
# THE INDIAN NECK OSSUARY

## Chapters in the Archeology of Cape Cod, V

Cultural Resources Management Study No. 17

Division of Cultural Resources
North Atlantic Regional Office
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Cover Illustration: Part I, Figure 10

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Francis P. McManamon, James W. Bradley and Ann L. Magennis

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Boston, Massachusetts

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# EDITOR'S PREFACE AND ACKNOWLEDGEMENTS

The surpising discovery of an ossuary on Indian Neck, the salvage of a substantial body of archeological and physical anthropological data from it, and the presentation of interpretations of these data here have been possible only through the efforts and assistance of many individuals.

Without the patience of William and Rita Connelly of South Glastonbury, Connecticut and their generous permission to excavate the burial, none of this would have been possible. Only supreme effort throughout long, attentive hours of work by the crew of Jim Bradley, Helen Delano, Gene Ham, Annie Harlow, Susan LoGuidice, and Tom Mahlstedt permitted the careful recovery and recording of the burial feature. The burial was uncovered one day and completely removed the next! Obviously corners had to be cut to accommodate such a schedule, but many data were recovered effectively despite the short time.

Such a smooth and timely response to the discovery would have been impossible without the cooperation of the Superintendent of Cape Cod National Seashore, Herb Olsen, then - State Archeologist Valerie Talmage, and Executive Director of the Massachusetts Commission on Indian Affairs John Peters. During the excavation John Portnoy and Mike Soukup, National Park Service biologists lent their time and energy to sift the backhoe backdirt and added importantly to the artifact and skeletal sample from the site.

The most important information to come out of this discovery comes from the physical anthropological work. George Armelagos initiated this work and supported it at the University of Massachusetts at Amherst. Without Ann Magennis' careful, detailed description, analysis, and interpretation, we would know far, far less than we do about the burial population and, by extension, their contemporaries. Ann has my special thanks for her extra efforts in producing this volume and her part in it.

Irene Duff typed and proofread several versions of the preliminary report on the ossuary and recently Toni Lo Coco has done the same for Part I. Without their skillful work and care for the project, this volume would not exist physically. Tom Mahlstedt drafted the figures in Part I. Tom's research on ossuaries reported from other areas, which was part of the preliminary report, helped Jim Bradley and me formulate some of the ideas in Part I. George Stillson quickly and efficiently prepared the cover and title page designs.

During the summer of 1985 most of the skeletal remains were turned over to the Massachusetts Commission on Indian Affairs for reinterment. Reburial occurred as part of an agreement made at the time of the initial discovery between the Commission on Indian Affairs and the State Archaeologist at the Massachusetts Historical Commission. This agreement stipulated the conditions under which salvage and any subsequent analysis would take place. It was agreed that one year would be set aside for detailed study of the remains, after which they would be returned to the Commission on Indian Affairs for reburial. In the end, it took over six years to complete the analysis.

The topic of reinterment of remains is controversial among Indians, archeologists, physical anthropologists, and, increasingly, politicians and the general public. I doubt that the three authors of this volume could agree completely on the reinterment of the ossuary remains, so I shall speak my own piece on this outcome.

I think it is very unfortunate that these remains were reinterred at this time. The ossuary skeletal population was a unique resource for viewing the prehistory of New England which includes the heritage and history of native peoples in New England. Magennis' report provides a wealth of detail on the remains. Her interpretations contain information unavailable from other sources that we have. Good as Ann's report is, there are more detailed studies that could be done; as new techniques of analysis are developed, even more information might have been obtained.

The ossuary skeletal population was by far the largest, best provenienced, and best excavated collection that existed for New England. In future considerations of reinterment, let us hope that the Native American community, archeologists and anthropologists, and public officials charged with making the decisions can reach an agreement that avoids the loss of such an important public resource.

Francis P. McManamon
Boston, Massachusetts
3 July 1986

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# PART I

# THE INDIAN NECK OSSUARY AND LATE WOODLAND PREHISTORY IN SOUTHERN NEW ENGLAND

The Indian Neck Ossuary and Late Woodland Prehistory in Southern New England

Francis P. McManamon and James W. Bradley

## Introduction

In September 1979 archeologists working on a survey of Cape Cod National Seashore were called to the scene of a discovery of a skeleton on Indian Neck near the shore of Wellfleet Harbor in Wellfleet, Massachusetts (Figure 1). A backhoe operator excavating a large hole for a spectic tank had unearthed some human skeletal material. The archeologists quickly determined that the skeletons probably were prehistoric. In order to salvage the remains before they were destroyed completely by further backhoe excavations, it was agreed that the Park Service archeologists would excavate the remaining in situ materials. Archeological excavations commenced at the beginning of the following week and after two days of careful fieldwork an unexpected, but intriguing, burial feature had been uncovered.

The burial that the backhoe had discovered turned out to be neither a single burial, nor a cemetery made up of a series of single burials, but a multiple, secondary interment known technically as an ossuary. The burial feature was composed of a thick layer of unburned and disarticulated human skeletal material about 40 centimeters below the ground surface. Beneath this bone layer was another layer of human bone that had been burned intensely as part of a cremation.

The burial feature was overlain by a Late Woodland and Contact period midden (Bradley et al. 1982). The midden was covered by 5-10 cm of topsoil and sand (Figure 2). The midden had a dark, organic soil matrix with shell, a small amount of animal bone, lithic debris, and pottery embedded in the matrix (Figures 3 and 4). The few diagnostic lithics recovered suggest a Late Woodland date for the midden (Figure 5). The highly fragmented pottery remains (Figure 6) provide no specific chronological information, but are not inconsistent with a Late Woodland date. A fragment of sheet metal recovered in the upper portion of the midden (Figure 7) implies that at least a part of the deposit was laid down after European contact, i.e., probably post-1500. A detailed analysis of this piece confirming its European manufacture is presented in Childs (1986).

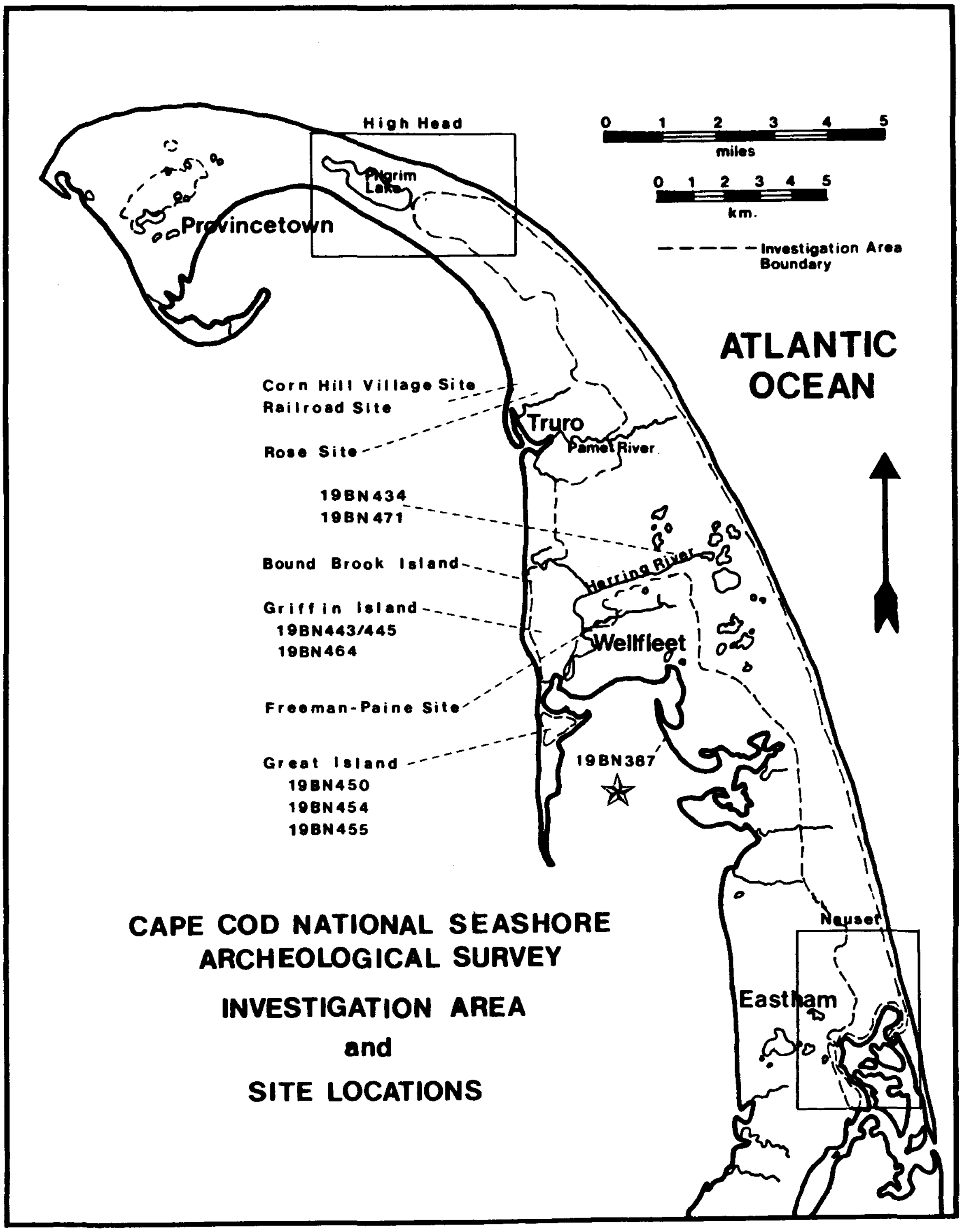


FIGURE 1. General Location of Prehistoric Sites on the Bayside of the Outer Cape, Including the Indian Neck Ossuary (19BN387, Starred).

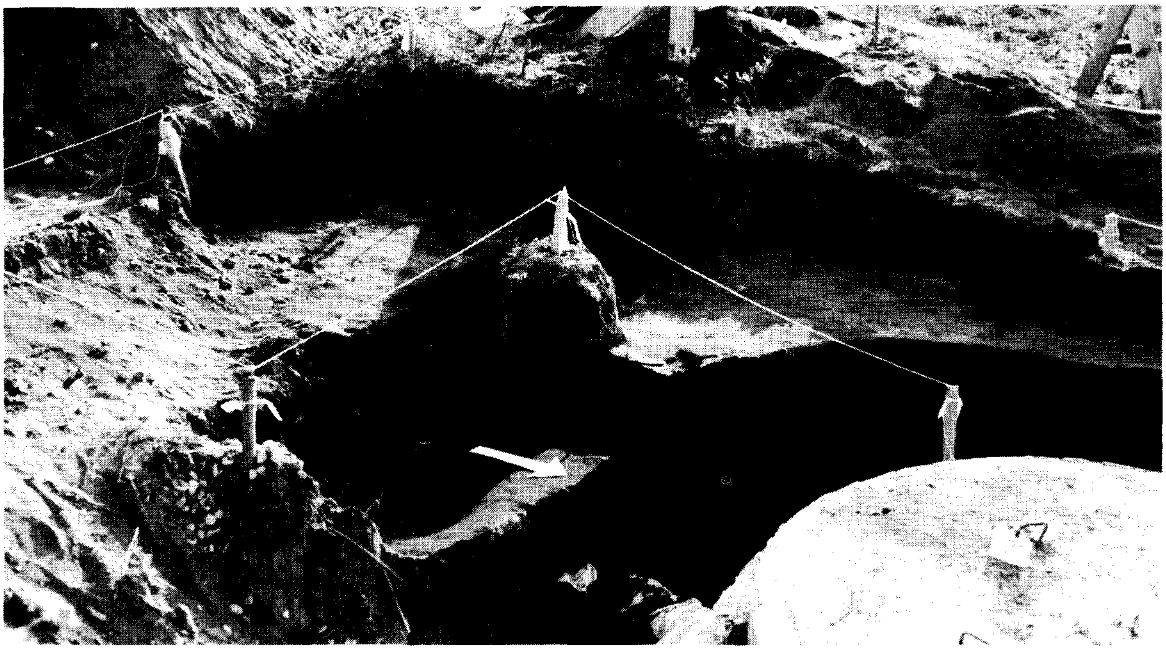

FIGURE 2. View From the Northeast of the Top of the Late Woodland - Contact Midden Covering the Ossuary.

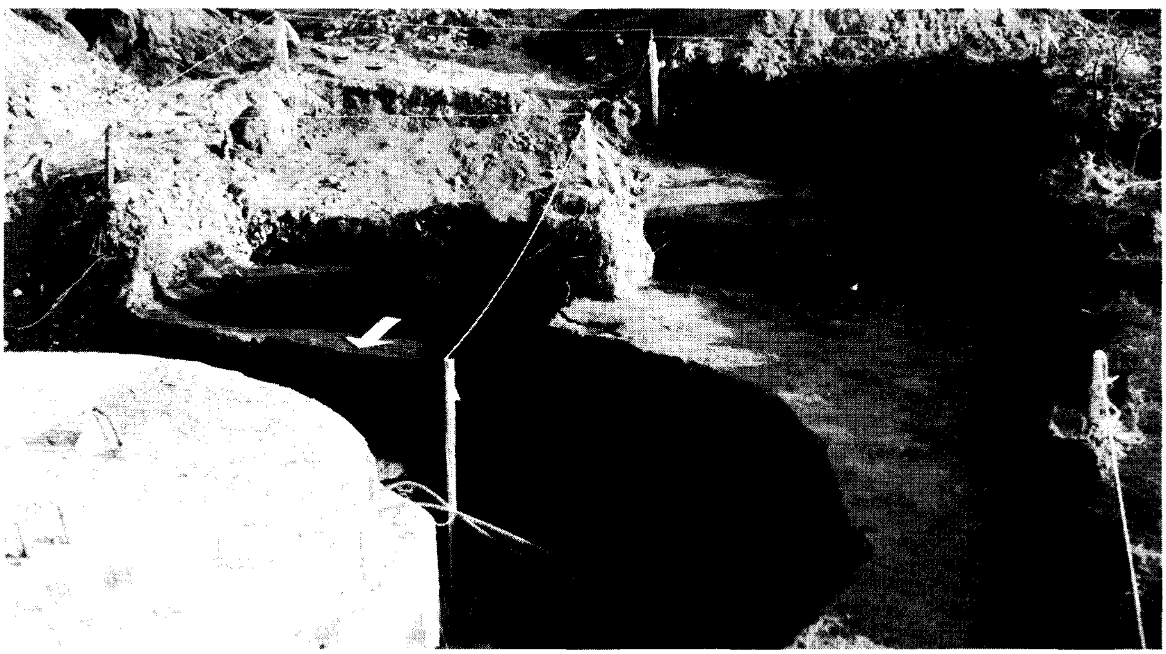

FIGURE 3. View From the North of the Excavation of the Midden. Note the Shell Visible in the Top and the Profile of the Midden.

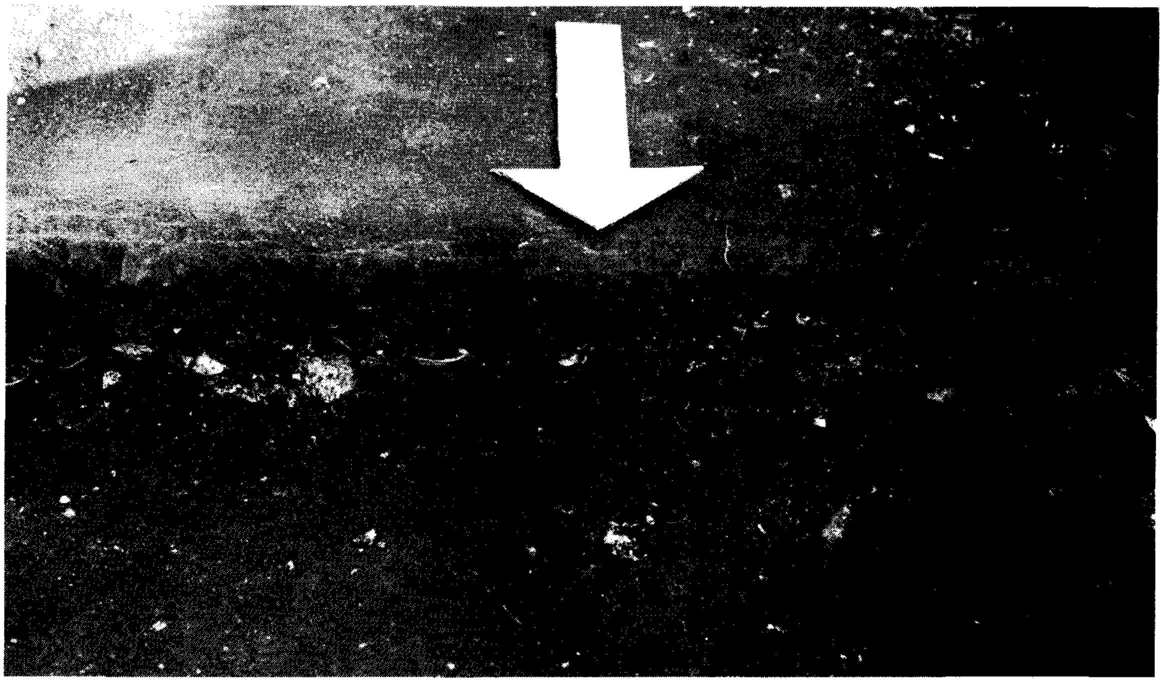

FIGURE 4. Detail of the Top of the Midden.

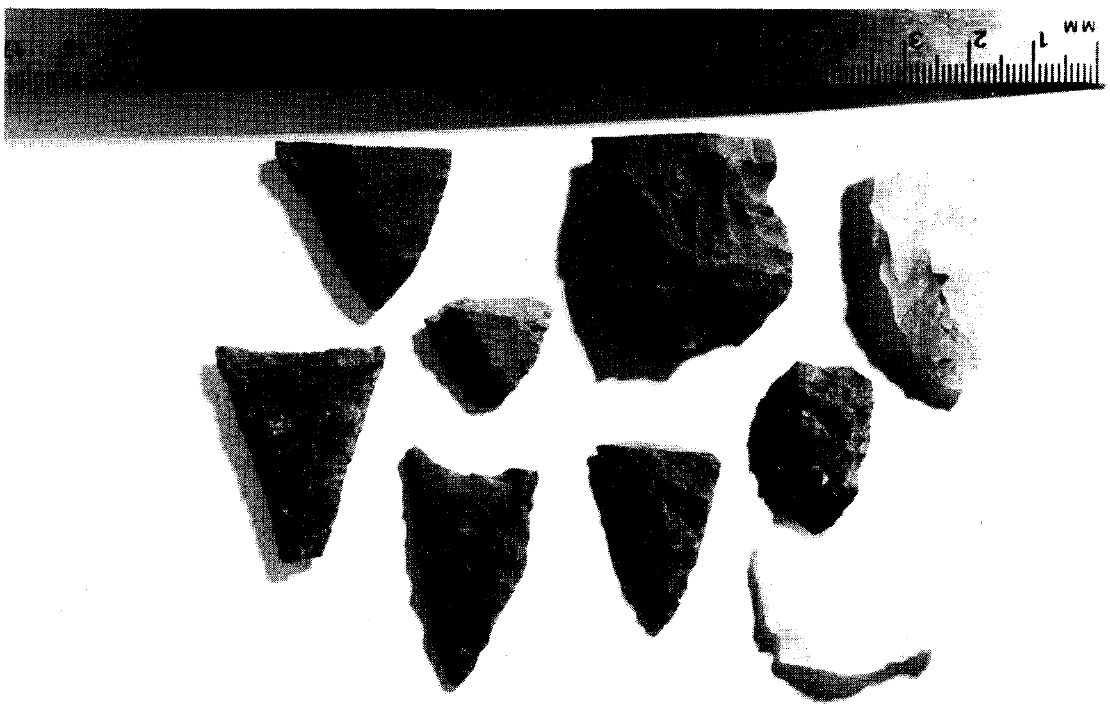

FIGURE 5. Points and Other Bifaces From the Midden.

