, Fishery Bulletin 64.

Gardner, William M., and Charles W. McNett, Jr.
1971 Early Pottery in the Potomac. Proceedings of the Middle Atlantic Archeology Conference, pp. 42-53.

Garrod, D.A.E., L.H. Dudley Buxton, G.E. Smith, and D.M.A. Bate
1928 Excavation of a Mousterian Rock Shelter at Devil's Tower, Gibralter. Journal of the Royal Anthropological Institute 58:33-113.

Gifford, Diane P.
1980 Ethnoarcheological Contributions to the Taphonomy of Human Sites. In Fossils in the Making, edited by A.K. Behrensmeyer and A.P. Hill, pp. 93-106. University of Chicago Press, Chicago.

1981 Taphonomy and Paleoecology: A Critical Review of Archaeology's Sister Disciplines. Advances in Archaeological Method and Theory 4:365-438.

______, and A. Kay Behrensmeyer
1977 Observed Formation and Burial of a Recent Human Occupation Site in Kenya. Quaternary Research 8(3):245-266.

Gifford, E.W.
1916 Composition of California Shellmounds. University of California, Publications in American Archaeology and Ethnology 12(1):1-29.

1939 The Coast Yuki. Anthropos 34:292-375.

1949 Diet and Age of the California Shellmounds. American Antiquity 14:223-224.

______, and D. Shutler
1956 Archaeological Excavations in New Caledonia. University of California, Publications in American Archaeology and Ethnology 18(1).

Gill, Edmund D.
1954 Aboriginal Kitchen Middens and Marine Shell Beds. Mankind 4(6):249-254.

Gillespie, R., and R.B. Temple
1977 Radiocarbon Dating of Shell Middens. Archaeology and Physical Anthropology in Oceania 12(1):26-37.

Gilmore, Kathleen
1974 Cultural Variation on the Texas Coast: Analysis of an Aboriginal Shell Midden, Wallisville Reservoir, Texas. University of Texas at Austin, Texas Archaeological Survey, Research Report 44.

Glassow, M.A.
1967 Considerations in Estimating Prehistoric California Coastal Populations. American Antiquity 32:354-359.

Gluckman, Stephen J.
1973 Woodland in the Potomac Basin. Ph.D. dissertation, Department of Anthropology, Catholic University of America. University Microfilms International 74-9895.

Glynn, Frank
1953 The Pilots Point Submerged Sites. Archaeological Society of Connecticut, Bulletin 27:11-29.

Goldthwait, Richard P.
1935 The Damariscotta Shell Heaps and Coastal Stability. American Journal of Science 30:1-13.

Goodale, Jane
1971 Tiwi Wives: A Study of the Women of Melville Island, North Australia. American Ethnological Society, Monograph 51.

Goodyear, Albert C., and L.O. Warren
1972 Further Observations on the Submarine Oyster Shell Deposits of Tampa Bay. Florida Anthropologist 25(2):49-66.

Gordon, Claire C., and Jane E. Buikstra
1981 Soil pH, Bone Preservation, and Sampling Bias at Mortuary Sites. American Antiquity 46(3):566-571.

Gordon, J., and M.R. Carriker
1978 Growth Lines in a Bivalve Mollusk: Subdaily Patterns and Dissolution of the Shell. Science 202(3):519-521.

Gould, Richard A.
1980 Living Archaeology. Cambridge University Press, Cambridge.

Grayson, Donald K.
1973 On the Methodology of Faunal Analysis. American Antiquity 39(4):432-439.

1978 Minimum Numbers and Sample Size in Vertebrate Faunal Analysis. American Antiquity 43(1):53-65.

1979 On the Quantification of Vertebrate Archaeofaunas. Advances in Archaeological Method and Theory 2:199-237.

1981 The Effects of Sample Size on Some Derived Measures in Vertebrate Faunal Analysis. Journal of Archaeological Science 8(1):77-88.

Green, Stanton W.
1980 Broadening Least-Cost Models for Expanding Agricultural Systems. In Modeling Change in Prehistoric Subsistence Economies, edited by T.K. Earle and A.L. Christenson, pp. 209-241. Academic Press, New York.

Greengo, R.E.
1951 Molluscan Species in California Shell Middens. University of California, Archaeological Survey Report 13

Greenwood, Roberta S.
1961 Quantitative Analysis of Shells from a Site in Goleta, California. American Antiquity 26(3):416-420.

Griffith, Daniel R.
1977 Townsend Ceramics and the Late Woodland of Southern Delaware. M.A. thesis, Department of Anthropology, The American University, Washington, D.C. Xerox University Microfilms, Master's thesis 13-10,467.

1980 Townsend Ceramics and the Late Woodland of Southern Delaware. Maryland Historical Magazine 75(1):23-41.

Groot, G.R., and Y.H. Sinoto
1952 The Shell Mounds of Ubayama. Archaeologia Nipponica 2, Nipponica First Series. Archaeological Institute of Japan, Itikawa.

Gunn, R.C.
1846 On the Heaps of Recent Shells which Exist Along the Shores of Tasmania. Tasmania Journal II.

Gusinde, Martin
1937 Die Yamana: vom Leben und Denken der Wassernomaden am kap Hoorn [The Yahgan: The Life and Thought of the Water Nomads of Cape Horn]. Modling bei Wein, Anthropos-Bibliothek. HRAF SH 6.

Haag, William G.
1942 Early Horizons in the Southeast. American Antiquity 7(3): 209-222.

1948 An Osteometric Analysis of Some Aboriginal Dogs. University of Kentucky, Reports in Anthropology 7(3).

1975 The Palaeoecology of the South Atlantic Coast. Geoscience and Man 12:77-81.

Hadlock, Wendell S.
1943 Bone Implements from Shell Heaps Around Frenchman's Bay, Maine. American Antiquity 4(4):341-353.

Hall, C.A., Jr., W.A. Dollase, and C.E. Corbato
1974 Shell Growth in Tivela stultorum and Callista chione: Annual Periodicity, Latitudinal Differences, and Diminution with Age. Paleogeography, Paleoclimatology, and Paleoecology 15:33-61.

Hall, Martin
1980 A Method for Obtaining Metrical Data from Fragmentary Molluscan Material Found at Archaeological Sites. South African Journal of Science 76(6):280-281.

Hallam, A.
1967 The Interpretation of Size-Frequency Distributions in Molluscan Death Assemblages. Palaeontology 10(1):25-42.

Hallowell, A. Irving
1926 Bear Ceremonialism in the Northern Hemisphere. American Anthropologist 28(1):1-175.

Ham, Leonard C.
1976 Analysis of Shell Samples. In "The Glenrose Cannery Site," edited by R.G. Matson, pp. 42-78. National Museum of Man, Mercury Series, Archaeological Survey of Canada, Paper 52.

______, and Moira Irvine
1975 Techniques for Determining Seasonality of Shell Middens from Marine Mollusc Remains. Syesis 8:363-373.

Hamilton, Augustus
1908 Fishing and Sea-Foods of the Ancient Maori. Dominion Museum, Bulletin 2.

Hamor, Ralph
1957 A True Discourse of the Present State of Virginia, (reprint of the 1615 London edition). Virginia State Library, Richmond.

Hancock, D.A., and A.C. Simpson
1962 Parameters of Marine Invertebrate Populations. In The Exploitation of Natural Animal Populations, edited by E.D. Le Cren and M.W. Holdgate, pp. 29-50. Blackwell Scientific, Oxford.

Handsman, Russel G., and Charles W. McNett, Jr.
1974 The Middle Woodland in the Middle Atlantic: Chronology, Adaptation, and Contact. Unpublished manuscript.

Harney, W.E.
1954 Australian Aboriginal Cooking Methods. Mankind 4(6):242-246.

Harrington, R.A., G.C. Matlock, and J.E. Weaver
1979 Length-Weight and Dressed-Whole Weight Conversion Tables for Selected Saltwater Fishes. Texas Parks and Wildlife Department, Management Data Series 6.

Harris, Marvin
1979 Cultural Materialism. Random House, New York.