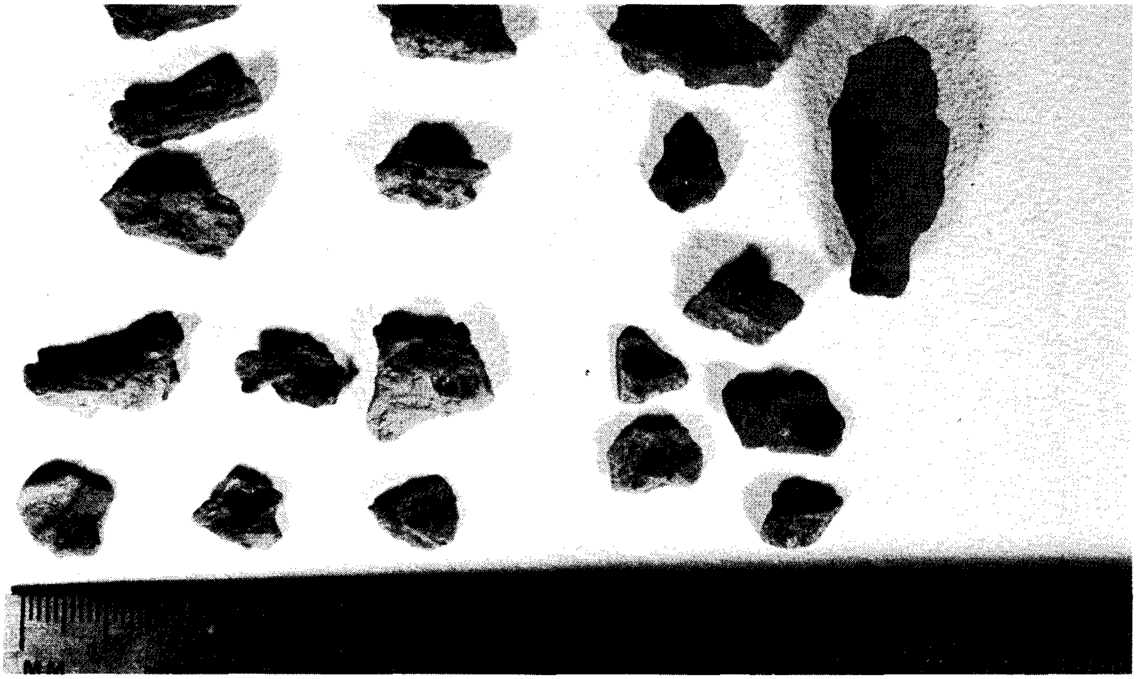

FIGURE 6. Pottery Sherds From the Midden.

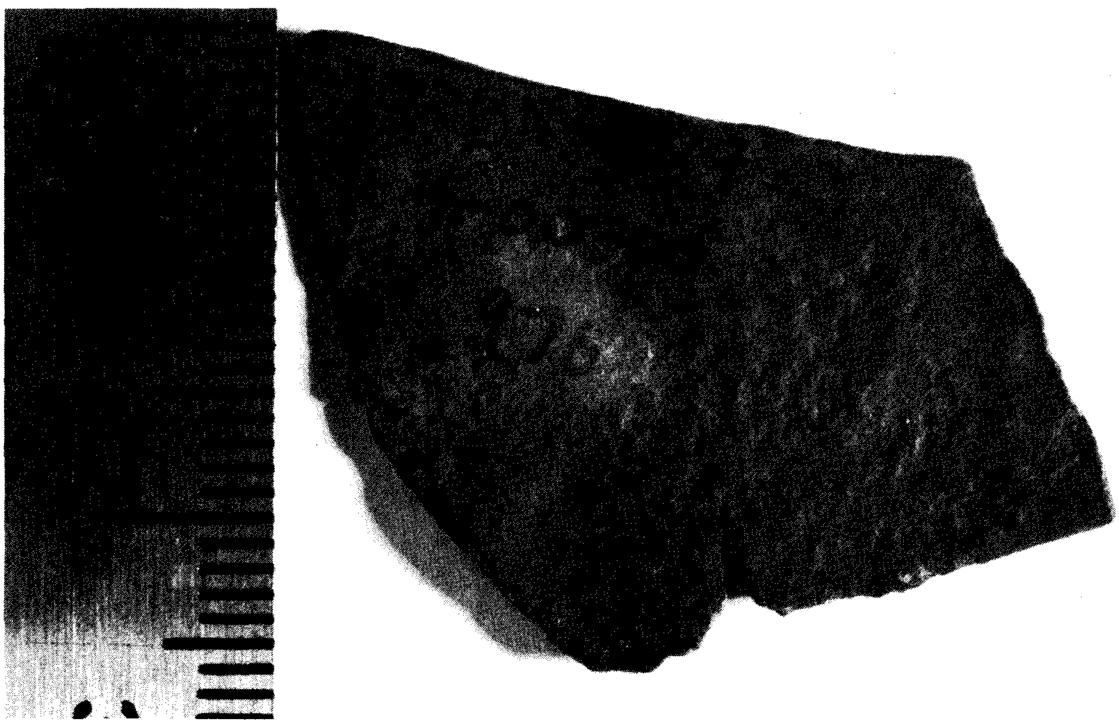

FIGURE 7. European-Manufactured Sheet Metal From the Midden.

Our aim here is focused on the burial feature; we shall first describe the unusual burial discovered below the midden. It is one of two well-documented examples of ossuaries in the Northeast outside of northwestern New York State and adjacent Canada and the Potomac-Chesapeake area (The other site is the Archery Range Site ossuary in Bronx County, New York, excavated by Edward Kaeser in 1959 and reported by Kaeser [1970]). Following the description, information summarized from Ann Magennis' detailed physical anthropological investigation of the skeletal remains (see Part II of this volume) will be used to make inferences about the demography and health of the prehistoric Native American population represented by the burial population. Then, the last sections of this part will consider inferences that can be made about the settlement system and other aspects of Late Woodland cultural adaptation given the existence of the ossuary and considering other archeological data available from outer Cape Cod.

## The Burial Feature

### The Unburned Bone Layer

The upper and larger component of the ossuary was a concentration of disarticulated and semi-articulated skeletal remains. The burial feature emerged gradually after the lowest level of the midden had been removed and a sterile layer of mottled soil encountered. As this mottled layer was removed carefully, the top of the burial feature began to appear (Figures 8 and 9). Due to the extreme rarity of ossuaries in this part of the Northeast, the appearance of this one was a bit of a shock. Fortunately, copies of Ubelaker's works (1974, 1978) on human remains, which contain many illustrations of ossuaries, were at hand. After reassuring ourselves of what we were dealing with, we proceeded with the excavation.

The ossuary lay at a depth of between 33.5 cm and 70 cm below the surface. The general appearance of this level was that of a mounded, semi-chaotic pile. Though the original shape probably was oval with the long axis north-south, the deposit had been truncated by the backhoe. The remaining undisturbed portion, estimated to be about half of the original feature, included the southern end of the oval and measured approximately 120 cm on both its east-west and north-south axes (Figure 10). The backhoe appeared to have cut through the bone concentration at or near its maximum thickness, which was about 30 cm.

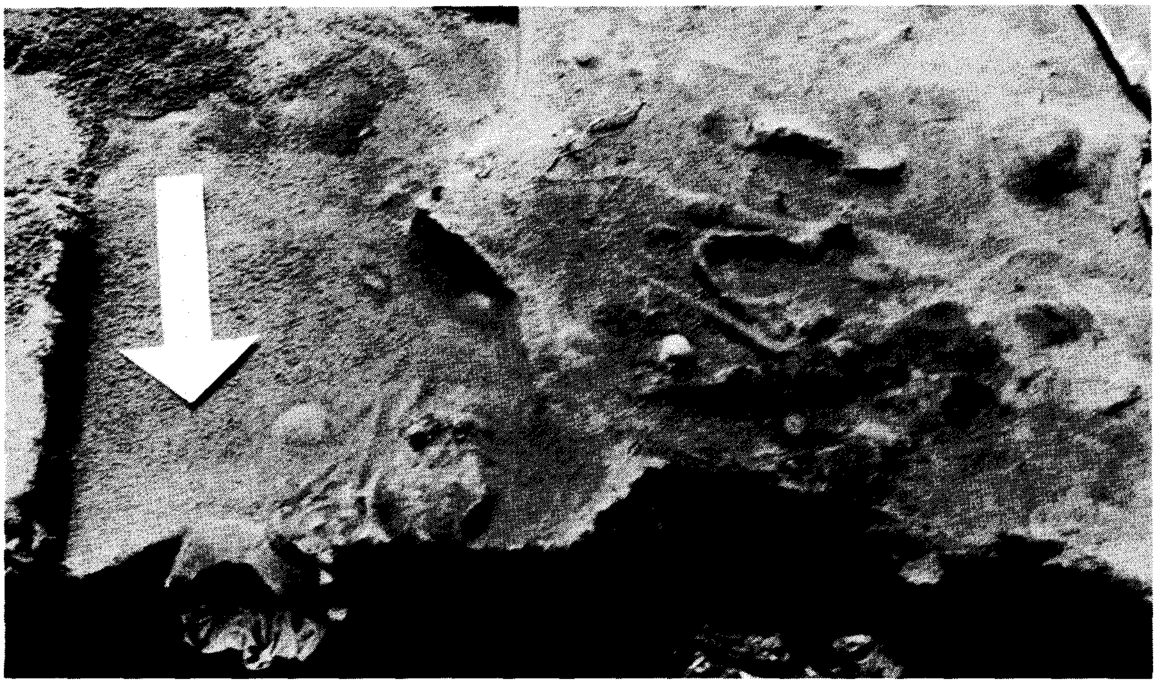

FIGURE 8. The Top of the Ossuary Beginning to Become Visible

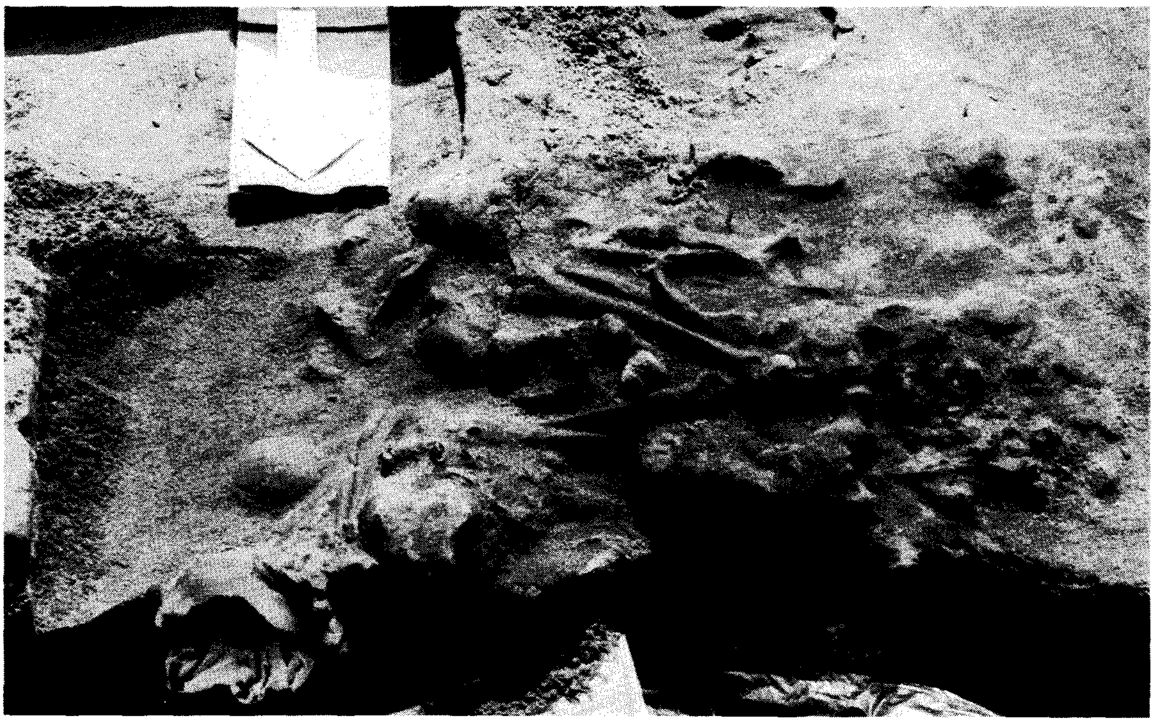

FIGURE 9. The Top of the Ossuary Further Exposed.

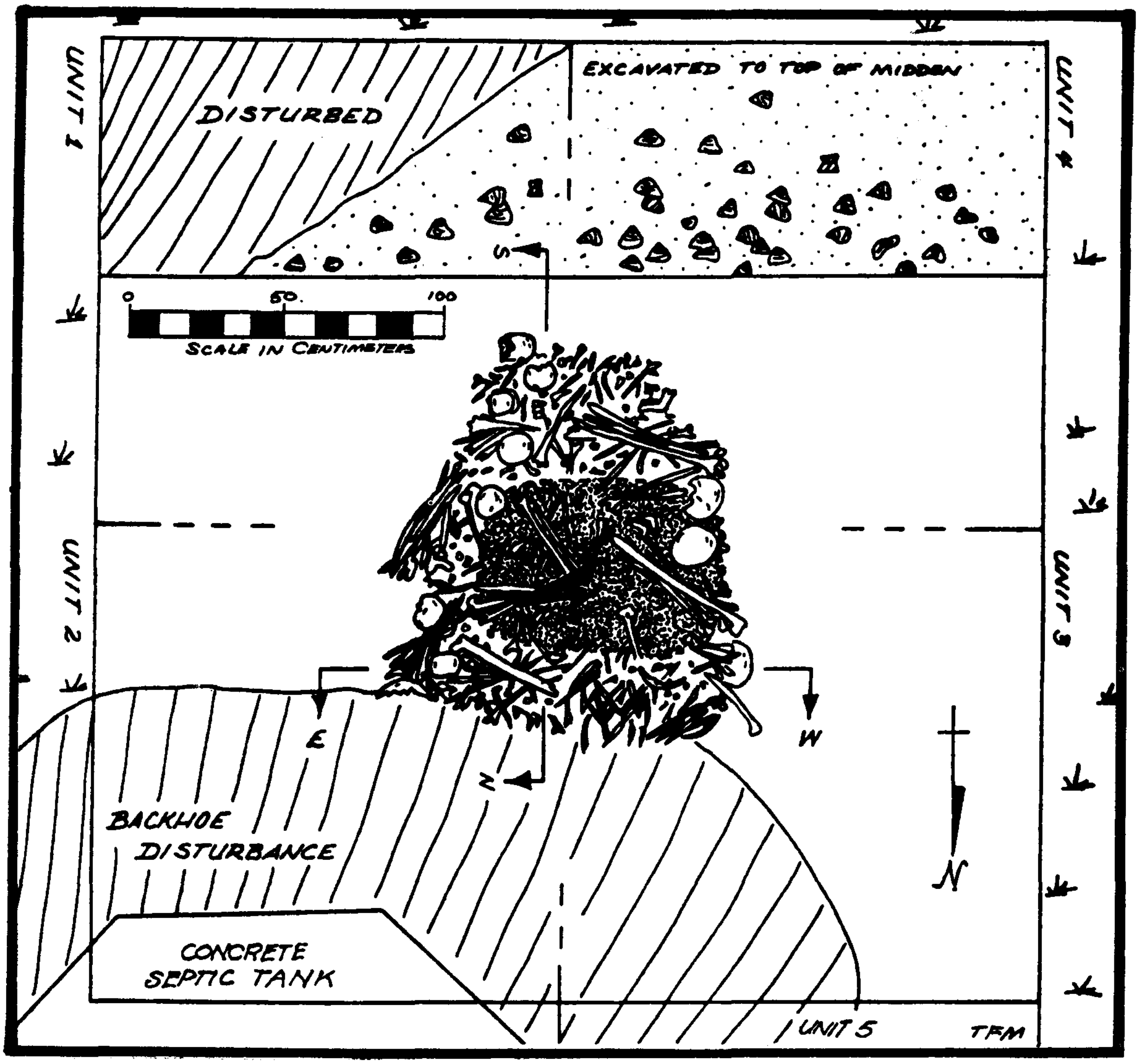


FIGURE 10. Plan View of the Indian Neck Ossuary (By Thomas F. Mahlstedt, From the Bulletin of the Massachusetts Archaeological Society 43(2)

Although at a quick glance the burial feature appeared to be a jumbled and disorganized mass of bone, there was evidence of internal organization. Crania tended to be concentrated along the eastern and western margins of the feature while the post-cranial bones were placed in between. Several of the long bones were clustered into bundles (Figures 11 and 12). After removal from the ground, the bones were taken to laboratory facilities for initial cleaning and bagging. This provided an opportunity for more detailed examination of the bundled remains. At least four long bone clusters were noted. Each appeared to contain bones relating to one individual, for example, 2 humeri, 2 femora and 2 tibiae, although other bones were often present as well. In the ground these clusters were fairly well defined, the bones tightly packed and oriented together.

Laboratory examination also provided an opportunity to document evidence of articulation. While most of the remains were disarticulated, indicating that the soft tissue had decomposed or been removed prior to burial, there were a few exceptions. In three instances the mandible as well as the first two or three cervical vertebrae remained articulated with the cranium. The only other examples of articulation were remnants of vertebral columns. Nine separate instances were noted usually involving no more than a half dozen vertebrae.

Given the evidence for a mortuary practice which involved the reburial of disarticulated or bundled remains, it seemed likely that some evidence of deliberate fleshing would be present. Despite careful examination, however, only one clear instance of cut marks was observed. These were found around the orbits (eye sockets) of one cranium, particularly on the zygomatic arches and frontal bone. In Part II, Chapter 3 of this volume, Magennis discusses in detail the likely mortuary practices of preparing the deceased for interment.

One final chracteristic of the unburned bone layer was noted. Many of the bones from the lowest portion of the level were charred slightly on their lower surface. This indicates that the disarticulated portion of the ossuary was directly connected with the underlying cremation level. This relationship is discussed in greater detail below.

## The Cremation

The unburned bone level was exposed and cleaned as much as possible without removing any of it (Figures 13 and 14).

FIGURE 11. West Side of the Unburned Bone Level Showing the Arrangement of the Crania and Postcranial Bones.

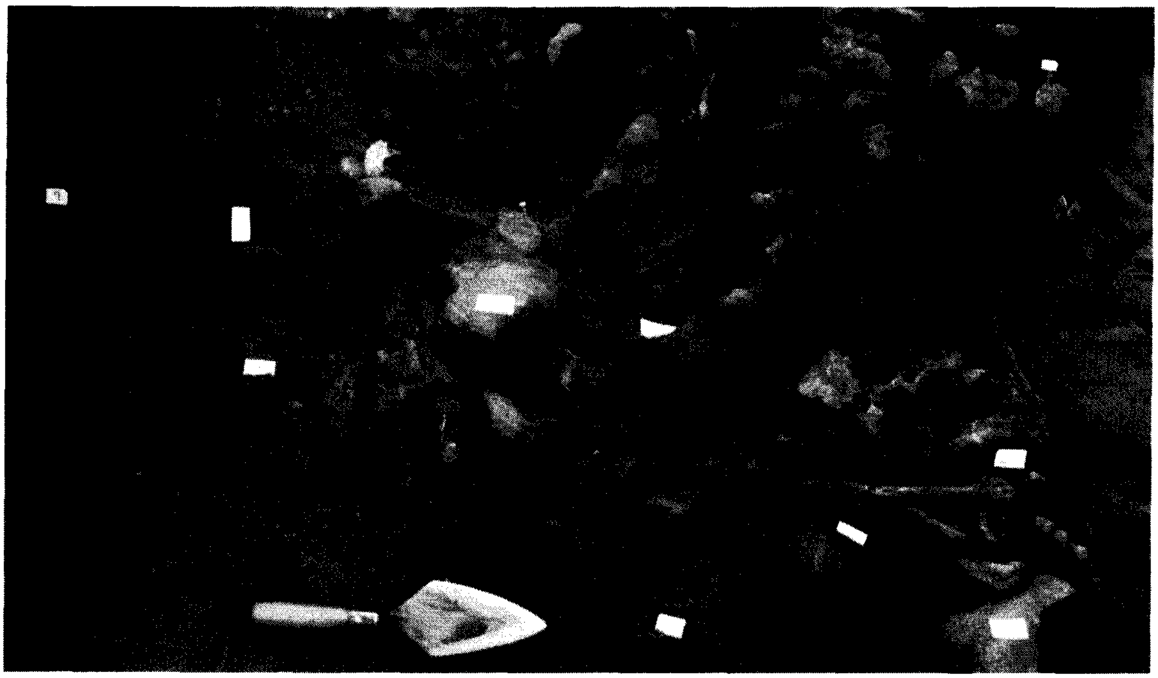

FIGURE 12. East Side of the Unburned Bone Level Showing the Arrangement of Crania and Postcranial Bones.