Hassan, Fekri A.
1980 The Growth and Regulation of Human Population in Prehistoric Times. In Biosocial Mechanisms of Population Regulation, edited by M.N. Cohen, R.S. Malpas, and H.G. Klein, pp. 305-319. Yale University Press, New Haven.

1981 Demographic Archaeology. Academic Press, New York.

Haven, Dexter S., William J. Hargis, and Paul C. Kendall
1978 The Oyster Industry of Virginia. Virginia Institute of Marine Science, Special Report 168.

Heath, Dwight B., editor
1963 A Journal of the Pilgrims at Plymouth: Mourt's Relation (edited 1622 text). Corinth, New York.

Henthorn, William E.
1968 Recent Archaeological Activity in North Korea (II): The Shell Mound at Sop'ohang. Asian Perspectives XI 1968:1-17.

Hester, J.J., and Kathryn J. Conover
1970 Ecological Sampling of Middens on the Northwest Coast. Northwest Anthropological Research Notes 4(2):137-152.

Hester, Thomas R., and T.C. Hill, Jr.
1975 Eating Land Snails in Prehistoric Southern Texas: Ethnohistoric and Experimental Data. Nautilus 89(2):37-38.

Hey, R.W.
1967 Appendix 4A: Land Snails. In The Haua Fteah (Cyrenaica), by C.B.M. McBurney, p. 358. Cambridge University Press, Cambridge.

Hiatt, Betty
1967-1968 The Food Quest and the Economy of the Tasmanian Aborigines. Oceania 38:99-133, 190-219.

1970 Woman the Gatherer. In "Woman's Role in Aboriginal Society," edited by Fay Gale, pp. 2-8. Australian Institute of Aboriginal Studies, Australian Aboriginal Studies 36, Social Anthropology Series 6.

Higham, Charles
1976 The Economic Basis of the Fovean Straits Maori in Prehistory. In Problems in Economic and Social Archaeology, edited by G. de G. Sieveking, I.H. Longworth, and K.E. Wilson, pp. 221-233. Duckworth, London.

Hildebrand, Samuel F., and William C. Schroeder
1972 Fishes of the Chesapeake Bay (reprint of a 1928 edition). Smithsonian Institution Press, Washington, D.C.

Hill, Andrew
1979 Butchery and Natural Disarticulation: An Investigatory Technique. American Antiquity 44(4):739-744.

Hoffman, Charles A., Jr.
1967 Bahama Prehistory: Cultural Adaptation to an Island Environment. Ph.D. dissertation, Department of Anthropology, University of Arizona. University Microfilms International 68-1018.

Holmes, Nicholas H., and E. Bruce Trickey
1974 Late Holocene Sea-Level Oscillations in Mobile Bay. American Antiquity 39(1):122-124.

Holmes, William H.
1903 Aboriginal Pottery of the Eastern United States. Smithsonian Institution, Bureau of American Ethnology, 20th Annual Report for 1898-1899.

1907 Aboriginal Shell Heaps of the Middle Atlantic Tidewater Region. American Anthropologist 9:113-128.

1912 Shell-heaps. In "The Handbook of American Indians," edited by F.W. Hodge. Smithsonian Institution, Bureau of American Ethnology, Bulletin 30 (Part 2):541-544.

______, William J. Dinwiddie, and Gerard Fowke
1891 General Archaeology of the Tidewater Country: Lower Potomac, James and Chesapeake. National Anthropological Archives Manuscript 2125, Smithsonian Institution, Washington, D.C.

Hughes, P.J., and R.J. Lampert
1977 Occupational Disturbance and Types of Archaeological Deposit. Journal of Archaeological Science 4:135-140.

Hughes, Walter W., and C.D. Clausen
1980 Variability in the Formation and Detection of Growth Increments in Bivalve Shells. Paleobiology 6(4):503-511.

Hurley, William M.
1979 Prehistoric Cordage: Identification of Impressions on Pottery. Aldine Manuals on Archaeology 3. Taraxacum Inc., Washington, D.C.

Hurt, Wesley R.
1974 The Interrelationships Between the Natural Environment and Four Sambaquis, Coast of Santa Catarina, Brazil. Indiana University Museum, Occasional Papers and Monographs 1.

Ingle, Robert M., and Charles E. Dawson, Jr.
1952 Growth of the American Oyster, Crassostrea virginica (Gmelin) in Florida Waters. Bulletin of Marine Science of the Gulf and Caribbean 2(1):393-404.

Irimoto, Takashi
1977 Ecology of the Sea-food Gatherers on the Rocky Coast of Kawaguchi. In Human Activity System: Its Spatio-temporal Structure, edited by Hitushi Watanabe, pp. 91-116. University of Tokyo Press, Tokyo.

Jardine, W.G.
1977 Location and Age of Mesolithic Coastal Occupation Sites on Oronsay, Inner Hebrides. Nature 267(5607):138-140.

______, and A. Morrison
1976 The Archaeological Significance of Holocene Coastal Deposits in Southwestern Scotland. In Geoarchaeology: Earth Science and the Past, edited by D.A. Davidson and M.L. Shakley, pp. 175-195. Westview Press, Boulder, Colorado.

Jewitt, John R.
1815 A Narrative of the Adventures and Sufferings of John R. Jewitt; Only Survivor of the Crew of the Ship, Boston, During a Captivity of Nearly Three Years Among the Savages of Nootka Sound. Loomis and Richards, Middletown, Connecticut.

Jochelson, Waldemar
1933 History, Ethnology and Anthropology of the Aleut. Carnegie Institution of Washington, Publication 432.

Jochim, Michael A.
1976 Hunter-Gatherer Subsistence and Settlement: A Predictive Model. Academic Press, New York.

1979 Breaking Down the System: Recent Ecological Approaches in Archaeology. Advances in Archaeological Method and Theory 2:77-117.

Johnson, Frederick and Hugh M. Raup
1947 Grassy Island: Archaeological and Botanical Investigations of an Indian Site in the Taunton River, Massachusetts. Robert S. Peabody, Foundation for Archaeology, Papers 1(2).

Jones, Douglas S.
1980 Annual Cycle of Shell Growth Increment Formation of Two Continental Shelf Bivalves and Paleoecologic Significance. Paleobiology 6(3):331-340.

Jones, Rhys
1971 The Demography of Hunters and Farmers in Tasmania. In Aboriginal Man and Environment in Australia, edited by D.J. Mulvaney and J. Golson, pp. 271-287. Australian National University Press, Canberra.

1980 Hunters in the Australian Coastal Savanna. In Human Ecology in Savanna Environment, edited by D.R. Harris, pp. 107-146. Academic Press, New York.

Jordan, Douglas F.
1963 The Jungerman Site. In "Papers on the Jungerman and Goodman Sites, Florida." Contributions of the Florida State Museum, Social Sciences 10:1-23.

Kalm, Peter
1966 Travels in North America, two volumes. Dover, New York.

Kennedy, Jean
1981 Lapita Colonization of the Admiralty Islands? Science 213:757-759.

Kennish, Michael J.
1980 Shell Microgrowth Analysis. In Skeletal Growth of Aquatic Organisms, edited by D.C. Rhoads and R.A. Lutz, pp. 255-294. Plenum Press, New York.

Killingley, John S.
1981 Seasonality of Mollusk Collecting Determined from O-18 Profiles of Midden Shells. American Antiquity 46(1):152-158.

Klein, Richard G.
1975 Middle Stone Age Man-Animal Relationships in Southern Africa: Evidence from Die Kelders and Klasies River Mouth. Science 190:265-267.

1979 Stone Age Exploitation of Animals in Southern Africa. American Scientist 67(2):151-160.

1980 The Interpretation of Mammalian Faunas from Stone-Age Archeological Sites. In Fossils in the Making, edited by A.K. Behrensmeyer and A.P. Hill, pp. 223-246. University of Chicago Press, Chicago.

Knapp, Marian L.
1973 Archaic Seasonal Patterning and Shellfish Use in Southeastern New England. Master's thesis, Hunter College, CUNY.