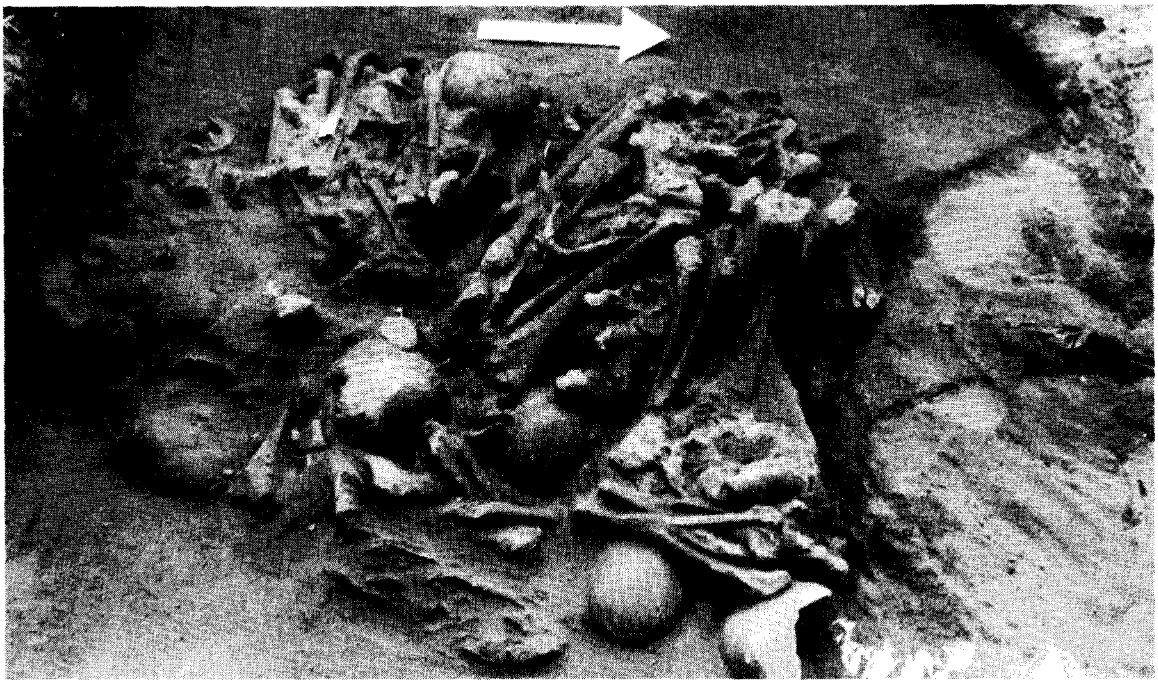

FIGURE 13. Top of the Ossuary Exposed Before Excavation.

FIGURE 14. Top of the Ossuary Exposed Before Excavation.

As the unburned bones were removed, an area of calcined bone began to appear on the western side of the ossuary (Figures 15 and 16). The calcined bone turned out to be the top of a cremation that was an integral part of the burial feature.

The cremation was located beneath the central portion of the unburned layer (Figures 17, and 18). This part of the burial feature was a compact mass of densely packed, calcined human bone. It measured 54 by 76 cm horizontally and was between 10 and 20 cm thick. Being slightly south of the center of the unburned portion of the feature, the cremation had not been visible in the initial backhoe cut. There were no obvious patterns in bone placement or organization in this level (Figures 19 and 20). As was the case throughout the ossuary, there were very few associated artifacts. In only one case was one of the artifacts diagnostic (see following section).

The soil underneath and around the immediate edges of the cremation was a dark, reddish-orange sand into which the ossuary pit had been dug. Though initial speculation suggested that the cremation had been performed in situ, two factors argue against this. No charcoal was evident in or recovered with the cremation. In addition, the discoloration of the underlying subsoil was rather limited considering the advanced degree to which the bones had been incinerated. This suggests that the individuals were cremated elsewhere, though undoubtedly nearby, and the still smoldering remains placed at the bottom of the excavated pit. At this point, the disarticulated and bundled remains were piled on top of the cremated bones. Enough heat remained to cause charring on the lowermost level of the dry bones. Magennis also considers this question in Chapter 3 of Part II.

## Chronology

In the Introduction to this part, the Late Woodland - Contact date for the midden covering the ossuary was described. Given the stratigraphic information, then, the ossuary should date from no later than the Late Woodland. Fortunately two additional sources of chronological information were available: artifacts associated with the unburned bone level and radiocarbon dating.

Very few artifacts were found in the unburned bone portion of the feature and only one could be considered diagnostic. One large triangular felsite point, the only potentially diagnostic artifact recovered, was found in situ at the edge of the feature. It was not clear whether its

FIGURE 15. Earliest Appearance of the Calcined Bone of the Cremation.

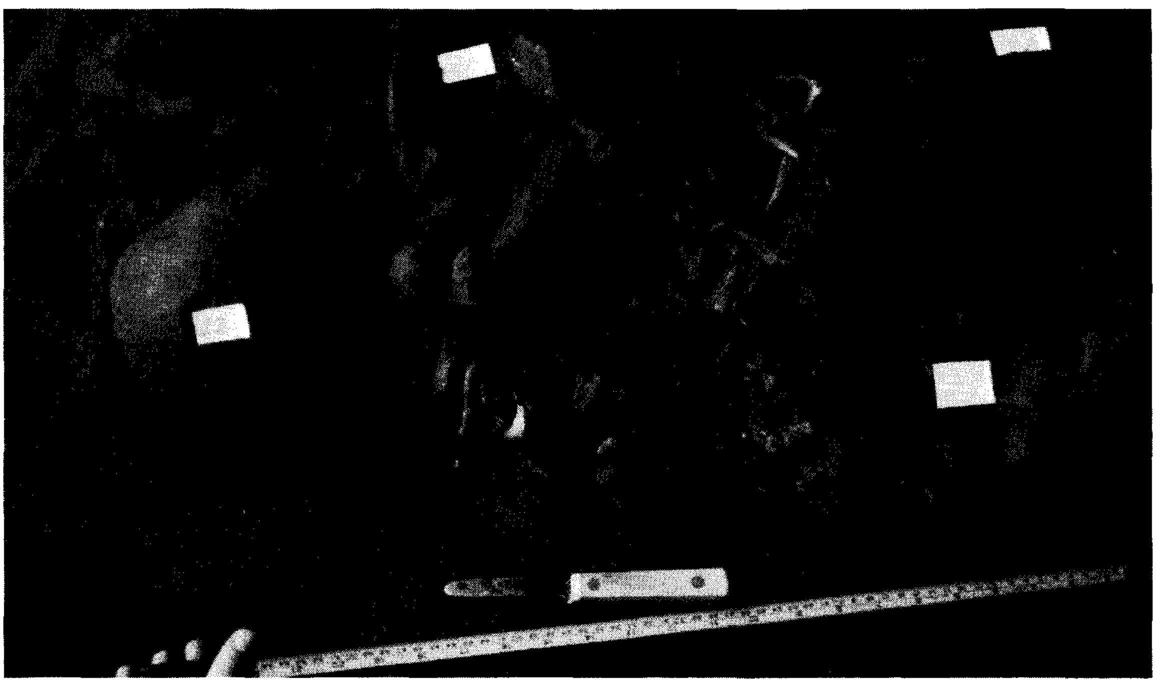

FIGURE 16. Calcined Bone Appearing on the West Side of the Ossuary.

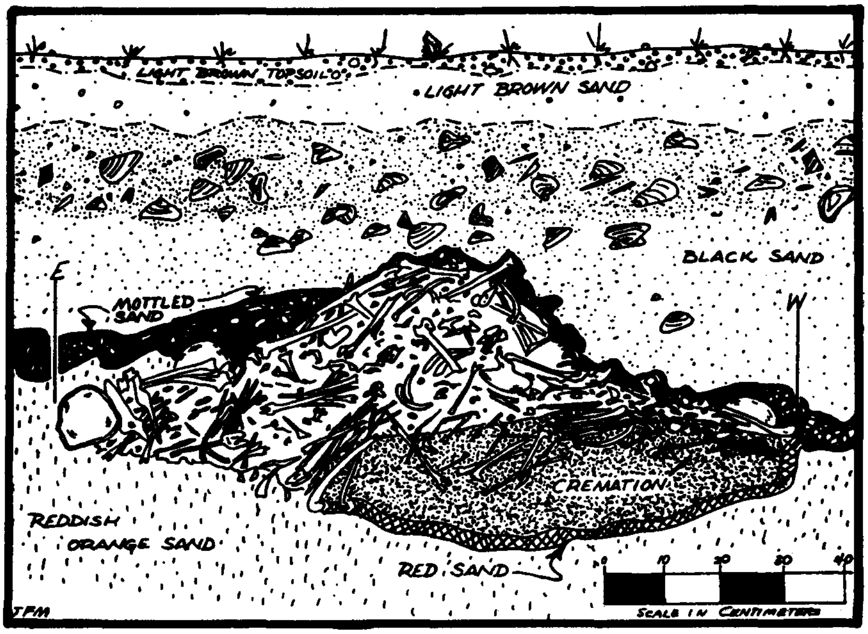


FIGURE 17. East/West Profile of the Indian Neck Ossuary (By Thomas F. Mahlstedt, From the Bulletin of the Massachusetts Archaeological Society 43(2).

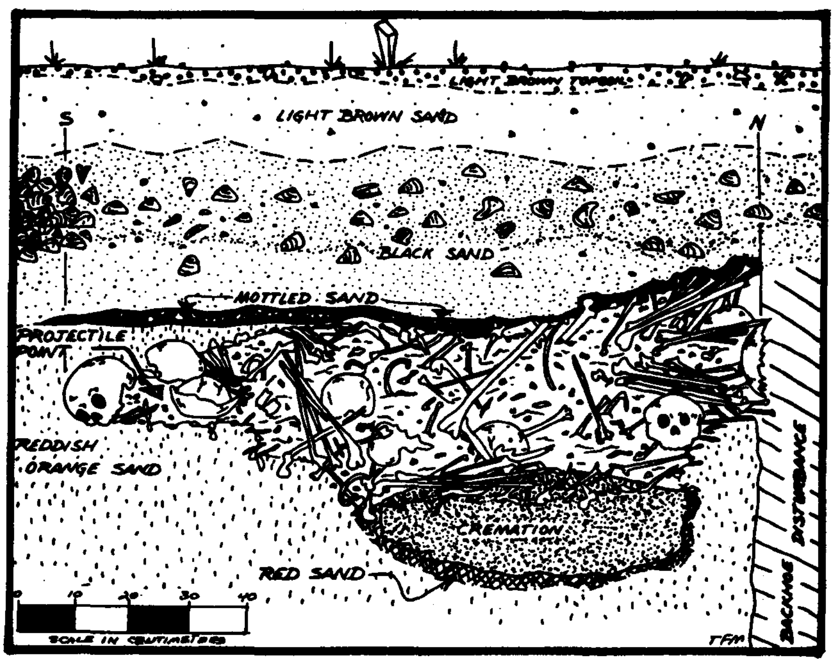


FIGURE 18. North/South Profile of the Indian Neck Ossuary (By Thomas F. Mahlstedt, From the Bulletin of the Massachusetts Archaeological Society 43(2).

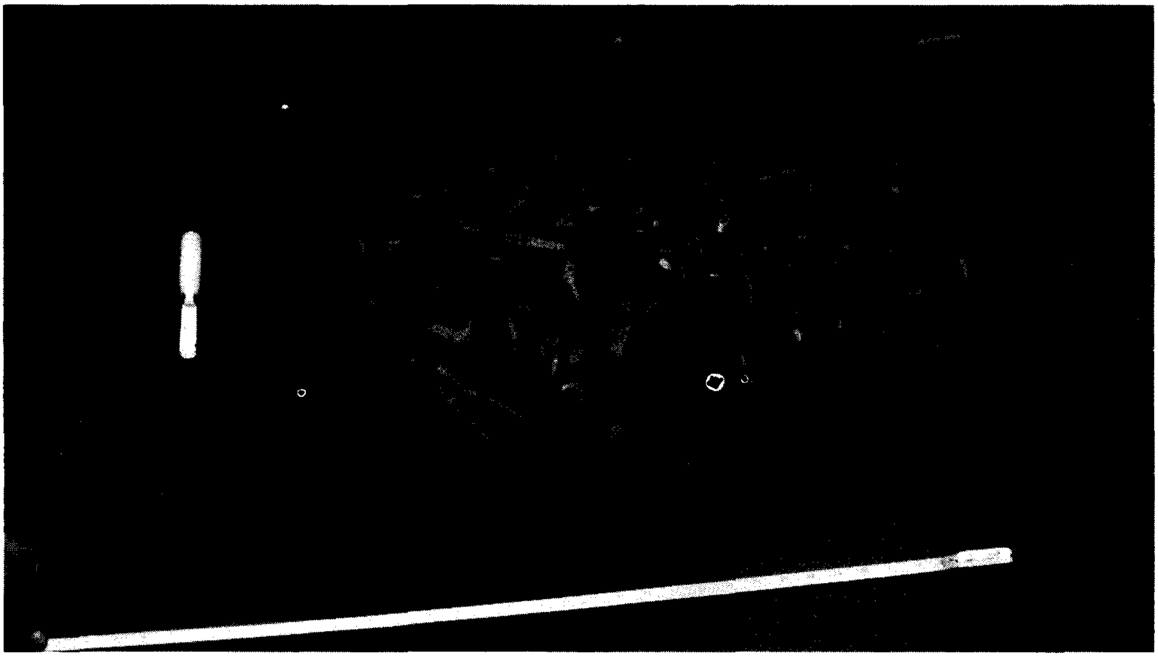

FIGURE 19. Top of the Cremation Exposed (Knife is Pointing North; Tape is Extended To One Meter).

FIGURE 20. Top of the Cremation Exposed (Knife is Pointing North; Tape is Extended To One Meter).

inclusion was intentional or accidental. The only other materials recovered were three small flakes (two felsite and one quartz) and three small fragments of shell. The point can be classified as a Levanna type and supports a Late Woodland date for the ossuary.

Five radiocarbon dates have been obtained from bone samples taken from the unburned bone level. The first two dates obtained were from one right distal end tibia fragment, plus some additional fragments. Dates were registered for the bone collagen and bone apatite. The bone collagen sample (GX-777-G) date was 915+120 radiocarbon years B.P. The bone apatite sample (GX-777-A) dated 935±125 B.P. As an experiment, Geochron Laboratories, at their own expense, processed bone charcoal from another sample of burned bone from the cremation layer. The estimated date for this sample (GX-7779) was 785±230 B.P. This estimate is far less precise than the others, but does overlap them substantially. All the dates are C-13 corrected.

In 1985 a pair of dates was obtained from Teledyne Isotopes, again on bone from the unburned level. Again, dates were registered for both the bone collagen and apatite fractions. The purpose of the additional dates was to check the original dates with an independent sample, and as it turned out, at another laboratory. The date on bone apatite was 1260±130 (I = 13,476) and the date on bone collagen 1490±80 (I = 13,477). The apatite date is consistent with the three dates on the earlier sample. All four of these dates overlap in the range of years A.D. 935-1020 (Figure 21). The second bone collagen date does not overlap with any other date even at the two standard deviation range. The reason for this discrepancy is unclear, however, the four dates tat do overlap confirm the Late Woodland temporal provenience for the ossuary. The dates allow us to be much more specific, in fact, indicating that the ossuary was constructed early in the Late Woodland, probably in the 10th or early 11th millenium.

## The Burial Population

A detailed description and analysis of the human remains by Ann Magennis of the University of Massachusetts is presented in Part II of this volume. The results provide an estimate for the number of individuals interred, as well as observations on the group members' ages, sex, and health. In this brief section we present a summary of some of Magennis' conclusions. The interpretations considered here relate to topics that are analyzed in the next section of Part II.

| C-14 Sample | Date |
|---|---|
| I-13,477 | A.D. 460± 80 |
| I-13,476 | A.D. 890±130 |
| GX-777-A | A.D. 1015±125 |
| GX-777-G | A.D. 1035±120 |
| GX-777-M | A.D. 1155±230 |

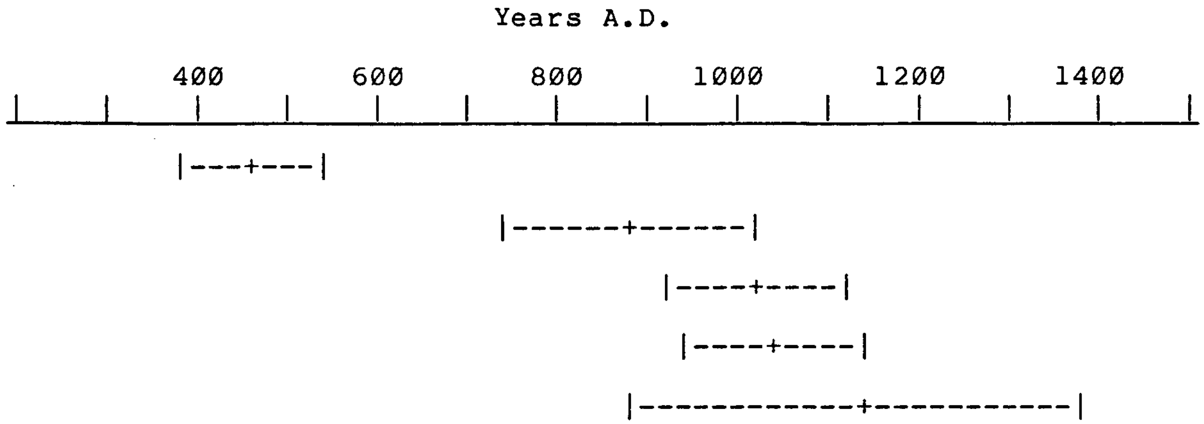


FIGURE 21. Radiocarbon Dates and Their Temporal Distribution (designations on bar graphs are to nearest quarter century).

A minimum of 47 individuals was present in the unburned bone level and nine individuals in the cremation. Minimum number counts were established by sorting all the bone according to type and determining the frequency of the most commonly occurring elements. Thirty-one adults, defined as those individuals greater than 18 years of age, were identified; the highest count was provided by the mandibular symphysis. The most commonly occurring element for the subadults was the femur, representing at least 22 individuals in the unburned level and at least three in the cremation.

Determination of sex of the prepubescent individuals was not attempted. Sex determination of adults was based on pelvic morphology. Of the 14 left innominates in the unburned level for which sex could be estimated, eight appeared to be male while six demonstrated female characteristics. Pelvic morphology suggests that at least two cremated individuals were female. Determination of sex was impossible on most of the cremated remains.

Both the cremation and the unburned levels contained individuals of each sex and with widely different ages, suggesting that the burial population accurately reflects all ages and both sexes of the living population from which it derived. There appeared to be no over- or under representation in the burial population.

Examination of the bones also revealed that the population represented had been a remarkably healthy one. There was little evidence of disease-related pathology and no unusual incidence of trauma. Contrary to initial popular speculations that mass burial might have resulted from an epidemic or other catastrophic occurrence, the burial feature represents the mortuary practices of a particular group in which all or most of those who died within a period of time were buried together ceremonially.

Careful examination of teeth for wear and caries was undertaken to derive inferences about diet and the use of refined carbohydrates, in this case ground maize. A subsistence system involving substantial amounts of ground maize suggests a substantially horticultural economy. A high frequency of dental chipping and low incedence of caries were observed by Magennis leading her to hypothesize a diet for the population in which ground cereal was not a major constituent (for more details see Chapter 2 of Part II).

Magennis also observed a relative frequency of periostitis, a non-specific boney response to infectious disease, in the burial population that is markedly lower that frequencies reported in studies of highly aggregated prehistoric horticultural groups. The relative frequency of periostitis in the Indian Neck population most nearly corresponds to the relative frequency reported for the burial population in the Kane Mounds, a Mississippian period mortuary site associated with dispersed, small farmstead settlements (for more details see Chapter 2 of Part II).

## Ossuaries and Cultural Adaptation

The Indian Neck ossuary is the first clearly documented ossuary in New England. It is an evocative archeological discovery. Interesting in and of itself and for what it tells us about the physiological and epidemiological characteristics and the mortuary practices of the Native Americans of that place and period. What might it also indicate about the prehistoric settlement systems and other aspects of human adaptation at about A.D. 1000 in the Northeast? What does its existence suggest, for example, about the permanence of prehistoric settlements and the reliability of food resources in coastal parts of the Northeast during the late Middle and Woodland periods (A.D. 500-1500)?

These particular questions are a matter of some controversy these days among archeologists studying the prehistory of the Northeast. The amount of archeological work conducted recently in the coastal Northeast has increased the available data and the number of those engaged in the argument substantially. From Maine to Manhattan archeologists have been poking into coastal archeological remains in unprecedented numbers. In Maine alone at least three major research projects have been undertaken between Penobscot Bay and Casco Bay (Hamilton and Yesner 1983; Sanger 1982; Spiess et al. 1983; Spiess and Hedden 1983; Yesner 1980a, b). Massachusetts has seen recent work in the Merrimack estuary (Barber 1979, 1982), Boston Harbor Islands (Luedtke 1975, 1980), Cape Cod (Borstel 1985; Mahlstedt 1986; McManamon [editor] 1984, 1985; thorbahn et al. 1980) and on Nantucket and Martha's Vineyard (Perlman 1977; Richardson 1983). In Rhode Island several projects have been done around Narraganset Bay (Kerber 1984, 1985; Thorbahn and Cox, n.d.) and in Connecticut the net of recent river valley surveys is relentlessly closing in on the coastal zone and Connecticut River estuary (Feder 1981; McBride and Dewar 1981). Coastal New York continues this pattern with work at several locations on Long Island and New York harbor (Ceci 1979, 1982; Gwynne 1982; Lightfoot 1985; Lightfoot et al. 1985; Silver 1980).

Interpretations of this new surfeit of data are beginning to emerge. The interpretations can be simplified into three general models that reflect differing interpretations of cultural adaptations in the prehistoric coastal Northeast. As with all models, these present incomplete, simplified views of reality. They focus on three aspects of prehistoric cultural adaptations in coastal New England: (1) the synchronic and diachronic variety of activities carried out at coastal occupations, (2) the seasonal timing of activities, and (3) when and why year-round occupation of the coastline bagan.

The models are derived from iterpretations offered by Lynn Ceci of Queens College (Ceci 1979, 1982) , Bert Salwen of New York University (Salwen 1965, 1978), Dean Snow of S.U.N.Y. at Albany (Snow 1980), David Sanger of the University of Maine (Sanger 1982), Art Spiess of the Maine Historic Preservation Commission, and Bruce Bourque and Stephen Cox of the Maine State Museum (Spiess et al.1983). It should be recognized that not all these researchers have suggested that their interpretations be applied to the entire Northeastern coast, nor will that necessarily be the suggestion we make here.

Model #1 follows Ceci's (1979, 1982; cf. Silver 1980; McManamon 1984c:405-412) recent arguments for a "new paradigm" in the interpretation of prehistoric coastal settlement. Put succinctly, it posits sporadic summertime use of the coast until European contact about A.D. 1500, after which large sedentary villages began to occur there (Ceci 1982:7-8). Trade with Europeans and the specialized manufacture of wampum are the causal forces in this settlement reorientation. Though not discussed in detail, the range of activities in the coastal zone would have increased dramatically following Contact, and occupation during all seasons would have occurred. Prior to Contact very limited types of activities and only summer occupations are posited.

Model #2 has the coast used seasonally from at least the Late Archaic onward. Snow (1980:230), for example, identified coastal sites, for which he assumes summer occupation, as one of several southern New England Late Archaic site types, a pattern also suggested by Salwen (1965). The settlement system portrayed by this model revolves around seasonal movement. Settlements are moved several times per year to exploit subsistence resources that become available or abundant during different seasons. Citing several ethnohistoric sources, especially Roger Williams, Salwen (1978:164-165) extends this transhumant settlement system into the Late Woodland and Contact periods, the causal factor implicated again is seasonal variation in subsistence resources, locations, and abundance. In this model residence along the coast occurred primarily during the summer. This pattern would have resulted in a wider range of activities carried out more intensively along the coast than those associated with Model #1. The pattern should hold for all prehistoric periods from the Late Archaic onwards.

Model #3 posits year-round residence at selected locations along the coast. A variety of activities also would have occurred away from the main occupation resulting in relatively short-term, special activity sites. This model, among the three presented, would involve the greatest range of activities. By definition, occupation would have occurred during each season. The wide range of activities and variety of seasonal associations and site types that this model suggests seems to be the pattern being discerned after years of painstaking research along the Maine coast (Sanger 1982; Spiess, et al. 1982).

We have used, and perhaps misused, the ideas and interpretations of our colleagues to prepare these thumbnail models. The models should not be misinterpreted as statements of the positions taken by the colleagues, rather they are our interpretations and syntheses of the results published by others.

We believe that the mere existence of ossuaries, for there must be more, implies a more settled and stable adaptation by human populations at least in southern coastal New England than has been inferred by Models #1 and #2. Next we shall examine information about the kinds of cultural adaptations associated with ossuaries in other areas of eastern North America using ethnohistoric sources and archeological data. Following this we shall use data from the Cape Cod National Seashore Archeological Survey to examine further the nature of the prehistoric adaptations in this area during later prehistory.

## Ossuaries in Huronia, the Potomac area, and North Carolina

One type of analysis that might illuminate some of the characteristics of cultural adaptations with which ossuaries are associated is a comparison with the types of settlements associated with ossuaries in other parts of eastern North America. Ossuary burials were not an uncommon interment practice among Native American groups in eastern North America. Ossuaries are best known in the former territory of the Huron just north of Lake Ontario in Canada, from around the mouth of the Potomac River and Chesapeake Bay, and in the North Carolina tidewater coastal plain.

In Huronia, ossuaries were linked closely with sedentary villages, usually between 200 yards and half a mile of one (Heidenreich 1971:149). Typically one village was designated as the place where an ossuary would be created for the dead of several villages. The interment of remains was part of an elaborate celebration that included feasts and reunions. Related individuals and groups from other villages often attended, contributing their dead to the ossuary. Villagers might travel 10-12 miles with the remains of relatives to a host village for interment in a nearby ossuary (Tooker 1964:137). Feasts were held every 8, 10, or 12 years, possibly triggered by an impending movement of the village due to soil or firewood depletion (Heindenreich 1971:150; Tooker 1964:134-135).

The burial ceremonies that generated ossuaries seem to have been designed to reassert social ties among villagers who resided in neighboring villages, and shared a common ancestory in the original population of a single village. As population had grown groups would have budded off the original village to establish independent neighboring villages. The communal interment and ceremony associated with it were a means of inducing unity and harmony in the larger group that included those resident in the village and the kin and visitors from neighboring villages. Whatever its function, the resultant ossuaries were linked to relatively stable settlements. The practice of ossuary burial in Huronia was a component of a settlement system in which principal settlements were not shifted seasonally or yearly (Tooker 1964:139-140).

In the Potomac River and Chesapeake Bay area a similar treatment of the dead is known both ethnohistorically and archeologically. The direct association of ossuaries with large, fixed habitation sites seems likely (Ubelaker 1974:67-68). Unfortunately, the rich ethnohistoric record in the detailed reports of Recollect and Jesuit missionaries available for the Huron area is not duplicated in this area. The archeological data on this association of ossuaries with sedentary village life is far less detailed than from the Huron area.

In tidewater North Carolina, the practice of ossuary burial is known from the Late Woodland Colington phase (beginning about A.D. 800) onwards. Of the five ossuaries reported for this phase, all are associated closely with contemporaneous village sites (Phelps 1983:40-41).

These comparative data from three areas where ossuaries have been found archeologically and are described ethnohistorically indicate a consistent link between the communal ossuary burial and relatively settled village life. If this kind of association can be taken to have existed on Cape Cod from A.D. 1000 or so onwards, interpretations of prehistoric ways of life during the Late Woodland would be revised to reflect the type of adaptation described generally by Model #3. Ethnohistoric data from Cape Cod also can be used to reflect upon this possibility.

## Ethnohistory of the Outer Cape

The ethnohistorical data are particularily rich, coming from detailed accounts by Samuel de Champlain and the early English colonizers of southeastern New England. What have these accounts to say that casts light upon the question of the sedentary life of Native Americans during the Contact period (i.e., post A.D. 1500) in this area? The earliest detailed reports of encounters with the natives of Cape Cod result from a French effort to reconnoiter and chart the New England coast in the summer of 1605. Samuel de Champlain, later to be known as the Father of New France, served as the cartographer on this expedition. The French travelled down the coast after having survived a horrible winter on Saint Croix Island in the St. Croix River, the present-day boundary between the United States and Canada. Along the way they stopped at many points that later became major Euroamerican settlements--Gloucester, Boston, and Plymouth in Massachusetts, for example. At all of these locations and others the French observed and described large numbers of natives engaged in a variety of activities including fishing, food collecting, and farming. From July 20th to 25th 1605, near the furtherest southern extent of their travels, they anchored in Nauset Bay on the ocean side of Cape Cod, in the modern town of Eastham, Massachusetts (see Figure 1). There Champlain (1922:349) reported observing "...a bay with wigwams bordering it all around" (Figure 22). This report of settlement in the Nauset vicinity is especially relevant because Nauset Bay is within a few miles of Indian Neck.

The French returned to the southern coast of Cape Cod in the autumn of 1606. In early October they again anchored at Nauset. The French leader, Pourtrincourt "...paid a visit to the port in the shallop. There came to meet him some 150 Indians, singing and dancing in accordance with their custom

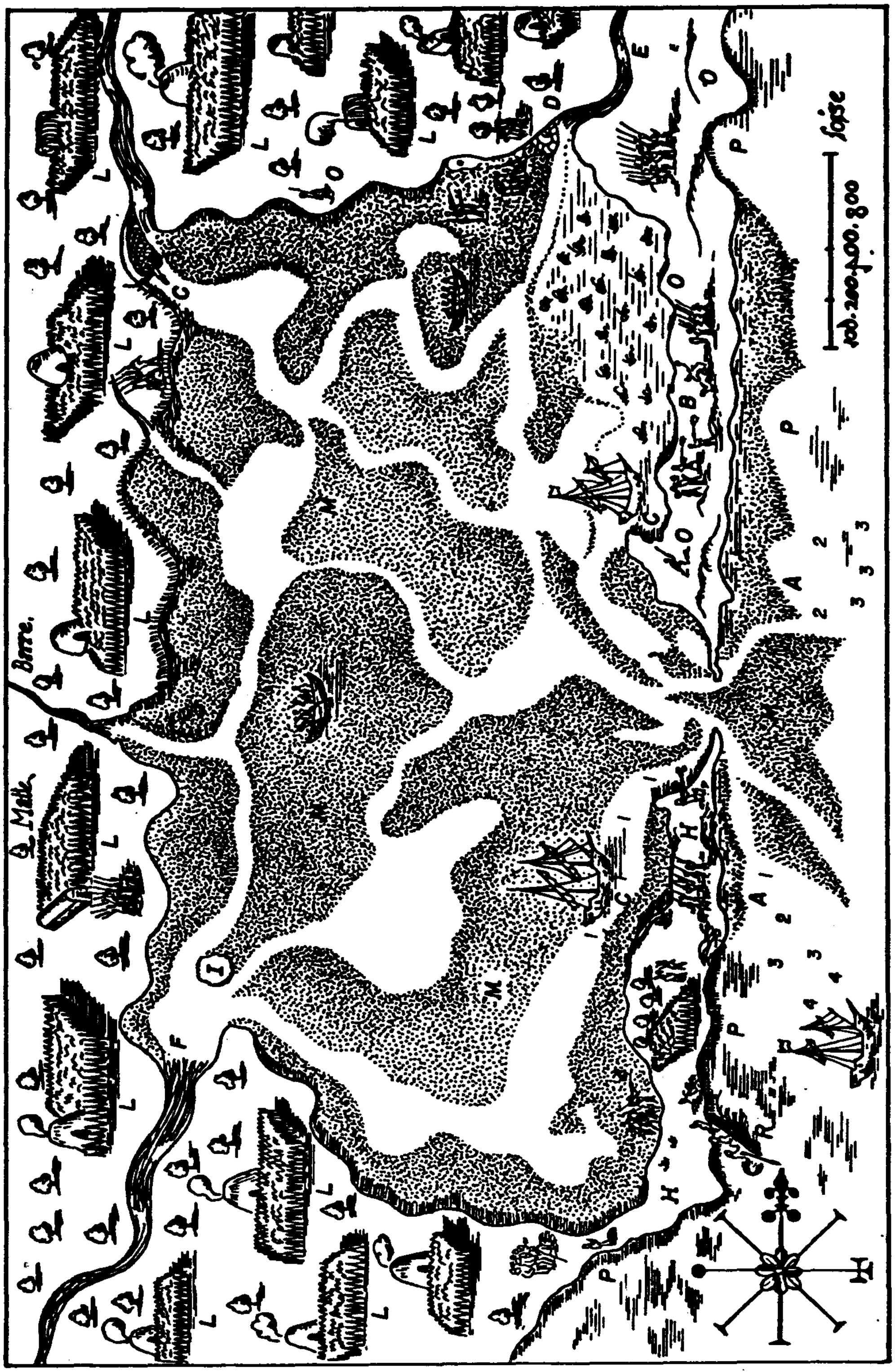

FIGURE 22. Champlain's Map of Nauset.

(Champlain 1922:405)." So, again the French had found substantial numbers of natives at Nauset, this time during the fall of the year. Champlain reported seeing large numbers of natives and their habitations and fields at many locations along the New England coast during both the 1605 and 1606 expeditions. In fact, after leaving Nauset Harbor in mid-October 1606, the French sailed farther south along the Cape's ocean coast, eventually putting in at Stage Harbor in present-day Chatham, about twenty miles from Nauset. In this embayment they were confronted by "...five or six hundred Indians... (Champlain 1922:411)." Champlain (1922:410) noted that

> all the inhabitants of this place are much given to agriculture, and lay up a store of Indian corn for the winter.

He further described the manner in which the corn was preserved in large subsurface storage pits.

> In the sand on the slope of the hills they dig holes some five to six feet deep more or less, and place their corn and other grains in large grass sack, which they throw into the said holes, and cover them with sand to a depth of three or four feet above the surface of the ground. They take away this grain according to their needs, and it is preserved as well as it would be in our graineries (Champlain 1922:410-411).

These are only snippets from Champlain's observations of native life in southern New England, but they underline two aspects of human adaptations frequently associated with sedentary settlements--horticulture and food storage. Both of these were practiced by Cape Cod natives by 1600.

Champlain and the French never returned to southern New England after these two trips in the early 1600's; their efforts were directed to the north and west. The English were next to visit southern New England, and in November 1620 the first English group to succeed in settling there permanently arrived. The Pilgrims settled in Plymouth eventually, but for over one month after they made landfall, the Mayflower anchored in what is now Provincetown Harbor. From there the English staged three short explorations of outer Cape Cod. Their intent was to learn whether the land and available fresh water in this area were sufficient to support them, and to ascertain the disposition of the natives living there already. In addition, the accounts of their expeditions (e.g., Bradford 1961; Heath 1963) provide rich lodes of data about the precolonization landscape. It is possible to derive from these accounts further information about the Native American patterns of settlement.

The first exploration of the Pilgrims from the 25th to the 27th of November covered from the northern shore of Provincetown Harbor to the southern bank of the Pamet River in present-day Truro, Massachusetts. Along the way the English encountered a pattern of vegetation that sounds remarkably like that of today. Patches of dense underbrush that "tore their armor" were interspersed with sections of open woodland. The open woodland probably was the result of deliberate burning of underbrush by the natives to increase food for deer (e.g. see Day 1953).

Other, more obvious evidence of human modifications were apparent to the English. They reported clearly marked, well-used paths and land that showed signs of having been cleared and cultivated within the last few years, 50 acres in one area by one estimate. They noted a series of smaller cornfields that had been cultivated that very year. At one of these they found the remains of a wigwam that had been erected near the fields. They also found a buried cache of corn, probably the result of that year's work. It was covered by a "newly done" heap of sand that covered "...a fine great new basket full of fair corn of this year (Heath 1963:27)". A description that sounds remarkably close to Champlain's quoted above. The basket contained three or four bushels of corn. The explorers found the remains of "...an old fort or palisade" and native graves with grave goods as well (Heath 1963:27). To complete their encounter with the cultural landscape of the resident natives, one of the English, William Bradford, the future, many-term governor of Plymouth Colony, accidently ensnared himself in a native trap intended for deer.

The English explorers hadn't found native villages similar with the highly concentrated and enclosed settlements of the Huron or Iroquois, or the large ceremonial and residential settlements of the highly aggregated prehistoric horticultural societies of the Midwest and Southeast. They had, on the other hand, encountered many examples of extensive, regular uses of the land by the current residents. The only inhabitants that they had sighted had been on the beach along Provincetown Harbor at the outset of their venture, and these natives had fled before the approaching English.

Between December 7th and 10th the Pilgrims undertook a second exploration. This time a small party of men sailed by shallop to the mouth of the Pamet River in present-day North Truro. This was near the furthest extent of their first trip. They hiked up and down the Pamet River, reporting nothing of interest. Then they returned to the Corn Hill area, probably where they had found the corn cache during their first reconnaissance. There they dug up more corn caches, expropriating in all about ten bushels of corn. During their digging they also discovered a grave containing an adult and child and grave goods.

Again on this trip the explorers found "...beaten paths and tracks of the Indians". One very broad track turned out to be a deer drive. In addition, this time several wigwams were found. These were unoccupied, but they must have been abandoned very recently, perhaps only upon the approach of the Pilgrim explorers. The contents, of one included a virtual catalog of items for daily use by a native family. Inside the house were:

> wooden bowls, trays and dishes, earthen pots, handbaskets made of crabshells wrought together, also an English pail or bucket; it wanted a bail, but it had two iron ears. There was also baskets of sundry sorts, bigger and some lesser, finer and some coarser; some were curiously wrought with black and white in pretty works, and sundry other of their household stuff. We found also two or three deer's heads, one whereof had been newly killed, for it was still fresh. There was also a company of deer's feet stuck up in the houses, harts' horns, and eagles' claw, and sundry such like things there was, also two or three baskets full of parched acorns, pieces of fish, and a piece of a broiled herring. We found also a little silk grass, and a little tobacco seed, with some other seeds which we knew not. Without was sundy bundles of flags, and sedge, bushes, and other stuff to make mats. There was thrust into a hollow tree two or three pieces of vension, but we thought it fitter for the dogs than for us. Some of the best things we took away with us, and left the houses standing still as they were (Heath 1963:29).

Following this reconnaissance the explorers returned again to the Mayflower. They set out once more on 16 December. Their third exploration was aimed further south along the shore of Cape Cod Bay toward present-day Eastham and Wellfleet. After landing south of it, part of the group walked north reconnoitering the shore of Wellfleet Harbor. They did not note any native habitations or other structures, The archeological data come from two complimentary sources, an analysis of existing artifact collections from Cape Cod and the Islands conducted by the Massachusetts Historical Commission (Mahlstedt 1985), and field investigations carried out within the Cape Cod National Seashore from 1979 through 1986 by the National Park Service (Borstel 1985; McManamon ed. 1984, 1985). Mahlstedt's analysis indicates that the Late Woodland sites are among the most frequent in occurrence. Based on diagnostic lithics, 144 sites with Late Woodland occupation have been reported from the Cape and Islands, 18% of all known sites (779). This number is particularly impressive when compared to that for sites of the Small Stem Tradition (149) which usually dominates local and regional sequences in eastern Massachusetts. Keeping in mind that an unknown number of sites presently attributed to the Late Archaic on the basis of their Small Stemmed components may, in fact, be Early Woodland, and that there are twenty-one additional sites identified with only a general Woodland affiliation based on ceramics, one is left with the impression that the prehistoric population of Cape Cod was at its greatest during the Late Woodland period (Mahlstedt 1986).

Two additional conclusions are indicated by the Massachusetts Historical Commission survey. One is that the range of Late Woodland site locations is extremely diverse. The Late Woodland population appears to have exploited virtually every available habitat, interior as well as coastal. Second, while the number of Contact period sites known on the Cape is markedly less than that for the Late Woodland, their distribution and overall characteristics are very similar (Bradley 1986; Loparto 1986). This similarity suggests that there was considerable continuity in native culture before and after European contact. No significant changes in native settlement and subsistence patterns appear to have taken place until the pandemics of the early 17th century and the establishment of permanent European communities.

Many of the general patterns which emerge from the Massachusetts Historical Commission survey are supported by the field survey and subsequent site examination conducted within the National Seashore. The archeological survey of the National Seashore discovered and examined sites throughout the outer Cape. Concentrations of prehistoric sites were found around Nauset Marsh in Eastham, one location visited by Champlain, and at High Head in North Truro, an area through which the Pilgrims passed on their first reconnaissance. Analysis of the data has focused on describing and comparing the types and integration of and seasonal organization of activities, and the extent of contact with other human populations (McManamon 1984c).

Substantial deposits of prehistoric remains were found and examined at 19 sites within the investigation area. Many of these sites were too large to be analyzed as single occupations or activity loci, so they were subdivided into about 176 smaller spatial units referred to as concentrations. The term concentration was used because these intrasite units tended to be areas within each site where lithic artifacts, shell remains, midden or other features, fire-cracked rock, or combinations of these were more or less concentrated spatially. Roughly 40% of the concentrations could be associated reasonably well with a general prehistoric time period. These concentrations were analyzed more completely (McManamon 1984a, b).

Analysis of some of the survey data indicates that year-round activities occurred at or in close proximity to the archeological sites that have been studied. This pattern is evident in the results of seasonality analysis of *Mercenaria mercenaria* shell remains and the diversity, and density of various kinds of archeological remains that have been recovered.

## Seasonal Organization

Due to the apparent abundance of shellfish remains in many of the sites examined by the survey, seasonality analysis through the inspection of growth lines in shell, specifically *Mercenaria mercenaria*, was selected as a means of obtaining information on the season of occupation and activities in concentrations. A pilot study done in 1981 by Mary Hancock, then on the survey staff, showed promising results and eventually 16 components in 15 concentrations and 7 sites were analyzed (Table 1). Hancock's (1984) study included the collection of modern *Mercenaria mercenaria* individuals and the examination of growth line variation during the course of a year.