Knight, Vernon J., Jr.
1976 Archaeological Investigations on Dauphin Island, Mobile County, Alabama. Unpublished manuscript. University of Alabama, Department of Anthropology.

Koike, Hiroko
1973 Daily Growth Lines of the Clam, Meretrix lusoria: A Basic Study for the Estimation of Prehistoric Seasonal Gathering. Journal of the Anthropological Society of Nippon 81:122-138.

1979 Seasonal Dating and the Valve-Pairing Technique in Shell-midden Analysis. Journal of Archaeological Science 6(1): 63-74.

Koloseike, Alan
1968 The Logic of Midden Analysis with Respect to Shell. University of California Archaeological Survey, Annual Report 10:371-382.

1969 On Calculating the Prehistoric Food Resource Value of Molluscs. University of California, Los Angeles, Archaeological Survey, Annual Report 11:143-162.

1970 Costs of Shell Analysis. American Antiquity 35(4):475-480.

______, and M. Peterson
1963 Macro-Column Shell Analysis. University of California, Los Angeles, Archaeological Survey Annual Report 1962-1963: 439-459.

Kroeber, A.L., and S.A. Barrett
1960 Fishing Among the Indians of Northwestern California. Anthropological Records 21(1).

Labillardiere, J.J.H.
1799-1800 Relation du Voyage a la Recherche de la Perouse, two volumes and atlas. Paris.

Lampert, R.J.
1971 Burrill Lake and Currarong: Coastal Sites in Southern New South Wales. Terra Australis 1:1-86.

Larson, Lewis H.
1980 Aboriginal Subsistence Technology on the Southeastern Coastal Plain During the Late Prehistoric Period. University Presses of Florida, Gainesville.

Lee, David S., Arnold Norden, Carter R. Gilbert, and Richard Franz
1976 A List of the Freshwater Fishes of Maryland and Delaware. Chesapeake Science 17(3):205-211.

Lefler, Hugh T., editor
1967 A New Voyage to Carolina by John Lawson (edited 1708 text). University of North Carolina Press, Chapel Hill.

Lenik, Edward J.
1977 The Spirit Pond Shellheap. Archaeology of Eastern North America 5:94-107.

Lethbridge, T.C.
1928 Shell Mounds and Winkle Pins. Archaeologia Cambrensis 83(1):175-181.

Lie, Rolf W.
1980 Minimum Number of Individuals from Osteological Samples. Norwegian Archaeological Review 13(1):24-30.

Lightfoot, Kent, and Reynold J. Ruppe
1980 Oyster Carrying Capacity at Venice, Florida, Two Thousand Years Ago. Florida Bureau of Historic Sites and Properties Bulletin 6:47-60.

Linares de Sapir, Olga F.
1971 Shell Middens of Lower Casamance and Problems of Diola Protohistory. West African Journal of Archaeology 1:23-54.

Liversage, D.L.
1968 Excavations at Dalkey Island. Proceedings of the Royal Irish Academy 66(C):52-233.

Loftfield, Thomas C.
1970 Shell Midden Sites of the Harkers Island-North River Area, North Carolina. Unpublished Master's thesis, Department of Anthropology, University of North Carolina, Chapel Hill.

Long, Stanley, and Marcia V.V. Wire
1966 Excavations at Barra de Navidad, Jalisco. Antropologica 18:3-81.

Loomis, F.B., and D.B. Young
1912 On the Shell Heaps of Maine. American Journal of Science 34:17-42.

Loosanoff, Victor L., and Charles A. Nomejko
1949 Growth of Oysters, O. virginica, During Different Months. Biological Bulletin 97(1):82-94.

Lothrop, Samuel K.
1928 The Indians of Tierra del Fuego. Heye Foundation, Museum of the American Indian, Contributions 10. HRAF SH4 3.

Lubell, D., F.A. Hassan, A. Gautier, and J.L. Ballais
1975 The Prehistoric Cultural Ecology of Capsian Escargotieres. Libyca: Anthropologie, Prehistoire, Ethnographie 23:92-121.

1976 The Capsian Escargotieres. Science 191:910-920.

Lumley, Henry de
1972 A Paleolithic Camp at Nice. In Old World Archaeology, edited by C.C. Lamberg-Karlovsky, pp. 33-41. W.H. Freeman, San Francisco.

Lutz, Richard A.
1976 Annual Growth Patterns in the Inner Shell Structure of an Estuarine Bivalve. Marine Biological Association (UK) 56: 723-731.

______, and Donald C. Rhoads
1977 Anaerobiosis and a Theory of Growth Line Formation. _Science_ 198:1222-1227

1980 Growth Patterns Within the Molluscan Shell. In _Skeletal Growth of Aquatic Organisms_, edited by D.C. Rhoads and R.A. Lutz, pp. 203-254. Plenum Press, New York.

Lyell, Charles
1849 _A Second Visit to the United States of America_, two volumes. New York.

Lyman, R. Lee
1979 Available Meat from Faunal Remains. _American Antiquity_ 44(3):536-546.

McBurney, C.B.M.
1967 _The Hauah Fteah (Cyrenaica) and the Stone Age of the South East Mediterranean_. Cambridge University Press, London.

McCollough, Major C.R., and Charles H. Faulkner
1973 Excavation of the Higgs and Doughty Sites, I-75 Salvage Archaeology. _Tennessee Archaeological Society, Miscellaneous Paper_ 12.

MacCord, Howard A., Sr.
1969 Camden: A Postcontact Indian Site in Caroline County. _Archeological Society of Virginia, Quarterly Bulletin_ 24(1): 1-55.

1972 The Presnall Site, Westmoreland County, Virginia. _Archeological Society of Virginia, Quarterly Bulletin_ 25(3): 197-207.

McGee, W.J.
1898 The Seri Indians. _Bureau of American Ethnology, Seventeenth Annual Report, 1895-1896_ (Part I):1-344.

McGeein, D.J., and W.C. Mueller
1955 A Shellmound in Marin County, California. _American Antiquity_ 21:52-62.

McGuire, J.D.
1883 Shell Heaps of South River, Maryland. _Smithsonian Miscellaneous Collections_ 25(4):31.

McHugh, J.L., R.T. Oglesby, and A.L. Pancheco
1959 Length, Weight, and Age Composition of the Menhaden Catch in Virginia Waters. _Limnology and Oceanography_ 4(2):145-162.

McNett, Charles W., Jr., and William M. Gardner
1971 Shell Middens of the Potomac Coastal Plain. Proceedings of the Middle Atlantic Archeology Conference, pp. 21-31.

1975 Archaeology of the Lower and Middle Potomac. Unpublished manuscript.

Madsen, A.P., S. Muller, C. Neergaard, C.G.J. Petersen, E. Rostrup, K.V.J. Steenstrup, and H. Winge
1900 Affaldsdynger fra Stenalderen i Danmark. C.A. Reitzel, Copenhagen.

Maggs, T., and E. Speed
1967 Bonteberg Shelter. South African Archaeological Bulletin 22(3):80-93.

Mangerud, Jan
1972 Radiocarbon Dating of Marine Shells. Boreas 1:143-172.

Manson, Carl
1948 Marcey Creek Site: An Early Manifestation in the Potomac Valley. American Antiquity 13(3):223-227.

Mansueti, Alice J., and Jerry D. Hardy, Jr.
1978 Development of Fishes of the Chesapeake Bay, Part I. Smithsonian Institution Press, Washington, D.C.

Marquardt, William H., and Patty Jo Watson
1977 Natural and Cultural Processes in the Formation of an Archaic Shell Midden on the Green River, Kentucky. Research Proposal Submitted to the National Science Foundation.

Marrinan, Rochelle A.
1975 Ceramics, Molluscs, and Sedentism: The Late Archaic Period on the Georgia Coast. Ph.D. dissertation, Department of Anthropology, University of Florida. University Microfilms International 76-12,090.

Martof, B.S., W.M. Palmer, J.R. Bailey, and J.R. Harrison
1980 Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina, Chapel Hill.

Marye, William B.
1938 Shell Heaps on Chesapeake Bay. In Reports of the Susquehanna River Expedition by Warren K. Moorehead, pp. 123-128.

Massey, A.L.
1914 Notes on the Evidence of Age Afforded by the Growth Rings of Oyster Shells. Scientific Investigations of the Fisheries Branch of Ireland for 1913, 11:1-12.

Massola, Aldo
1971 The Aborigines of South-Eastern Australia As They Were. Griffin, Adelaide.

Matson, R.G.
1976 The Glenrose Cannery Site. National Museum of Man, Mercury Series, Archaeological Survey of Canada, Paper 52.

May, J. Alan
1979 Shell Midden Formation Processes: A Methodological Perspective. Paper presented at the Southeastern Archaeological Conference, Atlanta, Georgia.

Meehan, Betty
1975 Shell Bed to Shell Midden. Ph.D. thesis, Australian National University, Canberra.

1977a Hunters by the Seashore. Journal of Human Evolution 6(4): 363-370.

1977b Man Does Not Live by Calories Alone: The Role of Shellfish in a Coastal Cuisine. In Sunda and Sahul: Prehistoric Studies in Southeast Asia, edited by J. Allen, J. Golson, and R. Jones, pp. 493-531. Academic Press, New York.

Meggers, Betty J.
1972 Prehistoric America. Aldine-Atherton, Chicago.

_______, Clifford Evans, and Emilio Estrada
1965 Early Formative Period of Coastal Ecuador: The Valdivia and Machalilla Phases. Smithsonian Contributions to Anthropology 1.

Meighan, Clement W.
1950 Excavations in Sixteenth Century Shellmounds at Drake's Bay, Marin County. University of California Archaeological Survey Report 9:27-32.

1959 The Little Harbor Site, Catalina Island: An Example of Ecological Interpretation in Archaeology. American Antiquity 24(4):383-405.

1969 Molluscs as Food Remains in Archaeological Sites. In Science in Archaeology, editors D. Brothwell and E. Higgs, pp. 415-422. London.

Mellars, Paul
1978 Excavation and Economic Analysis of Mesolithic Shell Middens on the Island of Oronsay (Inner Hebrides). In The Early Postglacial Settlement of Northern Europe, edited by Paul Mellars, pp. 371-396. University of Pittsburgh Press, Pittsburgh.

______, and Sebastian Payne
1971 Excavation of Two Mesolithic Shell Middens on the Island of Oronsay (Inner Hebrides). Nature 231(5302):397-398.

Merrill, A.S., K.O. Emery, and M. Rubin
1965 Ancient Oyster Shell on the Atlantic Continental Shelf. Science 147:338-340.

Mitchell, S.R.
1949 Stone-Age Craftsmen. Tait Book Company, Melbourne.

Moffet, Ross
1951 The Rose Site: A Stratified Shell Heap on Cape Cod, Massachusetts. American Antiquity 17:98-107.

1959 Notes on the Small's Swamp Shell Heap, Truro, Massachusetts. Bulletin of the Massachusetts Archaeological Society 21:1-14.

1962 A Shell Heap Site on Griffin Island, Wellfleet, Massachusetts. American Antiquity 28:96-100.

Moore, Clarence B.
1892-1893 Certain Shell Heaps of the St. Johns River, Florida, Hitherto Unexplored. American Naturalist 26:912-922, 27:113-117.

1899 Certain Aboriginal Mounds of the Coast of South Carolina. Philadelphia Academy of Natural Sciences, Journal (Second Series) 11 (Part 2):147-166.

Moorehead, Warren K.
1922 Archaeology of Maine. Andover Press, Andover, Massachusetts.

Moreau, Jean-Francois
1978 L'analyze des Coquillages Prehistoriques. Recherches Amerindiennes au Quebec 8(1):53-63.

Morel, J.
1974 La Faune de L'escargotiere de Dra-Mta-el-Ma-el-Abiod (Sud-Algerien). L'Anthropologie 78:299-320.

Morlot, A.
1861 General Views on Archaeology. Smithsonian Institution, Annual Report for 1860:284-343.

Morrison, J.P.E.
1942 Preliminary Report on Mollusks Found in the Shell Mounds of the Pickwick Landing Basin in the Tennessee River Valley. In "An Archeological Survey of Pickwick Basin in the Adjacent Portions of the States of Alabama, Mississippi and Tennessee," by William S. Webb and David DeJarnette, pp. 337-392. Smithsonian Institution, Bureau of American Ethnology, Bulletin 129.

Morse, Dan F.
1967 The Robinson Site and Shell Mound Archaic Culture in the Middle South. Ph.D. dissertation, Department of Anthropology, University of Michigan. University Microfilms International 67-17,818.

Morse, E.S.
1868 Evidence of Great Antiquity in the Shell Heaps at Goose Island. Proceedings of the Boston Society of Natural History 11:301-302.

1879 Shellmounds of Omori. University of Tokio Publications. Tokyo.

1882 Changes in Mya and Lunatia since the Deposition of the New England Shell Heaps. American Association for the Advancement of Science, Proceedings 30:345.

1925 Shell-Mounds and Changes in the Shells Composing Them. Scientific Monthly 21:429-440.

Mountjoy, Joseph B.
1974 San Blas Complex Ecology. In The Archaeology of West Mexico, edited by Betty Bell, pp. 106-119. Sociedad de Estudios Avanzados del Occidente de Mexico, A.D. Ajijic, Jalisco, Mexico.

Muncy, Robert J.
1962 Life History of the Yellow Perch, Perca flavescens, in Estuarine Waters of Severn River, a Tributary of Chesapeake Bay, Maryland. Chesapeake Science 3(3):143-159.

Murawski, Steven A., and Frederick M. Serchuk
1979 Shell Length-Meat Weight Relationships of Ocean Quahogs, Artica islandica, From the Middle Atlantic Shelf. National Shellfisheries Association, Proceedings 69:40-46.

Murdock, George P.
1967 Ethnographic Atlas: A Summary. Ethnology 6(2).

Nelson, Nels C.
1909 Shellmounds of the San Francisco Bay Region. University of California, Publications in American Archaeology and Ethnology 7:309-356.

1910 The Ellis Landing Shellmound. University of California, Publications in American Archaeology and Ethnology 7:357-426.

Nelson, Thurlow C.
1942 The Oysters. In "The Boylston Street Fishweir," edited by Frederick Johnson. Robert S. Peabody Foundation for Archaeology, Papers 2:49-64.

Neuman, Robert W.
1972 Archaeological Investigations at the Morton Shell Mound, Weeks Island, Iberia Parish, Louisiana. Report submitted to the National Science Foundation, Washington.

Newcombe, Curtis L.
1950 An Analysis of Certain Dimensional Relationships of the Virginia Oyster, Crassostrea virginica (Gmelin). American Naturalist 84(3):203-214.

Noe-Nygaard, Nanna
1977 Butchering and Marrow Fracturing as a Taphonomic Factor in Archaeological Deposits. Paleobiology 3(2):218-237.

Oberg, Kalvero
1973 The Social Economy of the Tlingit Indians. University of Washington Press, Seattle.

Okladnikov, Aleksei P.
1965 The Soviet Far East in Prehistory. Arctic Institute of North America, Anthropology of the North: Translations from Russian Sources 6.

Olsson, I.V.
1973 The Radiocarbon Dating of Ivory Coast Shell Mounds. West African Journal of Archaeology 3:215-220.

Opperman, Antony F.
1980 A Study of the Prehistoric Ceramics from Maycock's Point, Prince George County, Virginia. Unpublished Senior Honor's thesis, Department of Anthropology, College of William and Mary, Williamsburg.

Osborn, Alan J.
1977a Aboriginal Exploitation of Marine Food Resources. Ph.D. dissertation, Department of Anthropology, University of New Mexico, University Microfilms International 78-9451.

1977b Strandloopers, Mermaids, and Other Fairy Tales: Ecological Determinants of Marine Resource Utilization - The Peruvian Case. In For Theory Building in Archaeology, edited by L.R. Binford, pp. 157-205. Academic Press, New York.