The results of the shell seasonality study inform us directly only about the scheduling of shellfish collecting and processing. The righthand portion of the table shows the seasonal pattern of shellfish collecting for the Late Archaic through Late Woodland components. Some of the specimens could be assigned to a specific month of collection; for others a range of two to three months was assigned. Note the very large percentages of specimens for which only a general

TABLE 1

Seasonality Information Based upon Shellfish Analysis

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                           Number of
  Time                  Shell Specimens     No. of Specimens/Month
Period(s)  Conc.       W        GP      T     J F M A M J J A S O N D

   LA      308.42   1(11%)   4( 44%)   9        |-1-|  1 1
                                                     |-1-|
   LA      274.11   0        1( 20%)   5      |-1-|
                                            -1--|1                |--
                                              |-1-|

                                             J F M A M J J A S O N D

   MW-LW   308.71  17(71%)   5( 21%)  24    -1--|    1            |--
   MW      274.12   8(73%)   2( 18%)  11        |-1-|
   MW-LW   341.21  10(20%)  12( 24%)  50       2   2 5 1   1
                                              |-9-|   |-1-|
                                           -2--|-2-|-1-|-1-|      |--
   MW      390.33   2(25%)   1( 13%)   8       2 1
                                           -2--|                  |--

                                             J F M A M J J A S O N D

   LW      308.11   1(13%)   6( 75%)   8       1
   LW      308.33   1(20%)   1( 20%)   5      |-2-|
                                                |-1-|
   LW      308.42  18(34%)  14( 26%)  53       2 1 1               3
                                           -10-|                  |--
                                              |-1-|
   LW      323.21   4(66%)   1( 17%)   6                           1
   LW      323.22  17(27%)  34( 54%)  64       1                   4
                                           -5--|-1-|              |--
                                              |-2-|
   LW      323.23   4(33%)   6( 50%)  12                           2
   LW      341.24   0       2(100%)    2
   LW      288.42  19(35%)  13( 24%)  55      2|-2-|               1
                                           -6--|                  |--
   LW      288.52   5(26%)  12( 63%)  19   -2--|                  |--
   LW      410      4(50%)   0         8   -1--| |-1-|            |--
                                              |-2-|
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Key: W = too weathered to record; GP = estimate of slow vs. fast growth phase only; T = total number of specimens.

growth phase could be determined or that were too weathered for any estimate of season of collection to be made.

Visual inspection of the data indicates that between the Middle and Late Woodland periods a change occurred in the seasonal organization of this activity. Two of the Late Archaic and Middle Woodland components indicate that shellfish collecting was carried out during about two-thirds of the year. Most of the shell was collected during the winter and early spring, but a sizeable portion in the 308.42 and 341.21 samples were collected during the summer. Both of these components were dated by association with C-14 dates. Late Woodland components, by contrast, indicate mainly or exclusively winter and early spring collection times. A smaller follow-up study by Alison Dwyer (1986) of the National Park Service support these results.

The meanings of the seasonal patterns and the apparent temporal change are not fully understood. The pattern of seasonal exploitation contradicts interpretations that shellfish were used year-round by coastal populations during all prehistoric periods (Ritchie 1969:vii). At the same time, it runs counter to interpretations that Late Archaic coastal sites with abundant shellfish remains were mainly summer occupations (Snow 1980:230).

The scheduling of shellfish exploitation during the winter and late spring may be related to the notorious scarcity of other wild food resources in the Northeast at that time of the year. Although shellfish collection during the winter might have involved accepting wet, cold, and generally uncomfortable working conditions, they were an abundant available source of food when other sources were rare.

The apparent change of shellfish exploitation scheduling in the Late Woodland from winter through summer to winter alone might be related to increased attention being paid to the planting and care of cultivated crops in the summer during the Late Woodland. We know from ethnohistory that the tending of cornhills between planting time and harvest, typically a chore of women and children, required a substantial amount of time among the Huron (Heidenreich 1971:178-179; Tooker 1964). Furthermore, in his 1634 account of the natives of eastern New England William Wood described the planting and tending of corn as a primary responsibility of women (Wood 1977). If the Late Woodland inhabitants of Nauset had developed similar responsibilities for horticultural products, they might have had to make a scheduling choice and eliminate the time available for summertime shellfish harvesting and processing. Wood also noted that women were the collectors of shellfish, and that when he observed it, shellfish collecting was a winter activity.

Cleland (1976:71-73) has characterized late prehistoric cultural adaptations in much of eastern North America as focusing upon corn and other domesticated plants, although he notes that the intensity of the focus on these resources varied with the natural environmental conditions that govern the growing season. The apparent change in scheduling of shellfish exploitation during the Late Woodland might be an example of the scheduling changes that Cleland infers as having been concommitant with a greater concentration on horticultural products for subsistence. This is not to suggest that if such a shift occurred on the outer Cape it was sudden or final. Rather, there was a shift in emphasis in subsistence resources with horticultural activities being allocated more time by the late prehistoric populations.

The analysis of shellfish collection scheduling indicates two points about the larger issue of characterizing prehistoric settlement systems. The most important finding, perhaps, is the strong association of shellfish collecting with winter and early spring. This runs counter to existing interpretations of this activity.

The second major point is that the results indicate that from at least the Late Archaic onwards there was at least winter settlement on the coast of the outer Cape, and in all likelihood summer settlement as well. This also runs counter to prevalent interpretations that coastal settlement in southern New England was either seasonal, as stated in Model #2, or a product of the trade due to European contact, as stated in Model #1.

## The Density and Diversity of Remains

The density and diversity of various kinds of archeological remains found in sites on the outer Cape also were used to infer the permanence of prehistoric settlements and the range of activities. It is a reasonable postulate, confirmed by ethnoarcheological studies (e.g., Binford 1979), that the longer a group resides at a location, the denser the trash and garbage that it generates will be and the more diverse the broken and discarded items.

It also is reasonable to postulate that a group that is resident at a location for substantial periods of time, i.e., years or most of a year, periodically will clean the areas where they perform routine domestic activities, such as food preparation, tool maintenance, sleeping, playing, etc. This also is confirmed by ethnographic data. Murray (1980) performed an extensive analysis of ethnographic literature to determine the frequency with which discarded items actually were left at the location of their former use. She found that:

> ...element discard location [equals] use location at only one type of habitation site--that occupied by a migratory population...Almost all sedentary groups throw all garbage away from the use area. Detailed analysis of the spatial distribution of artifacts at long-term habitation sites therefore may tell archeologists nothing about where other activities beside discard were performed (Murray 1980:497-498).

It follows from this that archeological sites resultant from the settlements of sedentary groups will include areas, probably on the periphery of the actual occupation area, where deposits of garbage and trash were made. These kinds of deposits are referred to as secondary deposits (Schiffer 1976:129). Among other things, secondary deposits are characterized by relatively high diversities and densities of various kinds of remains. Therefore, if deposits that can be classified as secondary are discovered at a site, it is reasonable to infer that year-round, or at least seasonal, occuaption of the site occurred.

The relative densities and the diversity of various kinds of archeological remains were analyzed using order statistics and an exploratory data analysis approach (McManamon 1984a, b). Four types of deposits were identified and each concentration from all 19 sites analyzed were classified in to one type. The four types were:

(1) Primary deposit, limited activities: these concentrations were characterized by low density, low artifact diversity and a narrow range of types of remains.

(2) Primary deposit, wide range of activities: these concentrations were characterized by a higher diversity of artifact types and a wider range of types of remains than (1), but by less dense deposits than (3) or (4).

(3) Secondary deposit, shell midden: these concentrations were characterized by high densities of shell, but relatively low densities of other remains; the range of types of remains is not as wide, nor the diversity of artifact types as large as for (4).

(4) Secondary deposit, general midden: these concentrations had high densities of two or three kinds of remains, a wide range of kinds of remains and, usually, a high diversity of artifact types (McManamon 1984c:369).

Among the concentrations, those dated to the Late Woodland had the greatest frequency of general midden deposits (Table 2). This strongly suggests that by that period, if not before, permanent, year-round occupation of locations on the outer Cape occurred. This is in keeping with the pattern of adaptation suggested by the existence of the Indian Neck ossuary. Examination of radiocarbon dates for those of the midden deposits that have them indicate that the middens were deposited throughout the Late Woodland and that some exist from the earlier parts of the Woodland and even for the Late Archaic (Table 2). These latter dates suggest that sedentary occupation of some locations on the outer Cape began well before the Late Woodland. The abundance of Late Woodland dates implies, however, that such occupations were much more common during this period. Many of the dates designated as Late Woodland in fact overlap with te Middle Woodland when the standard deviation is subtracted from the estimate. Most of the dates are earlier than those for the ossuary and overlap partially with the ossuary dates. This suggests that the ossuary was an element of a cultural system that included sedentary settlements and that the system had existed for some time before the Indian Neck ossuary itself was created.

## Conclusion

In the first section of this part we described the archeological context of the Indian Neck ossuary and its chronology. In the subsequent sections we have attempted to describe the prehistoric social context in which the ossuary was created. We have described and interpreted the cultural landscape of the outer Cape in the early 1600s for information about the amount of human alteration of it and what this might indicate about the intensity of native use and the permanence of native settlement. Finally, we have summarized the archeological data, particularly from the Late

TABLE 2

Secondary Deposits Examined by the Cape Cod National Seashore Archeological Survey, 1979-1981 (from McManamon 1984c, Tables 16.13-16.17)

| Concentration | Type of Midden | Main Prehistoric Period(s) | Available C-14 Date(s) |
|---|---|---|---|
| 288.51 | shell | Late Archaic | |
| 390.34 | general | Late Archaic | |
| 336.14 | general | Late Archaic or Late Woodland | |
| 274.12 | general | Middle Woodland | A.D. 380±120; 470±90; 685±130; 665±120 |
| 390.33 | general | Middle Woodland | A.D. 350±130 |
| 308.42 | general | Middle or Late Woodland | |
| 308.71 | general | Middle or Late Woodland | |
| 341.21 | general | Middle or Late Woodland | A.D. 575±155; 950±145 |
| 308.11 | general | Late Woodland | |
| 308.14 | general | Late Woodland | |
| 308.21 | general | Late Woodland | |
| 308.22 | shell | Late Woodland | |
| 308.33 | general | Late Woodland | A.D. 670±80 (base of midden); 800±80;1060±145 |
| 323.22 | general | Late Woodland | A.D. 1440±110 |
| 341.23 | general | Late Woodland | A.D. 840±150; 875±110 |
| 341.24 | general | Late Woodland | A.D. 980±120; 1060±150 |
| 288.31 | general | Late Woodland | |
| 288.42 | shell | Late Woodland | |
| 288.45 | shell | Late Woodland | |
| 288.52 | general | Late Woodland | |
| 288.53 | general | Late Woodland | |

Note: Concentrations 308.33, 308.42, and 390.33 also have stratigraphically lower deposits radiocarbon dated to the Late Archaic time period. These lower deposits have not yet been analyzed to determine what type of deposit they represent.

Woodland period, on the seasonality of prehistoric shellfish collecting and the density and diversity of remains.

Our conclusion is that the human groups who constructed the ossuary enjoyed a relatively stable cultural adaptation to an environment rich in subsistence resources. They had a subsistence economy that included a wide range of types of food, some of which varied seasonally. Their economic activities probably included horticulture, but the fruits of this labor did not dominate their diet.

They lived in locations like those surrounding Nauset Marsh and Wellfleet Harbor. These locations allowed easy access to a variety of microenvironments ranging from tidal flats and salt marsh to freshwater wetland and wooded upland. Each environment contributed to subsistence and other parts of the economy. Extraction of the needed natural resources did not require movement of the principal residences. So, year-round residence at these locations was possible. The plans of their villages were more dispersed than those known commonly among the Iroquois and Huron. These settlements were smaller and far less aggregated than those of their intensely horticultural Midwestern contemporaries.

The patterns that we have summarized here are at odds with some of the other current interpretations of Late Woodland prehistory in coastal areas of southern New England. We believe that the prehistoric adaptation was very stable and well suited for the natural and social environment in which it developed. That certain parts of the adaptation survived the disruptions caused by arrival and colonization of Europeans illustrates this point. As the quincentenary of the Columbian discovery approaches more and more attention will focus on the intensive encounter between Europeans and Native Americans that began in the 15th century. To effectively interpret the events and outcome of this encounter we must understand correctly the states of native adaptations at that time. We hope that we have advanced our understanding of this topic for southern New England in this presentation.

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# PART II

# THE PHYSICAL ANTHROPOLOGY OF THE INDIAN NECK OSSUARY

Ann L. Magennis

## Preface

A frequent lament among bioarcheologists is that human skeletal remains are under-utilized as means to evaluate the adaptive success of past populations. Instead, they frequently are viewed from a typological perspective or are used for reconstructing culture history. This is especially true in New England, but the blame cannot be placed entirely on the past research interests of scholars in the region. New England generally lacks large, homogeneous skeletal series, which are pre-requisites for studies of biocultural adaptation. Rather, the skeletal data largely consist of isolated finds, and contextual information is frequently lacking, as pointed out by Schindler et al. (1981).

The Indian Neck ossuary stands out in several regards. It is one of the largest (if not the largest) skeletal series recovered to date in New England. It is also the only reported ossuary in the region. Spatially, the Indian Neck ossuary is isolated; the nearest examples of this type of mortuary feature occur in western New York, southern Ontario, and the Mid-Atlantic states. The Indian Neck ossuary is temporally isolated as well. Most of the ossuaries reported in the literature are more recent by several hundred years. Ossuaries outside of New England are associated with large, settled villages which relied on maize agriculture. There is no evidence, however, to suggest that large, nucleated settlements are associated with the Indian Neck ossuary, nor is there compelling evidence for intensive maize cultivation. This is true, not only for Indian Neck, but applies to New England as a whole.

These issues are currently at the center of an ongoing debate among archeologists. Ceci (1979-80, 1982) has argued that large, settled villages dependent on maize cultivation are a late phenomenon (i.e., Contact Period) in coastal areas. While there are those who would argue for an earlier and more intensive dependence on maize (e.g., Silver [1980-81]), the data are not currently sufficient to resolve this argument. In order to address these issues adequately, we need better information about population density, distribution, mobility, subsistence patterns, and the importance of cultigens in the diet.

The analysis of the human skeletal remains from the Indian Neck ossuary was undertaken with these concerns in mind. Demographic characteristics of the population, diet, and nutritional adequacy form the core of this analysis. Chapter 1 covers the demography of the Indian Neck series, including estimates of the minimum number of individuals, and the age/sex profile of the population. Techniques for dealing with the particular problems of ossuary analysis are also presented. Issues of diet, nutritional adequacy, and health are addressed in Chapter 2. Patterns of dental pathology are used to make inferences about diet, while skeletal indicators of stress are used as measures of nutritional adequacy and disease insult. Chapter 3 tackles the suite of behaviors associated with interment in the ossuary, including pre-interment body treatment, cremation, and final burial. The demographic profile of the sample is used to make inferences about that portion of the group which was afforded ossuary burial.

The issues of agriculture and settled village life have consequences for demography, nutritional intake, and health. The analysis of this skeletal series might shed light on the debate concerning these issues. By themselves, the skeletal data are suggestive, but in no way do they constitute definitive proof of agricultural involvement or high-density settlement. Appropriate data to address these questions must come from sites, features, and activity areas other than the ossuary. The data generated by the archeological survey and testing program on Cape Cod conducted by the National Park Service refine the questions asked by archeologists, and provide the first step to their resolution.

## Acknowledgements

A number of individuals contributed to the successful completion of the analysis and resulting report of the human skeletal remains from the Indian Neck ossuary. Without their support, this research would have been much more difficult. Assistance with cleaning, cataloging, and sorting the remains was provided by Debra Schindler and Bob Paine, allowing the otherwise long and tedious part of the analysis to be completed much more quickly. Debra Martin played an essential role in the data collection and interpretation of bone histology and subadult bone growth. That portion of the analysis was completed only through her expertise and guidance. Her contribution is gratefully acknowledged. Don DeBlieux's help with preparing the thin-sections and data collection is also appreciated. Thanks are due to Alan Goodman for providing guidance during the data collection and analysis of enamel hypoplasias. I benefitted greatly from frequent consultation with him. Any errors are mine, however.

Numerous discussions with John Cross, Fred Dunford, and Leslie Shaw helped place the Indian Neck ossuary in a spatial, temporal, ecological, and social context. Although that context is not explicitly presented in my part of this volume, their insights helped shape the analysis and formulate the questions that were addressed both implicitly and explicitly. Comments from Leslie Shaw and Debra Billings on portions of an earlier draft of this manuscript are also appreciated. John Cross deserves special thanks for the long hours he spent reading the entire manuscript, making much needed editorial comments, and checking for errors I could no longer see. I am indebted to him for all of his time, effort, constant encouragement, and thoughtful consideration.

This project could not have been completed if it had not been for the efforts of two people. Because of his concern with and interest in biocultural adaptation of past human populations, George Armelagos played an instrumental role in getting the Indian Neck skeletal series to the University of Massachusetts. It was only through his encouragement that I became involved in this research. He willingly gave his time, shared his expertise, and offered advice whenever it was needed. I gratefully acknowledge his support, both as a friend and as my advisor. Finally, I am deeply indebted to Frank McManamon. Through his efforts, he was able to secure the necessary funding which allowed me to see the analysis and writing through to the end. I appreciate his willingness to give me a free hand in deciding the course the analysis would take, and his careful reading and editorial comments on the drafts of each of the chapters improved the final product. Frank's patience with me for missing deadlines consistently is especially noteworthy. It is only though his commitment and dedication to the project that this volume has come to fruition.

# CHAPTER 1

## Demography of the Indian Neck Ossuary

### Introduction

One of the primary values of archeologically-derived skeletal samples is the information they can provide concerning morbidity, mortality, and longevity of past populations. Indeed, they are the only potential data we have to evaluate disease processes and epidemiological change and the impact on demographic structure of pre-urban populations in prehistory. Demographic variables such as population size, population structure, mortality rate, birth rate and life expectancy can be used to characterize human populations, but certain of these variables can also be used to measure the quality of life in paleopopulations. Numerous social, biological, and ecological factors determine the shape of the demographic profile of a population. Each of these factors must be considered before a proper interpretation of the observed demographic pattern can be made.

The composite life table and the derived mortality statistics are the key tools in paleodemographic reconstruction using skeletal remains. Certain assumptions must be made, however, when using the life table technique. Buikstra and Mielke (1985) identify and discuss in detail four crucial assumptions. First, it must be assumed that humans in the past aged at the same rate as individuals in contemporary populations--those individuals from which aging standards have been developed. Second is the issue of small population size and violation of the assumptions of stable population theory. Third, it must be assumed that cultural practices, preservation, and archeological recovery yield unbiased cemetery samples that are representative of the population from which they are derived. Finally, determination of sex and age at death must be accurate.

It is the latter two assumptions that have generated the most controversy and criticism from demographers. Howell (1976, 1982) is an avid critic of paleodemographic studies, specifically arguing that cemeteries are incomplete and age determinations are too imprecise. A recent critique of paleodemographic studies centers on the alleged inability to accurately estimate age at death which lead Bouquet-Appel and Masset (1982) to assert that vital rates computed from skeletal samples are invalid and simply reflect stochastic processes. Recently, numerous researchers have convincingly countered many of these criticisms (e.g., Buikstra and Mielke 1985; Buikstra and Konigsberg 1985; Lovejoy et al. 1985; Van Gerven and Armelagos 1983). In particular, Lovejoy and co-workers (1985) have refined a number of methods for adult age determination, and show how the use of a systematic method of aging can produce highly accurate estimates of age at death in skeletal samples. They further contend that continued refinements in methods of skeletal aging will allow reliable and accurate demographic reconstructions.

It could be argued that ossuaries are ideally suited for paleodemographic research. In fact, ossuary skeletal series frequently have been used for demographic reconstruction (e.g., Churcher and Kenyon 1960; Sullivan and Katzenberg 1981; Ubelaker 1974, among others). In contrast to some other types of cemetery samples, ossuaries may well represent all or nearly all the members of a group. In addition, it is inferred from the ethnographic record that ossuary burials represent those individuals who died within a relatively short period of time, perhaps only 10 to 20 years. Thus, it could be convincingly argued that ossuary mortality profiles are an accurate reflection of the population from which they are drawn. At the same time, however, reconstruction of demographic profiles from ossuary samples poses a critical problem because of the difficulty in accurately estimating age at death. The difficulty stems from the inherent inability to identify complete skeletons, which greatly reduces the accuracy of age at death estimates. This problem of incomplete skeletons also hampers our ability to diagnose diseases and evaluate dietary adequacy, and in turn, assess the impact these factors have on the morbidity and mortality of the population. While these problems are important considerations for and potential limitations of ossuary skeletal samples, they are not necessarily insurmountable.

The purpose of this chapter is to describe the demographic characteristics of the Indian Neck skeletal series. First, details of the determination of minimum number of individuals interred in the ossuary are presented. This information could be useful for inferring the size of the social unit which contributed to the cemetery. The second goal of the analysis presented in this chapter is aging and sexing of the skeletal remains. A number of criteria are used to determine age and sex and the resulting demogrpahic profiles are presented. Ideally, these data would be used to construct life tables and interpret the mortality experience of the Indian Neck population. However tempting this would be, life table construction for the Indian Neck series would be ill-advised and will not be attempted here because of small sample size, the fact that the entire sample was not recovered, and an inability to accurately age the skeletons. The derived mortality profiles are essential, however, for the analysis of diet and health presented in the next chapter, and for making inferences about treatment of the dead (the subject of Chapter 3).

## Minimum Number of Individuals

The first step in the analysis was the determination of the minimum number of individuals recovered from the burial feature. This was accomplished by sorting all the remains according to bone type and counting the most commonly occurring feature or element. The minimum individual counts by bone for adults and subadults in the unburned portion of the sample are presented in Table 1.1. Ribs, all vertebrae except the atlas, axis, and 12th thoracic, and phalanges are excluded from the minimum count due to the obvious difficulty of determining the exact element in question. Long bones considered to be adult are those that demonstrated complete epiphyseal union, generally those individuals at least 18 years of age. Subadults are those individuals less than 18 years of age. Some bones of the skeleton reach developmental maturity before the age of 18, including, among others, such things as the temporal and many of the hand and foot bones. Thus it is possible that some subadults are included in the adult category. This potential problem is probably minor since there are so few individuals between the ages of 10 and 20.

A minimum of 25 adults is represented by the mandibular symphysis, a number nearly equalled by the left temporal. At least 22 subadults are represented by femora. It should be noted that this count was established by seriating all femora in increasing size order, keeping left and right sides separate. Two left infant femora did not have a size matched representative on the right side, thereby raising the minimum number from 20 to 22. A similar situation occurred with the subadult dentition. The mandibles and maxillae were seriated in order of increasing age based on dental calcification and eruption. If an upper and lower dentition were of the same developmental age they were counted as a single individual. There were cases, however, in which a maxilla lacked a correspondingly aged mandible or vice versa. The same was true for right and left sides. Thus the minimum number of subadults based on dentitions is 19 rather than 16 as determined solely by counting the mandibles. The procedure for age seriating the

TABLE 1.1

Minimum Number of Individuals by Bone: Unburned Sample

| Bone | Adult Right | Adult | Adult Left | Subadult Right | Subadult | Subadult Left |
|---|---|---|---|---|---|---|
| Frontal | 16 | | 16 | 13 | | 13 |
| Temporal | 20 | | 24 | 15 | | 12 |
| Occipital | | 19 | | | 14 | |
| Maxilla | 18 | | 19 | 10[1] | | 11[1] |
| Mandible | | 25 | | | 16 | |
| Femur | 20 | | 16 | 17[2] | | 20[2] |
| Tibia | 14 | | 10 | 16 | | 11 |
| Fibula | 6 | | 7 | 6 | | 7 |
| Humerus | 20 | | 18 | 17 | | 13 |
| Radius | 10 | | 9 | 6 | | 9 |
| Ulna | 18 | | 13 | 8 | | 14 |
| Clavicle | 12 | | 12 | 7 | | 5 |
| Scapula | 14 | | 13 | 13 | | 13 |
| Innominate | 15 | | 15 | 14 | | 13 |
| Patella | 8 | | 7 | | 2 | |
| Atlas | | 9 | | | 6 | |
| Axis | | 8 | | | 8 | |
| 12th Thoracic | | 6 | | | 3 | |
| Sacrum | | 8 | | | 4 | |
| Calcaneus | 6 | | 16 | 4 | | 5 |
| Talus | 10 | | 14 | 6 | | 4 |
| Cuboid | 6 | | 7 | 1 | | 1 |
| Navicular | 10 | | 12 | - | | 2 |
| Cuneiforms: | | | | | | |
| 1 | 4 | | 8 | 1 | | - |
| 2 | 4 | | 9 | | | |
| 3 | 5 | | 6 | | | |
| Metatarsal: | | | | | | |
| 1 | 8 | | 7 | | | |
| 2 | 5 | | 7 | | | |
| 3 | 7 | | 4 | | 23 Total | |
| 4 | 7 | | 8 | | | |
| 5 | 6 | | 9 | | | |
| Capitate | 2 | | 2 | | | |
| Hamate | 1 | | 1 | | | |
| Lunate | 2 | | 2 | | | |
| Navicular | 5 | | 3 | | | |
| Greater Multang. | 4 | | 1 | | | |
| Lesser Multang. | - | | 2 | | | |
| Metacarpal: | | | | | | |
| 1 | 2 | | 5 | - | | 2 |
| 2 | 5 | | 6 | | | |
| 3 | 5 | | 5 | | | |
| 4 | 4 | | 3 | - | | 1 |
| 5 | 5 | | 7 | | | |

1 Minimum number of individuals represented is 19 based on age seriation.

2 Minimum number of individuals represented is 22 based on age seriation. See text for a detailed discussion.

subaults will be discussed in greater detail in the section on subadult age determination.

Minimum individual counts were determined for the cremations in the same manner as the unburned individuals. The mandible, left temporal, and left scapula all indicate that at least 6 adults are represented (Table 1.2). At least 3 subadults are represented as indicated by both the left ulna and the occipital.

Before turning to a discussion of age and sex determination, a brief but necessary digression is in order. The conditions which brought about the fortuitous discovery of the ossuary (a backhoe excavation for a septic tank) resulted in considerable destruction to the integrity of the burial feature and the skeletal material within it. The backhoe digging destroyed an indeterminate amount of the ossuary. Subsequent investigation by the Park Service archeologists understandably focused on that portion of the feature remaining *in situ.* Simultaneous efforts by volunteers recovered as much bone as possible from the backhoe backdirt. To that end, approximately half the total volume of backdirt was screened and the bones kept separate from those recovered from the intact portion of the feature.

As an aid in estimating the size of the original burial feature, a separate count was made of bones recovered from the backdirt. These numbers were compared to those obtained from the intact portion of the ossuary. Comparability was ensured by counting the same bony element or feature used to establish minimum counts for the total sample. The frequency of occurrence of each bone for subadults and adults recovered from the backdirt is presented in Table 1.3. For purposes of this comparison, ribs, vertebrae, and the bones of the hands and feet have been omitted. The numbers in the "total" column are taken from Table 1.1 and represent the total count for that bone or element for the entire unburned sample (the cremations were not disturbed). The percentage figure is computed by dividing the number of individuals in the backdirt represented by any given bone by the total count for that bone. For example, of the 25 adults represented by mandibles, 13, or 52% were recovered from the backdirt. Of the 20 right adult femora, one half are from the backdirt, and so on. Representation of adults in the backdirt varies considerably from bone to bone, ranging from slightly more than 25% to as much as 100% of the total sample. Proportionately, the subadults are not as frequently represented in the backdirt as compared to the adults. In a number of cases, the bones were recovered exclusively from the intact portion of the ossuary.

These numbers are somewhat difficult to interpret. It is recognized that minimum numbers of individuals may not be the

TABLE 1.2

Minimum Number of Individuals by Bone: Cremated Sample

| Bone | Adult Right | Adult Left | Subadult Right | Subadult Left |
|---|---|---|---|---|
| Frontal | 5 | 3 | 1 | 2 |
| Temporal | 5 | 6 | 1 | 1 |
| Occipital | 4 | | 3 | |
| Maxilla | 5 | 4 | 1 | 1 |
| Mandible | 6 | | 2 | |
| Femur | 1 | 4 | 2 | 1 |
| Tibia | 4 | 5 | 2 | 1 |
| Fibula | 4 | 4 | 1 | - |
| Humerus | 5 | 5 | 1 | - |
| Radius | 5 | 5 | 1 | - |
| Ulna | 5 | 5 | - | 3 |
| Clavicle | 4 | 5 | 2 | - |
| Scapula | 4 | 6 | 2 | 2 |
| Innominate | 4 | 5 | 2 | 1 |
| Patella | 2 | 2 | - | - |
| Atlas | 5 | | 1 | |
| Axis | 5 | | 2 | |
| 12th Thoracic | 1 | | 2 | |
| Sacrum | 3 | | 1 | |
| Calcaneus | 5 | 3 | 1 | 1 |
| Talus | 5 | 5 | 2 | 1 |
| Cuboid | 4 | 4 | 1 | 1 |
| Navicular | 4 | 5 | - | - |
| Cuneiform: | | | | |
| 1 | 1 | 4 | | |
| 2 | 2 | 2 | | |
| 3 | 4 | 4 | | |
| Metatarsal: | | | | |
| 1 | 4 | 6 | | |
| 2 | 3 | 5 | | |
| 3 | 4 | 4 | 5 Total | |
| 4 | 4 | 5 | | |
| 5 | 3 | 4 | | |
| Capitate | 1 | 2 | | |
| Lunate | 1 | 1 | | |
| Navicular | 1 | 1 | | |
| Lesser Multang. | 1 | - | | |
| Metacarpal: | | | | |
| 1 | 4 | 3 | | |
| 2 | 5 | 4 | | |
| 3 | 4 | 3 | 2 Total | |
| 4 | 2 | 2 | | |
| 5 | 1 | 4 | | |

TABLE 1.3

Minimum Number of Individuals From the Backdirt

Adults

| Bone | Right | | | Left | | |
|---|---|---|---|---|---|---|
| | Backdirt | Total | % | Backdirt | Total | % |
| Frontal | 8 | 16 | (50.0) | 8 | 16 | (50.0) |
| Temporal | 11 | 20 | (55.0) | 16 | 24 | (67.0) |
| Occipital | 6 | 19 | (31.6) | | | |
| Maxilla | 8 | 18 | (44.0) | 8 | 19 | (42.0) |
| Mandible | 13 | 25 | (52.0) | | | |
| Femur | 10 | 20 | (50.0) | 16 | 16 | (100.0) |
| Tibia | 4 | 14 | (28.6) | 5 | 10 | (50.0) |
| Fibula | 2 | 16 | (33.3) | 2 | 7 | (33.3) |
| Humerus | 10 | 20 | (50.0) | 7 | 18 | (38.9) |
| Radius | 4 | 10 | (40.0) | 1 | 9 | (11.1) |
| Ulna | 11 | 18 | (61.0) | 0 | 13 | ( 0 ) |
| Clavicle | 6 | 12 | (50.0) | 7 | 12 | (58.0) |
| Scapula | 7 | 14 | (50.0) | 3 | 13 | (23.1) |
| Patella | 4 | 8 | (50.0) | 2 | 7 | (28.6) |
| Innominate | 9 | 15 | (60.0) | 6 | 15 | (40.0) |
| MEAN PERCENT | | | $\overline{X}$=47.6 | | | |

Subadults

| Bone | Right | | | Left | | |
|---|---|---|---|---|---|---|
| | Backdirt | Total | % | Backdirt | Total | % |
| Frontal | 7 | 13 | (53.8) | 6 | 13 | (40.0) |
| Temporal | 7 | 15 | (46.7) | 8 | 12 | (66.7) |
| Occipital | 2 | 14 | (14.3) | | | |
| Maxilla | 0 | 10 | ( 0 ) | 0 | 11 | ( 0 ) |
| Mandible | 2 | 16 | (12.5) | | | |
| Femur | 2 | 17 | (11.8) | 5 | 20 | (25.0) |
| Tibia | 0 | 16 | ( 0 ) | 0 | 11 | ( 0 ) |
| Fibula | 0 | 6 | ( 0 ) | 0 | 7 | ( 0 ) |
| Humerus | 1 | 17 | ( 5.9) | 1 | 13 | ( 7.7) |
| Radius | 2 | 6 | (33.3) | 0 | 9 | ( 0 ) |
| Ulna | 0 | 8 | ( 0 ) | 0 | 14 | ( 0 ) |
| Clavicle | 2 | 7 | (28.6) | 1 | 5 | (20.0) |
| Scapula | 0 | 13 | ( 0 ) | 0 | 13 | ( 0 ) |
| Patella | 0 | 1 | ( 0 ) | 0 | 1 | ( 0 ) |
| Innominate | 2 | 14 | (14.3) | 7 | 13 | (53.8) |
| MEAN PERCENT | | | $\overline{X}$=15.5 | | | |

best estimator of volume. Before bone weights could be taken, however, the entire sample was combined for subsequent analyses and those bones from the backdirt could not be separated with complete confidence. In an effort to overcome the problem and try to arrive at an estimate of the proportion of the ossuary which was recovered, a mean percent of bones from the backdirt is calculated. This number is derived by adding all the percentage figures and dividing by the number of bone classes. For adults, the mean percent of the total bone recovered from the backdirt is 47.6%. In other words, almost half of the total bone as determined from minimum number of adults was recovered from the backdirt. The mean value for the subadults is much lower (15.5%), so that approximately 84.5% of the subadult bone was recovered in situ. Given that the entire backdirt pile had not been screened for bone recovery, these numbers could suggest that at least half the ossuary was removed by the backhoe. As a worst-case scenario, assuming that all the backdirt had an equally likely chance of containing bone and only half the pile was screened, it is possible that as much as one-third of the entire unburned skeletal sample was not recovered.

## Sex Determination

Differences in morbidity and mortality between males and females have important implications for the maintenance, longevity, and social organization of any population. Thus, the correct determination of sex of skeletal remains is very important to the study of prehistoric behavior and population dynamics. The accuracy of sex determination is dependent on the completeness of the skeleton and whether the individual has reached sexual maturity at the time of death. Numerous studies on living populations show differences in maturation rate and body size between boys and girls. Unfortunately, few of these differences are unambiguously reflected in bony tissue. Despite this problem, a number of researchers have attempted to sex prepubescent skeletons using a variety of observational and metric techniques (e.g., Boucher 1955; Ditch and Rose 1972; Garn, Lewis and Kerewsky 1964; Hunt and Gleiser 1955; Reynolds 1945). All these studies have met with varying and limited success and depend on, among other things, complete skeletons and large samples. Because of the problems inherent with ossuary skeletal samples and because of the general lack of success of previous studies, sexing the Indian Neck subadults was not attempted.

Accurate sexing of adult skeletons is more straightforward and less problematic than for subadults. The degree of sexual demorphism has been studied both quantitatively and qualitatively and the results have been presented in numerous summary works (e.g., Bass 1971; Brothwell 1981; Krogman 1962; Ubelaker 1978; Workshop of European Anthropologists 1980). The most accurate indicator is the pelvis. Using a visual method of sex assessment, Phenice (1969) claims a 96% accuracy, corroborating the 95% accuracy of observational sexing using the pelvis alone as suggested by Krogman (1962). Dimorphic features of the cranium are also indicative of sex, but Krogman cautions that using the skull alone will produce, at best, accurate assignment only 90% of the time. The accuracy of sex determination based solely on visual assessment of mandibular morphology has not been tested on a sample of known gender. The cranium may exhibit a greater number of sexually dimorphic features, so that reliance on mandibular morphology alone is perhaps less likely to result in correct gender assignment than when using complete crania. If both the cranium and pelvis are available, however, accurate observational sexing is assured about 98% of the time (Krogman 1962).

Other researchers suggest that cranial and/or mandibular metrics provide a comparably accurate means of sexing. Discriminant functions have been derived from contemporary American white and black skeletal samples for the cranium and the mandible (Giles 1964, 1970; Giles and Elliot 1963). These researchers claim an accuracy of sex assignment 82-89% of the time. Although Giles and Elliot suggest that sexual dimorphism of the cranium and mandible outweigh racial differences, these functions are population specific, and applying them to other series requires an adjustment of the male-female dividing point for the population under study.

In a recent study, Meindl et al. (1985b) evaluated the accuracy of visually sexing crania and pelves by conducting a blind test on a skeletal sample of known sex. They also tested a number of the discriminant functions for cranial sexing presented by Giles and Elliot (1963). Their results confirm the findings of others: observational sexing is superior to metrical techniques; reliance on the crania alone can produce spurious results; and when both pelves and crania are considered, sex determination is very accurate.

When faced with the situation where cranial and pelvic elements are lacking, it is possible to estimate sex, although the determination is less reliable. Sex-related size differences in such features as the diameter of the humeral or femoral head or the circumference of the femoral mid-shaft have been used to discriminate sex metrically, and some studies claim accuracy at least as high as the more complex cranio-metric functions (e.g., Black 1978; DiBennardo and Taylor 1979; Krogman 1962; MacLaughlin and Bruce 1985). It must be cautioned, however, that absolute size and the magnitude of the differences is population-specific.

Sex determination of cremated human remains can be especially problematic. Van Vark (1974) appropriately points out that skeletal remains undergo variable changes in size and shape when burned. In addition, in any given skeletal series, the remains frequently consist of small fragments and each individual is differentially represented by bony elements. Gejvall (1963) examined 50 males and 49 females incinerated in a modern crematorium in Stockholm and, despite the difficulties just noted, he was able to determine sex in the majority of cases using both visual and metric techniques. These methods, particularly metrics, are most successful when applied to large series where sex can be established by visual assessment on a core sample of the most complete and best peserved individuals. A number of appropriate populaton-specific male-female metric sectioning points can then be established (see Gejvall 1963; Lisowski 1968; Wells 1960).

Inter-population metric comparisons of cremated remains are especially problematic due to bone shrinkage. Researchers conducting experimental studies of burned bone report a wide range in the amount of bone shrinkage, varying from none to as much as 25% (see references in Buikstra and Swegle n.d. and Shipman et al. 1984). Herrmann (1977) notes that shrinkage depends on a number of factors, among which are the relative proportion and distribution of compact and spongy bone, the mineral content of bone, and the temperature to which the bone has been heated. Buikstra and Swegle (n.d.) found that shrinkage of calcined bone did not exceed 6% in their experimental burning study but concur with Herrmann that the degree to which a bone has been incinerated and the conditions under which bones are cremated contribute to the amount of dimensional reduction. In a recent experimental study in which bones were burned under controlled conditions, Shipman and co-workers (1984) found that the percent shrinkage covaries with temperature. They suggest that application of a standard correction factor to measures of cremated bone is inappropriate, and instead suggest using a sliding scale "once the temperature to which the bones...have been heated has been established on other grounds" (Shipman et al. 1984:322).

Because complete skeletons are lacking in ossuaries and since there is differential representation of the bony elements used in sexing, various criteria are used for this study. These include observational sexing of the pelvis, cranium, and mandible and metric sex discrimination using maximal femoral head diameter and mid-shaft circumference of the femur. For the cremations, sex is assessed by visual inspection of the mandible. Metrics are not used primarily due to the problem of bone shrinkage discussed above.

The Indian Neck adult pelvic sample consisted of 14 left innominates. Dimorphic features used to determine sex are summarized in Bass (1971) and Krogman (1962) and include morphology of the symphyseal face and inferior pubic ramus, size of the sciatic notch, and relative size of the acetabulum. Based on these criteria, 8 were judged to be males and 6 were females (Table 1.4). Of the 5 innominates in the cremated sample, only two were complete enough to be judged for sex. These were both females (Table 1.4).

Only 12 skulls were complete enough to be sexed. Those morphological features observed included size and rugosity of the occipital, mastoids, and malars; degree of development of the supraorbital ridges; and size of the palate. Of the crania, 6 demonstrated "very male" morphology and only 3 exhibited female characteristics. Two of the 3 remaining crania are probable females and the other is likely a male (Table 1.4). The cremated crania were too framented to be useful in the assignment of sex.

Of the 25 adults represented by mandibles, 18 were sufficiently complete for observational sexing. Those characteristics considered were overall size and thickness of the mandible, symphyseal height and ramus breadth, gonial angle, and shape of the chin. Based on these criteria, 7 are judged to be distinctly male and 4 are distinctly female. Four of the remaining mandibles are most likely female and the other 3 are most likely male (Table 1.4). The cremated mandibles are surprisingly complete and the shape of the bone is not unduly distorted by warping and shinking. Only one mandible was too fragmented to be useful in observational sexing. Two exhibit female characteristics while the remaining 3 are probable males (Table 1.4).

Maximum diameter of the femoral head could be obtained from 10 right femora in the Indian Neck series. Summary data presented in Krogman (1962) suggest that males possess femoral head diameters of 46mm or greater while females generally measure 42mm or less. Individuals that fall in the range of 43-45mm cannot be sexed with any degree of confidence. Based on these size criteria, there are 6 males and only 2 females while 2 could not be assigned to either sex (Table 1.5).

In a recent study using the Libben series, Black (1978) used circumference of the femoral mid-shaft to discriminate sex. Based on this single measure, he was able to predict sex consistent with observational sexing of the complete skeleton 85% of the time. This method was tested against a modern cadaver sample of known sex by DiBennardo and Taylor (1979). Although mean male and female femoral circumference measures in the contemporary sample were absolutely larger than those of the Libben series, their findings corroborate those of Black.

TABLE 1.4

Representation of Adults by Sex:
Cranial, Mandibular, and Pelvic Morphology

| Bone | | Female | Probable Female | Probable Male | Male |
|---|---|---|---|---|---|
| Innominate | 1 | 6 | | | 8 |
| | 2 | 2 | | | |
| Cranium | 1 | 3 | 2 | 1 | 6 |
| Mandible | 1 | 4 | 4 | 3 | 7 |
| | 2 | | 2 | 3 | |

1 Unburned Sample
2 Cremated Sample

TABLE 1.5

Sex Distribution of the Unburned Adult Sample:
Femoral Head Diameter and Femoral Mid-Shaft Circumference

Femoral Head Diameter

| | Female | ? | Male |
|---|---|---|---|
| | 41-42 mm | 43-45 mm | 46-50 mm |
| Number | 2 | 2 | 6 |

Femoral Mid-Shaft Circumference

| | Female | ? | Male |
|---|---|---|---|
| | 77-79 mm | 81-86 mm | 87-97 mm |
| Number | 4 | 4 | 8 |

These researchers claim an accuracy in sex assignment of only 82%, however.