1980 Comment on "Maritime Hunter-Gatherers: Ecology and Prehistory," by David R. Yesner. Current Anthropology 21(6):740-741.

O'Shea, John
1981 Coping with Scarcity: Exchange and Social Storage. In "Economic Archaeology," edited by Alison Sheridan and Geoffrey Bailey, pp. 167-183. British Archaeological Reports, International Series 96.

Oswalt, Wendell H., and James W. VanStone
1967 The Ethnoarcheology of Crow Village, Alaska. Smithsonian Institution, Bureau of American Ethnology, Bulletin 199.

Owen, Thomas M.
1922 Some Notes on the Shell Banks of the Alabama Coast. Arrow Points 4(1):1-7.

Palmer, Jay, and J. Raymond Williams
1977 The Formation of Goethite and Calcareous Lenses in Shell Middens in Florida. Florida Anthropologist 30(1):24-27.

Palmer, Robert E., and M.R. Carriker
1979 Effects of Cultural Conditions on Morphology of the Shell of the Oyster. National Shellfisheries Association, Proceedings 69:58-72.

Palmer, S.
1977 The Mesolithic Cultures of Britain. Dolphin Press, London.

Paloumpis, Andreas A.
n.d. A Laboratory Manual on Fish Osteology. Illinois State University, Normal, Illinois.

Panella, G., and C. MacClintock
1968 Biological and Environmental Rhythms Reflected in Molluscan Shell Growth. Journal of Paleontology 42(5) Part 2:64-80.

Paradiso, John L.
1969 Mammals of Maryland. United States Bureau of Sport Fisheries and Wildlife, North American Fauna 66.

Parkington, John E.
1972 Seasonal Mobility in the Late Stone Age. African Studies 31: 223-243.

1976 Coastal Settlement Between the Mouths of the Berg and Olifants Rivers, Cape Province. South African Archaeological Bulletin 31(3-4):127-140.

Parmalee, Paul W., and Walter E. Klippel
1974 Freshwater Mussels as a Prehistoric Food Resource. American Antiquity 39(3):421-434.

Paul, A.A., and D.A. Southgate
1978 The Composition of Foods. Elsevier, Amsterdam.

Peacock, William R.B.
1978 Probabalistic Sampling in Shell Middens: A Case Study from Oronsay, Inner Hebrides. In Sampling in Contemporary British Archaeology, edited by J. Cherry, C. Gamble, and S. Shennan. British Archaeological Reports, Oxford.

Pearson, Richard J.
1969 Archaeology of the Ryukyu Islands. University of Hawaii Press, Honolulu.

1977 Paleoenvironment and Human Settlement in Japan and Korea. Science 197:1239-1246.

Pequart, M., St.-J. Pequart, M. Boule, and H. Vallois
1937 Teviec: Station-Decropole Mesolithique du Morbihan. Archives de l'Institut de Paleontologie Humaine, Memoire.

_______, and St.-J. Pequart
1954 Hoedic: 2c Station Necropole du Mesolithique Cotier Armorican. De Sikkel, Anvers.

Perlman, Stephen M.
1973 Pecten irradians Growth Implications. Unpublished Master's thesis, Department of Anthropology, University of Massachusetts.

1977 Optimum Diet Models and Prehistoric Hunter-Gatherers: A Test on Martha's Vineyard. Ph.D. dissertation, Department of Anthropology, University of Massachusetts. University Microfilms International 77-15,110.

1980 An Optimum Diet Model, Coastal Variability, and Hunter-Gatherer Behavior. Advances in Archaeological Method and Theory 3:257-310.

Peron, M.F.
1809 A Collection of Modern and Contemporary Voyages and Travels. Richard Phillips, London.

Petersen, C.G.J.
1922 Om Tidsbestemmelse og Ernaeringsforhold i den Aeldre Stenalder i Danmark. Det Kangelige Danske Videnskabernes Selskab, Biologiske Meddelelser 3:3-20.

Peterson, Nicholas
1973 Camp Site Location Amongst Australian Hunter-Gatherers. Archaeology and Physical Anthropology in Oceania 8(3):173-193.

1976 Ethno-archaeology in the Australian Iron Age. In Problems in Economic and Social Archaeology, edited by G. de G. Sieveking, I.H. Longworth, and K.E. Wilson, pp. 265-275. Duckworth, London.

Poiner, Gretchen

1976 The Process of the Year Among Aborigines of the Central and South Coast of New South Wales. Archaeology and Physical Anthropology in Oceania 11(3):186-206.

Potter, Stephen R.

1976 An Ethnohistorical Examination of Indian Groups in Northumberland County, Virginia: 1608-1719. Unpublished Master's thesis, Department of Anthropology, University of North Carolina, Chapel Hill.

1982 An Analysis of Chicacoan Settlement Patterns. Ph.D. dissertation, Department of Anthropology, University of North Carolina, Chapel Hill.

Powell, B.W.

1965 Spruce Swamp: A Partially Drowned Coastal Midden in Connecticut. American Antiquity 30(4):460-469.

1971 Notes on Salwen's comments on "Archaeological Potential of the Atlantic Continental Shelf," American Antiquity 36(2):212-213.

Price, T.J., G.W. Thayer, M.W. LaCroix, and G.P. Montgomery

1976 The Organic Content of Shells and Soft Tissues of Selected Estuarine Gastropods and Pelecypods. Proceedings of the National Shellfisheries Association 65:26-31.

Prummel, W.

1975 Some Reflections on the Faunal Remains of the Roman Castellum Valkenburg, Excavation 1962. In Archaeozoological Studies, edited by A.T. Clason, pp. 225-229. American Elsevier, New York.

Putnam, Frederick W.

1884 The First Notice of the Pine Grove or Forest River Shellheap. Essex Institute, Bulletin 15:86-92.

Quick, J.A., Jr., and J.G. Mackin

1971 Oyster Parasitism by Labyrinthomyxa marina in Florida. Florida Department of Natural Resources Marine Research Laboratory, Professional Paper 13.

Quinn, David B., editor

1967 Observations Gathered out of a Discourse of the Plantation of the Southern Colony of Virginia by the English, 1606 by George Percy. University of Virginia Press, Charlottesville.

_______, and Alison M. Quinn, editors
1973 Virginia Voyages from Hakluyt. Oxford University Press, London.

Rau, Charles
1872 Artificial Shell-Deposits in New Jersey. Smithsonian Institution, Annual Report for 1864:370-374.

1884 Prehistoric Fishing in Europe and North America. Smithsonian Contributions to Knowledge 25.

Rauth, Jose Wilson
1971 Nota Previa Sobre a Escavacae do Sambaqui do Ramal. Museu Paraense Emilio Goeldi, Programa Nacional de Pesquisas Arquelogicas 4:115-128.

Reichel-Dolmatoff, G.
1972 The Cultural Context of Early Fiber-Tempered Pottery in Northern Colombia. Florida Anthropologist 25(2; Part 2):1-5.

Reynolds, Elmer R.
1883a Memoir on the Pre-Columbian Shell-Mounds at Newburg, Maryland, and the Aboriginal Shellfields of the Potomac and Wicomico Rivers. International Congress of Americanists, Proceedings 5:292-314. Copenhagen.

1883b On the Aboriginal Shell Heaps at Pope's Creek, Maryland. Smithsonian Miscellaneous Collections 25(4):23.

1889 The Shell Mounds of the Potomac and Wicomico. American Anthropologist 2:252-259.

Rhoads, D.C., and G. Panella
1970 The Use of Molluscan Shell Growth Patterns in Ecology and Paleoecology. Lethaia 3:143-161.

Rice, Marshal
1971 Shell Middens. Maine Archaeological Society Bulletin 11(2): 4-7.

Ritchie, William A.
1969 The Archaeology of Martha's Vineyard. Natural History Press, Garden City, New York.

Roberts, Mervin F.
1979 The Tidemarsh Guide. E.P. Dutton, New York.

Robertshaw, P.T.
1978 Archaeological Investigations at Langebaan Lagoon, Cape Province. Palaeoecology of Africa 10:139-154.

Roche, Jean
1960 Le Gisement Mesolithique de Moita do Sebastae (Muge, Portugal). Instituto de Alta Cultura I.

1965 Donnees recentes sur la stratigraphie et la chronologie des amas coquilliers d'age mesolithique de Muge (Portugal). Quaternaria 7:155-164.

1972 Les Amas Coquilliers (CONCHEROS) Mesolithiques de Muge (Portugal). In Die Anfange des Neolithikums vom Orient bis Nord-Europa, VII, edited by J. Luning, pp. 72-107. Cologne.

Rostlund, Erhard
1952 Freshwater Fish and Fishing in Native North America. University of California, Publications in Geography IX.

Rothschild, Nan, and Lucianne Lavin
1977 The Kaeser Site: A Stratified Shell Midden in the Bronx, New York. New York State Archaeological Association, Bulletin 70:1-26.

Rowe, J.H.
1940 Excavations in the Waterside Shell Heap, Frenchman's Bay, Maine. Harvard University, Excavator's Club, Papers 1(3).

Rozoy, J.-G.
1978 Les Derniers Chasseurs: L'Epipaleolithique en France et Belgique. 2 volumes and atlas, Bulletins de la Societe Archeologique Champenois, Reims.

Ruppe, Reynold J.
1980 The Archaeology of Drowned Terrestrial Sites: A Preliminary Report. Florida Bureau of Historic Sites and Properties, Bulletin 6:35-45.

Ruppe, Tricia A.
1980 Analysis of the Mollusks from the Venice Site. Florida Bureau of Historic Sites and Properties, Bulletin 6:61-69.

Rye, Danny M., and Michael A. Sommer II
1980 Reconstructing Paleotemperature and Paleosalinity Regimes with Oxygen Isotopes. In Skeletal Growth of Aquatic Organisms, edited by D.C. Rhoads and R.A. Lutz, pp. 169-202. Plenum Press, New York.

Salwen, Bert
1965 Sea Levels and the Archaic Archaeology of the Northeast Coast of the United States. Ph.D. dissertation, Department of Anthropology, Columbia University. University Microfilms International 65-13,990.

1968 Muskeeta Cove 2: A Stratified Woodland Site on Long Island. American Antiquity 33(3):322-340.

1970 Cultural Inferences from Faunal Remains: Examples from Three Northeast Coastal Sites. Pennsylvania Archaeologist 40(1-2): 1-8.

Sambol, Melvin, and Robert M. Finks
1977 Natural Selection in a Cretaceous Oyster. Paleobiology 3: 1-16.

Sanger, David
1980 Coastal Archaeology and Site Loss in Maine. Western Washington University, Proceedings of the Coastal Archaeology Session at Newport, Rhode Island, pp. 8-12.

1981 Unscrambling Messages in the Midden. Archaeology of Eastern North America 9:37-42.

Sawbridge, David F., and M. Bell
1972 Vegetation and Soils of Shell Middens on the Coast of British Columbia. Ecology 53(5):840-848.

Schaaf, Jeanne M.
1981 A Method for Reliable and Quantifiable Subsampling of Archaeological Features for Flotation. Midcontinental Journal of Archaeology 6(2):219-248.

Schmitt, Karl, Jr.
1965 Patawomeke: An Historic Algonkian Site. Archeological Society of Virginia, Quarterly Bulletin 20(1):1-36.

Schoeninger, Margaret J., and Christopher S. Peebles
1981 Effect of Mollusc Eating on Human Bone Strontium Levels. Journal of Archaeological Science 8(4):391-397.

Schoute-Vanneck, C.A.
1960 A Chemical Aid for the Relative Dating of Coastal Shell Middens. South African Journal of Science 56(3):67-70.

Sears, William H.
1960 The Bayshore Homes Site, St. Petersburg, Florida. Contributions of the Florida State Museum, Social Sciences 6.

1963 The Tucker Site on Alligator Harbor, Franklin County, Florida. Contributions of the Florida State Museum, Social Sciences 9.

Segraves, B. Abbott
1974 Ecological Generalization and Structural Transformation of Sociocultural Systems. American Anthropologist 76:530-552.

Serrano, Antonio
1946 The Sambaquis of the Brazilian Coast. In "Handbook of South American Indians," edited by J.H. Steward, Smithsonian Institution, Bureau of American Ethnology, Bulletin 143(1): 401-407.

Severinghaus, C.W.
1949 Tooth Development and Wear as Criteria of Age in White-tailed Deer. Journal of Wildlife Management 13(2):195-216.

Shawcross, Wilfred
1967 An Investigation of Prehistoric Diet and Economy on a Coastal Site at Galatea Bay, New Zealand. Proceedings of the Prehistoric Society 33(7):107-131.

1972 Energy and Ecology: Thermodynamic Models in Archaeology. In Models in Archaeology, edited by D.L. Clarke, pp. 577-622. Methuen, London.

1975 Some Studies of the Influences of Prehistoric Human Predation on Marine Animal Population Dynamics. In Maritime Adaptations of the Pacific, edited by R.W. Casteel and G.I. Quimby, pp. 39-66.

Shenkel, J. Richard
1971 Cultural Adaptation to the Mollusk: A Methodological Survey of Shellmound Archaeology and a Consideration of the Shellmounds of the Marismas Nacionales, West Mexico. Ph.D. dissertation, State University of New York, Buffalo. University Microfilms International 71-22,599.

1974 Quantitative Analysis and Population Estimates of the Shell Mounds of the Marismas Nacionales, West Mexico. In The Archaeology of West Mexico, edited by Betty Bell, pp. 57-67.

Shimizu, Yuzuru, and Masako Yoshioka
1981 Transformation of Paralytic Shellfish Toxins as Demonstrated in Scallop Homogenates. Science 212:547-549.

Shotwell, J. Arnold
1955 An Approach to the Paleoecology of Mammals. Ecology 36(2): 327-337.

Shumway, George, Carl L. Hubbs, and James R. Moriarty
1961 Scripps Estates Site, San Diego, California: A La Jolla Site Dated 5460 to 7370 Years Before the Present. New York Academy of Science, Annals 93(3):37-132.

Simpkins, Daniel L.
1975 A Preliminary Report on Test Excavations at the Sapelo Island Shell Ring, 1975. Early Georgia 3(2):15-37.

Smith, Carlyle S.
1950 The Archaeology of Coastal New York. American Museum of Natural History, Anthropological Papers 43(2).

Smith, Harlan I.
1909 Shell Heaps of the Lower Fraser River, B.C. Memoirs of the American Museum of Natural History 4(4):133-191.

______, and W.J. Wintemberg
1929 Some Shell-heaps in Nova Scotia. National Museum of Canada, Bulletin 47.

Smith, Ira F., III
1979 Early Smoking Pipes in the Susquehanna River Valley. Pennsylvania Archaeologist 49(4):9-23.

Snow, Dean R.
1972 Rising Sea Level and Prehistoric Cultural Ecology in Northern New England. American Antiquity 37(2):211-221.

1978 Late Prehistory of the East Coast. Handbook of North American Indians, volume 15 (Northeast):58-69. Smithsonian Institution, Washington, D.C.

Solheim, Wilhelm G., II
1981 On Maritime Hunting and Gathering. Current Anthropology 22(1):84.

Sordinas, A.
1969 Investigations of the Prehistory of Corfu During 1964-1966. Balkan Studies 10:393-424.

Speck, Frank G., and Ralph W. Dexter
1948 Utilization of Marine Life by the Wampanoag Indians of Massachusetts. Journal of the Washington Academy of Sciences 38:257-265.

Speed, Elizabeth
1969 Prehistoric Shell Collectors. South African Archaeological Bulletin 24(3-4):193-196.

Stark, Barbara L.
1974 Patarata Island, Veracruz, Mexico and the Role of Estuarine Mangrove Swamps in Ancient Mesoamerica. Ph.D. dissertation, Department of Anthropology, Yale University. University Microfilms International 75-1347.