Femoral mid-shaft circumference was measured on 16 right femora from the Indian Neck sample. Since it is not possible to generate population-specific male and female means with appropriate sectioning points for this series, the sectioning points provided by Black (1978) for the Libben series and that provided by DiBennardo and Taylor (1979) for the modern sample are used. The mid-point of the male and female means for the Libben and contemporary series is 81mm and 86mm respectively. For this analysis, the mid-point values derived from these series are considered as end-points of a range representing maximum and minimum sectioning points. Those individuals in the Indian Neck series with measures of less than 81mm are considered female and those with a circumference greater than 86mm are considered to be male, while those that fall in the middle of this range cannot be sexed with confidence. The sex distribution based on mid-shaft circumference is presented in Table 1.5.

Considered alone, pelvic morphology provides the most accurate indicator of sex. In the Indian Neck series, only 8 males and 6 females could be sexed by the innominate, representing a little over half the minimum number of adults in the ossuary. Mid-shaft circumference of the femur, slightly more representative of the total adult sample (n=16, 64%), suggests that there are at least 8 males but only a minimum of 4 females. Although this criterion is less reliable, the standards were applied conservatively and correspond well with sexing of the pelvis. The mandible is the most commonly occurring bone available for sexing (n=18), representing 72% of the adults. The morphology of this element suggests that the number of males (10) slightly exceeds the number of females (8). The skull and femur head, representing only 48% and 40% of the minimum number of adults respectively, provide little additional information. Five of the 6 cremated adults are represented by the mandible and morphology suggests that 2 are female and 3 are male. Visual assessment of the pelvis corroborates that at least 2 females are represented in the cremations. These sample sizes are admittedly meager and the interpretive potential is limited. That females are nearly as well represented in the ossuary as males, however, clearly suggests that this form of burial is not restricted according to gender and more likely is afforded all of the group members. Similarly, cremation does not appear to be restricted according to sex.

## Subadult Age

Subadult age is generally determined on the basis of dental development, epiphyseal union, and long bone length. Dental development is the most useful for the younger ages while epiphyseal union plays an increasingly important role in age estimation for later subadult years. Regression equations expressing the correlation between dental age and long bone length have been computed for various skeletal series and provide an additional means of age estimation. Such standards are especially useful in those situations where dentitions are incomplete or totally missing. Alone, each of these criteria differ in accuracy of age estimation and each requires a unique set of assumptions and attendant shortcomings for their application. The use of multiple age indicators combined with a consistent program of seriation, however, enhances the reliability and accuracy of age assessment. Since discrete individuals are lacking in ossuaries, summary ages cannot be computed. Instead, each sample of elements must be aged by the relevant standards and the resulting demographic profiles compared.

Researchers would generally agree that dental development provides the most accurate estimate of subadult skeletal age. There is an extensive literature on dental development including growth and maturation as well as genetics. A brief discussion of the relative merits and reliability of timing of eruption and tooth calcification is presented in Ubelaker (1974). In his analysis of the Juhle ossuaries, Ubelaker (1974) aged the subadult dentitions using both eruption and calcification standards and found that the former produced consistently higher age estimates than the latter. Since dental calcification is less variable than eruption timing, this criterion is used for aging the Indian Neck ossuary subadults. Moorrees et al. (1963a, 1963b) provide two sets of calcification standards; one for 3 deciduous teeth and the other for 10 permanent teeth. Although separate standards are provided for males and females, the results are pooled since sex cannot be determined.

All subadult dentitions were seriated from youngest to oldest on the basis of dental development. This was accomplished by comparing the degree of calcification, although eruption was not totally ignored. Maxillae and mandibles were seriated separately and whenever possible, right and left mandibles and maxillae were matched by age. In those cases where right and left sides were not of sufficiently close age, they were considered to be separate individuals. Maxillae were also matched with mandibles according to age. If dental age was the same, the maxilla and mandible together were counted as a single individual. After the seriation was completed, each individual was assigned an age based on the standards provided by Moorrees et al. (1963a, 1963b). The subadult age distribution represented by dentitions is presented in Table 1.6.

A quick examination of Table 1.6 might lead to some confusion regarding numbers of individuals in any particular age category. It must be stressed again that maxillae were matched by age with mandibles. If the dental age was the same, it was counted as a single individual. By contrast, if the maxillary and mandibular dental ages were different, they were counted as separate individuals. For example, the numbers in the 0.5-0.9-year age category might suggest that only 2 individuals are represented. In this case, the maxillae represent 2 individuals of different age than the 2 individuals represented by mandibles. In the 5-6-year age group, 2 mandibles and maxillae were of the same age so that there are a minimum of 4 individuals represented in that age category. It is important to note that the youngest dentally aged individual is approximately 6 months of age. The other 3 individuals in the youngest age group are actually closer to 1 year of age.

For ossuary series, long bone length can be especially useful in aging subadults since the dentition is more fragile and may not be preserved as frequently as long bones. Unfortunately, there is a dearth of published standards that allow age estimation based on long bone growth. Johnston (1962) derived regression equations from the Archaic period Indian Knoll skeletal series, but includes only those individuals from birth to 5.5 years of age. More recently, Ubelaker (1978) published standards from a study comparing long bone growth to dental age for protohistoric Arikara Amerindians from South Dakota (Merchant and Ubelaker 1977). For that study, all subadults up to the approximate age of 18 are included. In order to use these standards for aging the Indian Neck ossuary subadults, it must be assumed that the genetic and environmental components of achieved adult stature are similar and that subadult growth rate is similar. The problems with making these assumptions are recognized, but lacking standards for skeletal series with close genetic and environmental affinities to the ossuary sample precludes a choice.

The femur, that element which was the most commonly represented and generally most complete, was used to estimate age. In an effort to overcome the problem of broken or incomplete bones, all femora were seriated according to size, smallest to largest, keeping right and left sides separate. Then, right and left femora were matched according to size. In some cases, a right femur did not have a corresponding size match among the left femora or vice versa. In effect, this raised the minimum number of individuals represented. A number of complete bones were present at various places in the

TABLE 1.6

Age Distribution of the Unburned Subadult Sample: Dental Development

| Age | Maxillae No. | Mandibles No. | Minimum Number |
|---|---|---|---|
| 0-0.5 | 0 | 0 | 0 |
| 0.5-0.9 | 2 | 2 | 4 |
| 1.0-1.9 | - | 5 | 5 |
| 2.0-2.9 | - | 1 | 1 |
| 3.0-3.9 | - | - | - |
| 4.0-4.9 | - | 1 | 1 |
| 5.0-6.9 | 3 | 3 | 4 |
| 7.0-8.9 | 1 | 1 | 2 |
| 9.0-10.5 | 2 | - | 2 |
| Total | | | 19 |

seriated femur assemblage. Diaphyseal length of these bones was measured to the nearest millimeter using a sliding caliper or osteometric board. Approximate ages were assigned based on the standards presented in Ubelaker (1978). Those whole bones were then used to define 5-year age intervals to which the incomplete diaphyses could be assigned. Obviously such a method is not a reliable means of determining an accurate age for an individual represented by an incomplete femur. This procedure, then, sacrifices a great deal of precision in age determination but allows the inclusion of individuals that would otherwise be excluded from the analysis. The representation of subadults by 5-year age categories is presented in Table 1.7.

As is the case for the dentition, it is notable that there were no femora so small as to be included in the birth to 6-month age category. To ensure that this age category was simply not represented by this bone, all other long bones were examined to see if any newborns were present. This search produced negative results. It is suggested that newborns and infants in their first 6 months of life are not included in the unburned portion of the ossuary. Furthermore, all of the individuals included in the 0.5-4.9 age group are 3 years of age or less, thus alleviating the potential problem of distinguishing between the first and second age categories. Two of the 3 individuals in the 15-20-year age group were assigned on the basis of epiphyseal union. In both cases, the distal epiphysis had not yet fused. According to standards presented in Krogman (1962) and McKern and Stewart (1957) fusion occurs between the ages of 15 and 17 in females and 16 to 18, sometimes as late as 20, in males.

Age distributions derived from dental development and femoral length produced very comparable results. For purposes of comparison, individuals represented by dentitions in the 0.5-0.9 age group are combined with those in the 1-4.9-year group. In the birth to 5-year age group, 10 individuals are represented by femora while 11 are represented by dentitions. In the 5-10-year age group, 1 more individual is represented by the dentition. Where the major difference occurs is in the 10-14.9- and 15-20-year age groups. No dental remains were identified that represent individuals from either of these age categories.

Three subadults were included in the cremations. Complete, albeit warped, ulnae of 2 allowed an estimation of diaphyseal length. Based on the standards presented by Ubelaker (1978), both these individuals are 7-10 years of age. Size of the proximal ulna and occipital condyle suggests that the third subadult is a newborn or late-term fetus (see Table 1.7).

TABLE 1.7

Age Distribution of Unburned and Cremated Subadults: Long Bone Diaphyseal Length

| Age | Femur[1] No. | Ulna[2] No. |
|---|---|---|
| 0-0.5 | - | 1 |
| .5-4.9 | 10 | - |
| 5-9.9 | 7 | 2 |
| 10-14.9 | 2 | - |
| 15-19.9 | 3 | - |

1 Unburned Sample
2 Cremated Sample

## Adult Age at Death

There are number of criteria that can be used to determine adult age at death. Among those most commmonly employed are metamorphosis of the face of the pubic symphysis, cranial suture closure, dental wear, and dental and long-bone microstructure. In general, one indicator is used to determine age. Most often this is the pubic symphysis and only when this feature is missing are other criteria considered. A recent study by Lovejoy and co-workers (1985) demonstrates the superiority of multifactorial aging over the single criterion approach. For that study, a sample of the Hammon-Todd Skeletal Collection was seriated using five different age indicators including metamorphosis of the pubic symphysis and the auricular surface, trabecular involution of the proximal femur, dental wear, and ectocranial suture closure. A final age was assigned to each individual as a weighted average of all five criteria. In order to test the reliability and accuracy of the summary aging technique, the procedure was repeated using a different sample of the Todd Collection. While this aging method is more accurate, it obviously cannot be used on ossuary skeletal samples. Seriation should reduce observer error, however, and the age profiles obtained from the various criteria can be compared as a means of checking for consistency.

The criteria used to estimate adult age at death for the unburned sample of the ossuary include the pubic symphysis, dental wear, and microstructural features of thin-sections taken from femoral mid-shafts. Lovejoy and co-workers (1985) describe a new method of age determination based on morphological changes in the auricular surface and claim it is at least as accurate as pubic symphyseal aging. In addition, another method for age estimation based on degree of ectocranial suture closure has been developed by Meindl and Lovejoy (1985) and has been shown to be a valuable indicator of age at death. Too few complete or nearly complete crania and auricular surfaces in the ossuary series, however, did not warrant application of these methods.

Morphological change of the face of the pubic symphysis traditionally has been regarded as the best indicator of adult age at death. Unfortunately, only 6 pubes from the ossuary were preserved; 3 right and 3 left. Ages were assigned, primarily using the 10-phase system described by Todd (1920,1921) and modified by Meindl et al. (1985). Standards for the three-component system devised by McKern and Stewart (1957) for males and a similar system for females (Gilbert and McKern 1973) were also compared. Of the left pubes, 2 were judged to be females aged 17-20. The other was a 50+ male. A male aged 25-30 and one aged 50+ are represented by right symphyses. In addition, there is a pubis that could not be sexed but was judged to represent an individual between the ages of 20 and 30. One additional 18-20 year-old female is represented by a right innominate. Although the symphysis is not preserved, lack of epiphyseal union provided the age estimate. The age distribution represented by pubic symphyses is summarized in Table 1.8.

A less commonly used means of aging skeletal remains than the pubic symphysis is dental attrition. A primary criticism of using dental wear is that attrition is highly variable both within and between populations and is therefore useful only as a means of distinguishing between young and old individuals. As Lovejoy (1985) points out, this is a valid criticism when attempting to assign age to a single skeleton. If an entire skeletal sample is considered systematically, however, dental wear can be a powerful aging tool (e.g., Miles 1963). In fact, Lovejoy et al. (1985) posit that dental wear is superior to all other criteria as a means of estimating age at death in archeological populations and even found it to be highly effective in the contemporary Todd Collection. Because differing types of diet and non-dietary tooth use affect the rate of tooth wear (see Molnar 1971, 1972, among others), a universal standard cannot be applied across populations. Instead, rate of attrition must be established for the population in question by determining functional wear gradients (see Brothwell 1981; Lovejoy 1985; Miles 1963, 1978).

Miles (1963, 1978) carefully describes the method of aging by molar wear. For this method, subadult dentitions in the 6-18-year age range are used to determine a functional rate of wear for each of the three molars. The rate of wear determined from these individuals is then used to estimate age of older individuals by means of seriation and reference to those of "known" age.

In the Indian Neck sample, 20 mandibles and 13 maxillae were used for dental aging. Initially they were seriated from youngest to oldest based on the amount of molar wear. Postmortem loss of anterior, single-rooted teeth was frequent and these teeth could not be used consistently. Once the dentitions were age-seriated, they were grouped according to similar degrees of molar wear.

For small skeletal series, aging by dental wear poses certain difficulties. In the case of the Indian Neck ossuary in particular, there were insufficient numbers of subadult dentitions in the 6- to 18-year age range to be able to establish a functional rate of dental wear for this population. The youngest individuals in the adult sample demonstrated at least polish or small wear facets on the occlusal surface of

TABLE 1.8

Age Distribution of the Unburned Adult Sample:
The Pubic Symphysis

| Left | Right |
| --- | --- |
| Two 17-20 Females | One 18-20 Female |
| One 50+ Male | One 25-30 Male |
| | One 50+ Male |
| | One 20-30 Sex Undetermined |

the third molars. The degree of wear suggests these individuals are approximately 20 years of age, thus establishing the minimum age of the adults. Because functional wear rates could not be established for the Indian Neck series, the remainder of the sample was divided into 10-year age groups using the sectioning points established according to the modal wear patterns presented by Lovejoy (1985) for the Libben series. The obvious difficulty with using the modal wear patterns of the Libben series to age the Indian Neck sample is the probable dietary differences between these two groups. The case for dietary similarities could be argued, however, since evidence suggests subsistence of the Libben population was hunting, gathering, and fishing. Fish constituted the largest portion of the food remains recovered from the site, followed by small mammal and vegetable remains (Lovejoy 1985). If the diet of the Indian Neck population was grittier than that of Libben, however, using the wear patterns established for that sample would result in an over-estimation of age in the Indian Neck series. The adult age distribution based on dental wear is presented in Table 1.9.

Methods for determining age at death based on internal remodeling of bone have been useful for ossuary series. Kerley (1965) pioneered a method of aging by the microscopic examination of cortical bone from mid-shaft thin sections of the femur, tibia, and fibula. Four structures are observed and quantified in each of four microscopic fields situated in the outer third of the long-bone cortex. Regression equations expressing the correlation of the number of these histological structures with age were then computed. Later, modifications of Kerley's original method were offered by Ahlqvist and Damsten (1969) and Singh and Gunberg (1970). Comparisons of these methods have been made by Bouvier and Ubelaker (1977) and Stout and Gehlert (1980). Because they were unable to achieve reasonable age estimates using the Singh and Gunberg (1970) method, Stout and Gehlert (1980) did not test that method. Of the other two methods, both comparison studies found that Kerley's (1965) method with the modifications in field size and regression formulae provided by Kerley and Ubelaker (1978) produced the most accurate age estimates. Based on a sample of 13 individuals of known age at death, Stout and Gehlert (1980) found that mean age computed by averaging the ages predicted by each of Kerley's regression formulae was the best predictor of age at death. The reliance on histological aging is not without its problems, however. Care must be taken to ensure that proper field size is utilized. More critical, perhaps, is the lack of consensus in the definitions of the histological structures themselves (Stout and Gehlert 1980). Further, a variety of disease processes and nutritional factors are known to alter patterns of cortical bone micromorphometry (Martin et al. 1981).

TABLE 1.9

Adult Age Distribution of the Unburned Sample: Dental Wear

| Age | Mandible | Maxilla |
|---|---|---|
| 20-30 | 9 | 6 |
| 30-40 | 3 | 3 |
| 40-50 | 3 | 1 |
| 50+ | 5 | 3 |
| Total | 20 | 13 |

It is with these cautions clearly in mind that microscopic age determination of the unburned adult sample from the ossuary was undertaken. These data were collected by the author and Debra L. Martin and have been presented only summarily (Bradley et al. 1982; Magennis and Martin 1982), and hence a more detailed discussion is warranted. Initially, thick sections were taken from the mid-shaft of 16 right adult femora. Thin-sections were removed with a Buehler Isomet saw and then cleaned in a dilute detergent solution in an ultrasonic cleaner. Once the sections were dry, they were mounted on glass slides, ground to a thickness of approximately 100um, polished, and cleaned again in a dilute bleach solution. Kerley's (1965) method with corrections provided by Kerley and Ubelaker (1978) was selected since it appears to produce a more accurate age estimate. The sections were examined at a magnification of 100X with a field size of 1.62mm which was set with a stage micrometer.

In the Kerley aging method, four structures are quantified. These include number of complete osteons, number of osteon fragments, percent of circumferential lamellar bone, and number of non-Haversion canals. In the ossuary sample, preservation of each of these structures varied greatly between individuals. In order to be as consistent as possible, only complete osteons were counted. There is some justification for this decision since Stout and Gehlert (1980) found that Kerley's regression formula for complete femoral osteons provided the greatest accuracy for estimating age for individuals less than 51 years of age. This single criterion was superceded in accuracy of aging for the entire age range only by mean regression age and femoral osteon fragments.

The microscopic age computed from the appropriate regression formula for each of the 16 right femora are presented in Table 1.10. Individuals are then grouped into 5-year age categories. For those individuals whose computed age was at the high end of any particular 5-year age category, rounding the decimal to the nearest whole year usually pushed the individual into the next older age category.

Comparison of the age distribution as determined by dental attrition and osteon counts shows that adults greater than 35 years of age are under-represented by the microscopic aging method. When relying on osteon counts alone, it would seem that there is a tendency to under-age individuals. Three individuals were determined to be between the ages of 16 and 20, yet all 3 demonstrated complete epiphyseal union, suggesting a slightly older age than that computed. At the older end of the age spectrum, 5 individuals represented by mandibles are 50+, 3 of which demonstrate antemortem loss of most teeth with significant alveolar resorption. Further, at least one 50+ aged male is represented by the pubic symphysis.

TABLE 1.10

Microscopic Age Determination of the Unburned Sample: Femoral Mid-Shaft

| Specimen Number | Estimated Age | Age Group |
|---|---|---|
| FR6 | 16.06 | |
| FR14 | 16.46 | 15-20 |
| FR19 | 18.97 | |
| FR16 | 19.84 | |
| FR3 | 21.84 | 20-25 |
| FR7 | 21.63 | |
| FR2 | 22.56 | |
| FR15 | 24.47 | |
| FR11 | 25.44 | 25-30 |
| FR12 | 26.44 | |
| FR5 | 29.54 | |
| FR4 | 32.81 | 30-35 |
| FR1 | 32.81 | |
| FR9 | 33.37 | |
| FR8 | 39.83 | 40-45 |
| FR10 | 43.50 | |

None of these older individuals appear to be represented by femora. Since advanced age is generally correlated with thinner long-bone cortices it is possible that femora of older individuals are most prone to post-mortem breakage and constitute a greater percentage of the substantial femur fragment category, and hence were excluded from the analysis.

Age estimation for the cremated adults is problematic. No pubic symphyses were preserved and no tooth crowns survived intact. One innominate, that of a female, demonstrated incomplete union of the iliac crest, suggesting this individual is 18-20 years of age. In the unburned sample, antemortem tooth loss was infrequent and confined to the oldest age groups where attrition was advanced. Caries rate in the Indian Neck sample is very low (see Chapter 2 for a detailed discussion), and tooth loss appears to be related to excessive attrition rather than caries. Antemortem loss of molars in 2 of the 6 cremated mandibles would suggest then, that these individuals are of advanced age, or 45+. This assertion is supported by cranial suture closure, where at least 2 individuals demonstrated complete closure and almost total obliteration of the sutures. Age could not be estimated for the remaining 3 adults. The lack of antemortem tooth loss would indicate, however, that these individuals are between 20 and 45+ years of age (see Table 1.11).

## Summary

Minimally, 56 individuals are represented in the Indian Neck ossuary; of these, 9 were cremated. The number of individuals originally interred in the ossuary was undoubtedly greater than this since, an indeterminate amount of the burial feature was removed by a backhoe and all the bones were not recovered.