______, and Barbara Voorhies
1978 Future Research Directions. In Prehistoric Coastal Adaptations: The Economy and Ecology of Maritime Middle America, edited by B.L. Stark and B. Voorhies, pp. 275-304. Academic Press, New York.

Statham, E.J.
1892 Observations of Shell-Heaps and Shell-Beds. Journal of the Royal Society of New South Wales 26:304-314.

Stearns, Richard E.
1943 Some Indian Village Sites of Tidewater Maryland. Natural History Society of Maryland, Proceedings 9.

Stein, Julie K.
1980 Geoarchaeology of the Green River Shell Mounds, Kentucky. Ph.D. dissertation, University of Minnesota. University Microfilms International 81-02166.

Steneck, R.S., R.A. Lutz, and R.M. Cerrato
1978 Abstract: Age and Morphometric Variation in Subtidal Populations of Mussels. National Shellfisheries Association, Proceedings 68:86-87.

Stenzel, H.B.
1971 Oysters. In Treatise on Invertebrate Paleontology, Part N (Bivalvia): Volume 3 (Molluscs 6), edited by R.C. Moore, pp. N953-N1224. University of Kansas, Lawrence.

Stephenson, Robert L., and Alice L.L. Ferguson
1963 The Accokeek Creek Site: A Middle Atlantic Seaboard Culture Sequence. University of Michigan, Museum of Anthropology, Anthropological Papers 20.

Steponaitis, Laurie Cameron
1980 A Survey of Artifact Collections from the Patuxent River Drainage, Maryland. Maryland Historical Trust, Monograph Series 1.

Stewart, Omer C.
1943 Notes on Pomo Ethnogeography. University of California Press, Berkeley and Los Angeles. HRAF NS18.

Stewart, Robert E., and Chandler S. Robbins
1958 Birds of Maryland and the District of Columbia. United States Bureau of Sport Fisheries and Wildlife, North American Fauna 62.

Stockton, Eugene D.
1973 Shaw's Creek Shelter: Human Displacement of Artefacts and its Significance. Mankind 9(2):112-117.

Stoltman, James B.
1974 Groton Plantation: An Archaeological Survey of a South Carolina Locality. Monographs of the Peabody Museum 1.

Straus, L.G., and G.A. Clark
1978 Prehistoric Investigations in Cantabrian Spain. Journal of Field Archaeology 5(3):289-317.

Straus, L.G., J. Altuna, G.A. Clark, M. Gonzalez Morales, H. Laville, A. Leroi-Gourhan, M. Menendez de la Hoz, and J.A. Ortea
1981 Paleoecology at La Riera (Asturias, Spain). Current Anthropology 22(6):655-682.

Straus, L.G., G.A. Clark, J. Altuna, and J. Ortea
1980 Ice-Age Subsistence in Northern Spain. Scientific American 242(6):142-153.

Stuart, David E.
1977 Seasonal Phases in Ona Subsistence, Territorial Distribution and Organization. In For Theory Building in Archaeology, edited by L.R. Binford, pp. 251-283. Academic Press, New York.

Stuiver, Minze, and H.W. Borns, Jr.
1975 Late Quaternary Marine Invasion in Maine. Geological Society of America Bulletin 86:99-103

Suttles, Wayne
1968 Coping with Abundance: Subsistence on the Northwest Coast. In Man the Hunter, edited by R.B. Lee and I. DeVore, pp. 56-68. Aldine-Atherton, Chicago.

Swadling, Pamela
1972 Shellfish Gathering in Prehistoric New Zealand. Unpublished Master's thesis, Department of Anthropology, University of Otago.

1976 Changes Induced by Human Exploitation in Prehistoric Shellfish Populations. Mankind 10(3):156-162.

1977 The Implications of Shellfish Exploitation for New Zealand Prehistory. Mankind 11(1):11-18.

Swanton, John R.
1946 Indians of the Southeastern United States. Bureau of American Ethnology, Bulletin 137.

Taira, Kazuhiro
1980 Radiocarbon Dating of Shell Middens and Holocene Sea-Level Fluctuations in Japan. Palaeogeography, Palaeoclimatology, Palaeoecology 32(1-2):79-87.

Tait, Lawson
1869 Note on the Shell-Mounds of Sutherland. Society of Antiquarians of Scotland, Proceedings 8(1):63-64.

Tartaglia, Louis J.
1976 Prehistoric Maritime Adaptations in Southern California. Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles. University Microfilms International 76-15,962.

1980 Late Period Site Catchments in Southern California. Anthropology UCLA 10(1&2):179-192.

Taylor, A.J.
1892 Notes on the Shell-Mounds at Seaford, Little Swanport. Royal Society of Tasmania, Papers and Proceedings for 1891:89-94.

Terrell, J.
1967 Galatea Bay: The Excavation of [illegible]ach-Stream Midden Site on Ponui Island in the Hauraki [illegible] New Zealand. Transactions of the Royal Societ[illegible] New Zealand 2(3):31-70.

Thomas, David H., and C.S. Larsen
1979 The Anthropology of St. Catherines Island, 2: The Refuge-Deptford Mortuary Complex. American Museum of Natural History, Anthropological Papers 56(1):161-179.

Thomas, K.D.
1978 Population Studies on Molluscs in Relation to Environmental Archaeology. In "Research Problems in Zooarchaeology," edited by D.R. Brothwell, K.D. Thomas and J. Clutton-Brock, pp. 9-18. University of London, Institute of Archaeology, Occasional Publication 3.

Thomas, Ronald A., and Nancy H. Warren
1970 A Middle Woodland Cemetery in Central Delaware: Excavations at the Island Field Site. Archaeological Society of Delaware, Bulletin 8.

Tite, M.S.
1972 Methods of Physical Examination in Archaeology. Seminar Press, London.

Toots, H.
1965 Sequence of Disarticulation in Mammalian Skeletons. University of Wyoming, Contributions in Geology 4:37-39.

Treganza, A.E., and Sherburne F. Cook
1948 The Quantitative Investigation of Aboriginal Sites: Complete Excavation with Physical and Archaeological Analysis of a Single Mound. American Antiquity 13(4):287-297.

Trinkley, Michael
1975 Preliminary Report of Archaeological Excavations at Lighthouse Point Shell Ring, South Carolina. Southern Indian Studies 27:2-36.

1976 Paleoethnobotanical Remains from Archaic-Woodland Transitional Shell Middens Along the South Carolina Coast. Southeastern Archaeological Conference Bulletin 19:64-67.

1980 Investigation of the Woodland Period Along the South Carolina Coast. Ph.D. dissertation, Department of Anthropology, University of North Carolina. University Microfilms International 80-22,517.

_______, and H. Trawick Ward
1978 The Use of Soil Science at a South Carolina Thom's Creek Culture Shell Ring. Florida Anthropologist 31(2):64-73.

Troels-Smith, J.
1967 The Ertebolle Culture and its Background. Paleohistoria 12:505-528.

Turnbaugh, William A., and Thomas H. Keifer
1979 Chemical Variation in Selected Soapstone Quarries of Southern New England. Man in the Northeast 18:32-47.

Turner, E. Randolph
1976 An Archaeological and Ethnohistorical Study on the Evolution of Rank Societies in the Virginia Coastal Plain. Ph.D. dissertation, Department of Anthropology, Pennsylvania State University. University Microfilms International 77-9745.

Uhle, Max
1907 The Emeryville Shellmound. University of California Publications, American Archaeology and Ethnology 7(1).

Vanuxem, Lardner
1843 On the Ancient Oyster Shell Deposits Observed Near the Atlantic Coast of the United States. Report of the 1st, 2nd, and 3rd Meetings of the Association of American Geologists and Naturalists:21-23.

Voigt, Elizabeth
1973 Stone Age Molluscan Utilization at Klasies River Mouth Caves. South African Journal of Science 69(10):306-309.

1975 Studies of Marine Mollusca from Archaeological Sites. In Archaeozoological Studies, edited by A.T. Clason, pp. 87-98. North-Holland/American Elsevier, Amsterdam.

Volman, Thomas P.
1978 Early Archeological Evidence for Shellfish Collecting. Science 201:911-913.

Voorhies, Barbara
1976 Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico. New World Archaeological Foundation, Paper 41.

Wagner, Gail E.
1982 Testing Flotation Recovery Rates. American Antiquity 47(1):127-132.

Walker, S.T.
1883 The Aborigines of Florida. Smithsonian Institution, Annual Report for 1881:677-680.

Wallace, Rod
1976 A Method for Determining Shell Size from Fragments. New Zealand Archaeological Association Newsletter 19(4):180-183.

Waring, Antonio J., Jr., and Lewis H. Larson, Jr.
1977 The Shell Ring on Sapelo Island. In "The Waring Papers," edited by Stephen Williams, revised edition. Peabody Museum of Archaeology and Ethnology, Papers 58:263-273.

Warner, W. Lloyd
1937 A Black Civilization: A Social Study of an Australian Tribe. Harper, New York. HRAF OI 17.

Warner, William W.
1976 Beautiful Swimmers: Watermen, Crabs and the Chesapeake Bay. Penguin, Harmondsworth, England.

Warren, C.N., and N.G. Pavesic
1963 Shell Midden Analysis of Site Sdi-603 and Ecological Implications for Cultural Development of Batiquitos Lagoon, San Diego County, California. University of California Archaeological Survey Annual Report, 1962-63:407-438.

Warren, Robert E.
1975 Prehistoric Unionacean (Freshwater Mussel) Utilization at the Widows Creek Site (1 JA 305), Northeast Alabama. Master's thesis, Department of Anthropology, University of Nebraska, Lincoln.

Waselkov, Gregory A.
1978 Evolution of Deer Hunting in the Eastern Woodlands. Mid-continental Journal of Archaeology 3(1):15-34.

1982 Appendix 4: Analysis of Faunal Remains. In An Analysis of Chicacoan Settlement Patterns, by Stephen R. Potter, pp. 383-389. Ph.D. dissertation, Department of Anthropology, University of North Carolina.

Waterbolk, H.T.
1968 Food Production in Prehistoric Europe. Science 162:1093-1102.

Watson, J.P.N.
1979 The Estimation of the Relative Frequencies of Mammalian Species: Khirokitia 1972. Journal of Archaeological Science 6:127-137.

Watt, Bernice K., and Annabel L. Merrill
1963 Composition of Foods: Raw, Processed, Prepared. United States Department of Agriculture, Agriculture Handbook 8.

Webb, William S.
1946 Indian Knoll, Site OH 2, Ohio County, Kentucky. University of Kentucky, Reports in Anthropology and Archaeology 4(3) Part 1:115-365.

1950a The Carlson Annis Mound: Site 5, Butler County, Kentucky. University of Kentucky, Reports in Anthropology VII(4).

1950b The Read Shell Midden. University of Kentucky Reports in Anthropology and Archaeology 7(5).

_______, and David L. DeJarnette
1942 An Archeological Survey of Pickwick Basin in the Adjacent Portions of the States of Alabama, Mississippi, and Tennessee. Bureau of American Ethnology, Bulletin 129.

1948a Little Bear Creek Site, Ct°8. Alabama Museum of Natural History, Museum Paper 26.

1948b The Perry Site, LU°25. Alabama Museum of Natural History, Museum Paper 25.

Weide, M.L.
1969 Seasonality of Pismo Clam Collecting at Ora-82. University of California, Archaeological Survey, Annual Report 11: 127-142.

Weslager, C.A.
1939 An Aboriginal Shell Heap Near Lewes, Delaware. Archaeological Society of Delaware Bulletin 3(2):3-8.

1941 Shell Heaps of the Delmarva Peninsula. Pennsylvania Archaeologist 11(1):17-24.

Wharton, James
1957 The Bounty of the Chesapeake: Fishing in Colonial Virginia. Virginia 350th Anniversary Celebration Corporation, Williamsburg, Virginia.

Whelan, J. Patrick
1967 A Partial Faunal Analysis of 4-ALA-12 and 13, Two San Francisco Bay Shellmounds. Department of Anthropology, San Francisco State College Occasional Papers in Anthropology 3.

White, Theodore E.
1953 A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. American Antiquity 18(4):396-398.

Whitehouse, David, and Ruth Whitehouse
1975 Archaeological Atlas of the World. W.H. Freeman, San Francisco.

Whitehouse, Ruth D.
1968 Settlement and Economy in Southern Italy in the Neothermal Period. Proceedings of the Prehistoric Society 38:332-367.

Whitlam, Robert G.
1981 Settlement-Subsistence System Type Occurrence and Change in Coastal Environments. Ph.D. dissertation, Department of Anthropology, University of Washington. University Microfilms International 81-13481.

Wilke, Steve, and Gail Thompson
1977 Prehistoric Archeological Resources in the Maryland Coastal Zone. Maryland Department of Natural Resources, Coastal Zone Administration.

Will, Richard T.
1976 Shell Heaps: An Environmental and Cultural Interpretation. Man in the Northeast 12:70-80.

Willey, Gordon R.
1949 Archeology of the Florida Gulf Coast. Smithsonian Institution, Miscellaneous Collections 113.

______, and C.R. McGimsey
1954 The Monagrillo Culture of Panama. Harvard University, Peabody Museum, Papers 49(2).

Wing, Elizabeth S.
1963 Vertebrates from the Jungerman and Goodman Sites. Florida State Museum, Social Sciences, Contribution 10:51-60.

1977 Subsistence Systems in the Southeast. Florida Anthropologist 30(2):81-87.

______, and Antoinette B. Brown
1979 Paleonutrition. Academic Press, New York.

Wintemburg, W.J.
1929 The Eisenhower Shell-heap, Mahone Bay, Nova Scotia. National Museum of Canada, Bulletin 47.

Winters, Howard D.
1969 The Riverton Culture. Illinois State Museum, Report of Investigations 13, Illinois Archaeological Survey, Monograph 1.

1974 Introduction to the New Edition. In Indian Knoll, by William S. Webb, pp. v-xxvii. University of Tennessee Press, Knoxville.

Wobst, H. Martin
1976 Locational Relationships in Paleolithic Society. Journal of Human Evolution 5(1):49-58.

Wright, Henry T.
1973 An Archeological Sequence in the Middle Chesapeake Region, Maryland. Maryland Geological Survey, Archeological Studies 1.

Wright, Louis B., and Virginia Freund, editors
1953 The Historie of Travell into Virginia Britania, by William Strachey. Hakluyt Society, Second Series, 103.

Wyman, Jeffries
1868a An Account of Some Kjockkenmoeddings or Shell-Heaps in Maine and Massachusetts. American Naturalist I:561-584.

1868b On the Fresh-Water Shell-Heaps of the St. Johns River, East Florida. American Naturalist II:393-403, 449-463.

1875 Fresh-water Shellmounds of the St. Johns River, Florida. Peabody Academy of Science, Memoir 1(4):1-94.

Yamazaki, S.
1975 Various Problems in the Study of Shellmounds in the Kyushu Region, Kyushu Kokogaku no Shomondai, edited by Fukuoka, Kokogaku, Kenkyukai, and Azuma, pp. 131-165. Tokyo.

Yellen, John E.
1977a Archaeological Approaches to the Present. Academic Press, New York.

1977b Cultural Patterning in Faunal Remains: Evidence from the !Kung Bushman. In Experimental Archeology, edited by D. Ingersoll, J.E. Yellen, and W. MacDonald, pp. 271-331. Columbia University Press, New York.

Yesner, David R.
1978 Animal Bones and Human Behavior. Reviews in Anthropology 5:333-355.

1980 Maritime Hunter-Gatherers: Ecology and Prehistory. Current Anthropology 21(6):727-750.

1981 Reply to G.A. Clark's "On Preagricultural Coastal Adaptations." Current Anthropology 22(4):445-446.