A summary of the entire age distribution established using all aging methods for the unburned portion of the ossuary is presented in Table 1.12. The age distribution of the cremations is not included in this table because the aging criteria differ from those used to age the unburned sample and the resulting age categories differ. Refer to Table 1.11 for the age distribution of the cremations. For the subadults, long-bone age corresponds well with that determined by dental development. Since more individuals are represented by femora, this criterion appears to characterize the subadults best. The greatest number of adults is represented by the mandible. Comparison of the adult age profiles based on molar wear and microstructure of the femur indicates that older individuals are underrepresented by the latter aging criterion. The most

TABLE 1.11

Age Distribution of the Cremated Sample[1]

| Age | Number | Criterion |
|---|---|---|
| Newborn | 1 | Size of ulna and occipital condyle |
| 7-10 | 2 | Diaphyseal length of ulna |
| 18-20 | 1 | Epiphyseal union |
| 20-45 | 3 | No antemortem tooth loss |
| 45+ | 2 | Antemortem tooth loss |

1 See text for detailed discussion of aging criteria

TABLE 1.12

Age Distribution of the Indian Neck Ossuary: Unburned Sample

| Age | Dental Calcification | Femoral Length | Dental Wear | Histology | Pubic Symphysis |
|---|---|---|---|---|---|
| 0-0.5 | | | | | |
| .5-4.9 | 11 | 10 | | | |
| 5-9.9 | 8 | 7 | | | |
| 10-14.9 | | 2 | | | |
| 15-19.9 | | 3 | | 3 | 2 |
| 20-29.9 | | | 9 | 7 | 2 |
| 30-39.9 | | | 3 | 6 | |
| 40-49.9 | | | 3 | | |
| 50+ | | | 5 | | 1 |
| Total | 19 | 22 | 20 | 16 | 5 |

likely age distribution for the unburned sample therefore, would be based on subadult femoral diaphyseal length and adult mandibular molar wear. The age distribution for the cremated sample is based on a variety of criteria. Construction of life tables and a detailed evaluation of the obtained vital rates is not warranted due to a number of factors, including 1) the small sample size of the ossuary, 2) the indeterminate amount of the sample which was not recovered, and 3) the difficulty in providing refined estimates of adult age at death. The age and sex distributions of both cremated and unburned samples, however, suggest that the Indian Neck ossuary represents all, or nearly all, of those individuals who were members of the group except those less than 6 months of age.

# CHAPTER 2

## Diet, Nutrition, and Health of the Indian Neck Population

### Introduction

Food procurement strategies and dietary reconstruction have traditionally been a concern among archeologists. Increasingly sophisticated methods have been developed for reconstructing paleoenvironments, for identifying the resource spectrum that was available, as well as isolating those resources actually utilized. Data derived from the study of plant and animal remains, environmental variables, and material culture should be considered in concert in order to understand or clarify diet, nutrition and subsistence patterns, and the biological consequences of these strategies for past human groups. Fundamental to these concerns is the study of the human skeletal remains for, it is precisely those remains which can provide a measure of the adaptive success of the populations.

Numerous studies have shown that environmental stress, particularly dietary and nutritional stress, can have a significant impact on skeletal growth and maintenance, morbidity and mortality. In turn, characteristic patterns of disturbed bone growth and pathology can aid in the identification of the stress which caused them. The purpose of this analysis is to examine patterns of certain classes of pathology and skeletal growth and maintenance in an effort to provide evidence potentially useful for the reconstruction of prehistoric diet and nutrition for the Indian Neck population. For the purposes at hand, diet is considered to be what is actually eaten while nutrition refers to the physiological adequacy of the diet.

The dentition is a particularly useful indicator of diet. Patterns of tooth wear can provide evidence for food resources utilized by human groups, food processing techniques, changes in the physical consistency of foods eaten, or non-dietary tooth use. Dental pathologies, particularly caries, also have been shown to be sensitive indicators of diet. Numerous studies have demonstrated that the incidence and patterning of caries increase in proportion to the amount of refined carbohydrates, softer foods, and sugar included in the diet. The first goal of this analysis is to provide evidence for the type of diet of the Indian Neck population. This will be accomplished through an analysis of patterns of dental enamel chipping, a particular type of dental wear. In addition, the prevalence and patterning of dental caries will be evaluated in an effort to provide a measure of the relative amount of refined carbohydrates included in the diet.

The second goal of this analysis is to provide a measure of nutritional quality and disease stress in the Indian Neck population. Evaluation of the impact of nutrition and disease stress in ancient populations requires a careful examination of skeletal pathologies. Diagnosis of a particular disease or nutritional deficiency is a difficult challenge. In some instances diagnosis is fairly secure, but more often than not, as Buikstra and Cook (1980) point out, disease processes result in ambiguity. This is because bone has a limited number of ways in which it can respond to dietary and disease insult. Skeletal growth and maintenance is determined by the interaction and balance of two processes, the formation of bone by osteoblastic cells, and the selective removal of bone by osteoclastic cells. A proper balance between the two processes is necessary for normal bone growth. Under pathological conditions, however, there is an imbalance in the rates of formation and resorption, and bone reacts by either increasing or decreasing formation, resorption, or a combination of the two processes at different sites within the bone. Interpretation of this dynamic process is complicated by the general nature of skeletal response to disruption, and many disturbances may produce similar results.

This is true not only of nutritional disturbances but of disease processes as well. To complicate the matter further, a disease may not necessarily produce an identical response in all individuals. Although a certain disease may cause a particular pattern of pathology, it may not be completely exhibited by a given individual. Also frustrating is the fact that certain recurring patterns of skeletal pathology are not clinically identifiable, as Palkovich (1978) points out.

Similarly, identification of specific nutritional deficiencies is inconclusive and ambiguous. This is partly due to an inability to isolate and identify the specific effects of a given deficiency. Numerous researchers point out that single deficiency diseases are relatively rare in human populations (Huss-Ashmorè et al. 1982; Martorell 1980; Scrimshaw et al. 1968). Steinbock emphasizes "that malnutrition is rarely selective for only one vital dietary component. Malnutrition (including malabsorption and excessive loss of nutrients) is almost always multiple, resulting in deficiency of several or many nutrients to varying degrees" (Steinbock 1976:232). Citing experimental studies in malnutrition, Huss-Ashmore et al. (1982) point out that many animals with nutritional imbalances are reluctant to eat and thus suffer to some degree from protein or energy deficits as well.

A further complicating factor in the identification of specific disease and nutritional deficiencies is the synergistic effect of these processes. Martorell (1980) points to the relative importance of deficiencies in energy as well as protein as causes of malnutrition. In turn, malnutrition results in an increased risk of infection since it plays a critical role in decreased immunocompetence. At the same time, however, infection is an important cause of malnutrition. In fact, Martorell (1980) suggests that infection is more important as a cause of malnutrition than dietary insufficiency. Infection influences nutritional status through its effects on appetite, and nutrient absorption and metabolism. He points to a paucity of studies relating illness and loss of appetite to a concomitant reduction in dietary intake, but suggests that the effect is profound. Illness, especially gastrointestinal infection, affects nutritional status by limiting absorption of nutrients. Thus, malnutrition frequently follows, even with sufficient dietary intake. Finally, infection has a deleterious effect on nutrient metabolism and utilization. Most pronounced are disturbances in protein metabolism. Studies of infectious disease processes point to their role in protein catabolism, which if sufficiently severe and prolonged, leads to the depletion of lean body mass (Scrimshaw et al. 1968).

Protein-energy malnutrition has the greatest impact on infants and children. In part, this stems from increased nutritional needs during periods of rapid growth--nutrient demands which are often incompletely met. Infants and children are also more likely to suffer from infectious diseases. Indeed, morbidity and mortality of these age groups provide the best reflection of the health status of a populaton. Adults, however, are not immune to the deleterious effects of dietary insufficiency and infectious disease. These factors frequently result in reduced work capacity as well as increased morbidity and mortality. The impact on the adult portion of the population can profoundly effect reproduction and economic production.

In studies of archeologically-derived skeletal samples, bioanthropologists have increasingly relied on the use of non-specific indicators of stress to evaluate dietary sufficiency and health of the population. These generalized stress indicators are so named because they result from any number of underlying causes and reflect physiological disruption. Among others, generalized stress indicators include dental enamel defects, radiopaque transverse lines (Harris Lines), patterns of juvenile growth, adult sexual dimorphism, cortical bone modeling and remodeling, as well as mortality patterns. Porotic hyperostosis, a skeletal lesion resulting from iron-deficiency anemia, provides strong evidence for nutritional deficiencies and frequently their synergistic relationship to infectious disease. Infectious disease loads are reflected in part by prevalence, severity, and patterning of skeletal lesions. Because these stress indicators are likely to have overlapping etiologies, use of a single indicator may not be especially informative. Thus, Goodman et al. (1984) advocate the use of several stress indicators simultaneously because it enhances our ability to delineate patterning of stress within a population. In turn, an understanding of patterning, particularly as it relates to mortality, may allow inference about underlying causation. Finally, patterning of nutritional and disease stress must be interpreted within an ecological and cultural context.

Ossuary skeletal series pose certain limitations on our ability to delineate patterns of stress within the population. Interpretation will be subject to a number of constraints. First is the inability to identify complete individuals. For example, this problem eliminates the possibility of using differential diagnosis to establish the occurrence of particular diseases, a procedure which requires, among other things, delineating patterned lesions within the individual and for the population. Second, an ossuary series consists of samples of skeletal elements, rather than samples of individuals. Thus, it is likely, for instance, that the sample of teeth used to assess enamel hypoplasias does not represent exactly the same sample of tibiae used to evaluate lesions indicative of infectious disease. Third, the successful Onterpretation of indicators of physiological disruption lies, in part, on the identificaton of age-specific response patterns, and their relationship to mortality. The problems associated with aging the skeletal elements compound the sampling problems. Age estimates are imprecise and age categories must be combined, thereby obscuring subtle differences in age-specific patterning of nutritional and disease stress.

Clearly, an investigation of the impact of dietary adequacy and disease insults in prehistoric populations using ossuary skeletal series sacrifices a great deal of precision, and interpretive potential is therefore compromised. It is possible, however, to alleviate or reduce the negative effect of some of these problems. By concentrating on the subadult portion of the population for which it is possible to estimate age at death by dental development as well as body size, age categories need not be so large, especially when compared to adults where defining 10-year age intervals would be optimistic. In addition, numerous studies, including those of archeological populations and contemporary groups, have yielded a diverse comparative data base. This provides, at the very least, an estimate of the relative impact of environmental insult experienced by the population being considered. This may not be entirely satisfying, for undoubtedly more questions will be generated than answered. By the same token, posing new hypotheses generates a fertile ground for further inquiry.

For this study, four general indicators of stress are used to evaluate nutritional adequacy and disease insult in the Indian Neck Population. These include subadult bone growth and maintenance; enamel hypoplasias (macroscopically observable enamel defects); porotic hyperostosis (an indicator of nutritional anemia); and periostitis (skeletal lesions indicative of generalized infectious insults). The primary focus is on the juvenile portion of the sample because the subadults provide a better reflection of the overall health and well-being of the population than do the adults.

## Diet and the Dentition

A variety of indicators of generalized stress are used to assess nutritional status and disease load of the Indian Neck population. These indicators provide some measure of the severity and/or duration of nutritional or disease insults and dietary adequacy. Particular features of the dentition, however, can be indicative of diet. Examined singly or in concert, caries, periodontal disease, and attrition have been used to estimate amount of carbohydrate intake, consistency of foods eaten, and methods of food preparation. The hard tissue changes which result from these processes readily lend themselves to comparisons between populations where diet is known.

Dental attrition has been used, not only as a means of estimating age at death, but as a powerful indicator of dietary and non-dietary tooth use as well. Numerous studies have ocumented the correlation between diet, food preparation techniques, and dental wear (see Powell [1985] for a review). In addition to diet and methods of food preparation, Molnar (1971) points out that technological activities can affect both the rate and types of dental wear. Molnar (1971) also suggests that, among other things, observed differences in dental wear patterns can be used to infer sexual division of labor or sex-related dietary differences, age-related dietary differences, or perhaps economic or dietary specializations which cross-cut age or sex boundaries.

Powell (1985) summarizes the results of several diachronic studies which show that the amount and rate of dental wear is inversely correlated with improvements in food processing techniques. In particular, the use of stone grinding implements for the preparation of flour has been implicated as a primary cause of increased rates in dental wear in many of those studies (e.g., Smith 1972). Relative proportion and types of food consumed also will alter the rate, amount, and pattern of wear. Patterns of dental wear must be interpreted within the context of the level of a group's technology, physical environment, and subsistence strategy. In addition to these factors, the ability to determine age at death is of critical importance, as is sufficient sample size. Since neither of these important criteria are met by the Indian Neck ossuary series, rates of dental wear relative to age cannot be determined and interpreting patterns of wear would prove elusive. This is most unfortunate, since the time period represented by the ossuary sample is one in which there may be a shift in subsistence pattern. Lacking appropriate floral and faunal assemblages, litle is known or can be inferred about this population's diet. The dentition could provide some of the desired information, if the conditions mentioned above could be met. Dental chipping (a particular type of wear) may prove to be useful, however, in generating hypotheses about diet during this period.

## Dental Chipping

The frequency and severity of dental chipping can also be used as an indicator of dietary status. Because of the similarities in appearance to chipped stone artifacts, Turner and Cadien (1969) refer to this type of dental wear as "pressure chipping", and describe it as a situation in which the enamel or dentin of a tooth crown may be splintered, fractured, or crushed to a major or minor degree. In their study of Eskimo, Aleut, and northern Indian dentitions, they found high frequencies of chipping among Eskimos and were able to distinguish those groups from the other arctic and subarctic samples. The high frequency of chipping, especially among the high arctic series (80-90% of the individuals), is attributed to differences in diet and tooth use. Turner and Cadien suggest that the harsh environment would pose a greater threat of starvation and that all possible nutrients would be extracted from an animal, including eating the bones and/or splintering them for the marrow (Turner and Cadien 1969).

In a later study of prehistoric Jomonese dentitions, Turner (1979) notes that few individuals demonstrate the extremely crushed occlusal surfaces frequently observed in the Eskimo samples. Among the Jomon, groups with a presumed mixed agricultural and hunting-gathering-fishing subsistence economy, chipping is infrequent, often restricted to one or a few teeth, and involves only a small portion of the crown. Turner compares the Jomon chipping frequencies with those of the samples cited above and finds no significant difference between the Jomonese and Aleuts. He attributes this to the dietary sufficiency of these two groups in contrast to the near starvation/crisis situation posited for the high arctic Eskimos (Turner 1979).

The Indian Neck dentitions were examined for evidence of dental chipping. In order to make these data comparable to those presented by Turner and Cadien (1969), only teeth from complete or nearly complete adult mandibles and maxillae are reported, despite the fact that chipping was observed on many of the isolated teeth. Here, adults are considered to be those whose third molars had erupted. Like the other two studies, no attempt was made to quantify severity of chipping, the location of chips on any given tooth, nor which teeth had at least one chip. It is recognized that all these variables may be important for isolating aspects of the environment and/or behavior responsible for producing enamel chips. Small sample size, large numbers of missing teeth for those few individuals with complete or nearly complete mandibles or maxillae, and frequent post-mortem enamel destruction simply did not allow such a fine-grained analysis.

All teeth were examined with the aid of a 10X binocular dissecting microscope. Due to the post-mortem enamel destruction noted above, only those chips which demonstrated smoothed edges or polished surfaces were scored. For this study, a chip could be as small as a tiny micro-flake removed from the enamel surface (Figure 2.1). Such small flakes often occurred around the perimeter of the tooth crown, but most frequently on the occlusal aspect of the interproximal wear facets. The molars were most prone to chipping. Not all chips were small, however. A number of individuals demonstrated more severe tooth destruction ranging from removal of the enamel on the entire buccal surface, to the extreme case where one quarter of the tooth crown had been chipped off (see Figure 2.2).

The frequency of dental chipping for the adult Indian Neck mandibles and maxillae are presented in Tables 2.1 and 2.2. In both tables, individuals are listed in order of increasing age as determined from the seriation by degree of molar wear. For each individual, the number of teeth that showed evidence of at least one chip is recorded. Of those individuals represented by maxillae, all had at least one tooth with a chip, while all but one of the individuals represented by mandibles had at least one chipped tooth. This frequency is higher than the 91.1% reported for the high Arctic adult Sadlermiut Eskimo

Figure 2.1: Small Dental Chip on Occlusal Aspect of Interproximal Surface of Mandibular Right Second Molar.

Figure 2.2: Large Enamel Chip on Buccal Surface of Mandibular Left First Molar.

(Turner and Cadien 1969). In part, this must be due to different criteria for what is considered a dental chip. Neither Turner and Cadien (1969) or Turner (1979) clearly state the criteria they used, a problem further compounded by the fact that the accompanying photograph shows only the maxillary anterior teeth (Turner and Cadien 1969). Alhough this issue is not addressed by Costa (1980), what could be considered severe dental chipping is clearly evident in the mandibular premolars and molars shown in his Figure 1 (Costa 1980:502).

Sex differences as well as age-correlated differences in dental chipping frequencies could be used to test hypotheses concerning a variety of factors contributing to the incidence of this type of dental wear. For example, Turner and Cadien (1969) did not find a significant difference in chipping between males and females in any of the skeletal series they examined, despite the fact that high Arctic Eskimo females use their teeth extensively for hide processing. This evidence is used to further support their hypothesis that hard inclusions in the diet, specifically bones, were a major cause of dental chipping rather than non-dietary differences in tooth use. Among the Jomon, however, Turner (1979) did find a significant sex difference in chipping, but offers no possible explanations. Although it is tempting to test hypotheses concerning gender differences related to diet or behavior within the Indian Neck population, such an exercise is not possible because the sample size is too small and many of the dentitions could not be sexed with confidence.

Age-related tooth use differences, either dietary or non-dietary, potentially could be evaluated using dental chipping data. Under conditions of constant exposure to dental chip- or trauma-producing factors, (for example, diet), an increase in chipping frequency with advancing age would be expected. Older individuals would be expected to show the cumulative effects of exposure from an early age onward. Further, teeth that are most heavily worn might be expected to demonstrate greater amounts of chipping. As the structural support afforded by the occlusal enamel is worn away, increased chipping around the perimeter of the occlusal surface (or more extreme responses such as that shown in Figure 2.1) might be expected. Deviations from this expected pattern might suggest different dietary or non-dietary tooth use behavior related to specific age groups.

The relationship between increased incidence of dental chipping and advancing age was examined for the Indian Neck maxillary and mandibular samples. As noted above, the dentitions were seriated according to molar wear, and this served as the age estimator. Mandibular and maxillary samples were divided in half, with the younger adults being those less than 30 years of age and the older adults being 30 years of age

TABLE 2.1

Adult Mandibles with Chipped Teeth*

| Specimen | No. Teeth Present | No. Teeth Chipped | Percent |
|---|---|---|---|
| UIV-C | 6 | 1 | 16.7 |
| 30 | 13 | 6 | 46.1 |
| 18 | 6 | 3 | 50.0 |
| 17 | 6 | 0 | -- |
| 5/35 | 16 | 6 | 37.5 |
| 13 | 6 | 2 | 33.3 |
| 33/28 | 7 | 4 | 57.1 |
| 27 | 10 | 4 | 40.0 |
| UI-20/B | 9 | 4 | 44.0 |
| Subtotal[1] | 79 | 30 | 40.0 |
| BD2 | 8 | 6 | 75.0 |
| BDE | 4 | 4 | 100.0 |
| BDA | 4 | 1 | 25.0 |
| BD1 | 4 | 4 | 100.0 |
| 16 | 13 | 7 | 53.8 |
| 12 | 16 | 8 | 50.0 |
| 15 | 6 | 5 | 83.3 |
| Subtotal[2] | 55 | 35 | 63.7 |
| Grand Total | 134 | 65 | 48.5 |

* Specimens listed in increasing age order based on dental wear
1 Adults 30 years of age or less
2 Adults greater than 30 years of age

TABLE 2.2

Adult Maxillae with Chipped Teeth*

| Specimen | No. Teeth Present | No. Teeth Chipped | Percent |
|---|---|---|---|
| BD5 | 8 | 2 | 25.0 |
| 6 | 7 | 3 | 42.9 |
| 32 | 4 | 3 | 75.0 |
| BD2 | 7 | 3 | 42.9 |
| 5 | 16 | 6 | 37.5 |
| 3 | 13 | 7 | 53.8 |
| 25/13/31 | 12 | 4 | 33.3 |
| Subtotal[1] | 67 | 28 | 41.8 |
| 9 | 9 | 3 | 33.3 |
| 8 | 9 | 3 | 33.3 |
| BD1 | 14 | 5 | 35.7 |
| 12 | 16 | 6 | 37.5 |
| 11 | 5 | 3 | 60.0 |
| 38 | 11 | 2 | 18.2 |
| Subtotal[2] | 64 | 22 | 34.4 |
| Grand Total | 131 | 50 | 38.2 |

* Specimens listed in increasing age order based on dental wear
1 Adults 30 years of age or less
2 Adults greater than 30 years of age

or greater. In the young adult mandibles, 30 of the 79 teeth present were chipped, while 35 of the 55 older adult teeth showed evidence of chipping. Forty percent of the teeth from younger individuals are chipped; 63.7% of the older adult teeth show evidence of enamel chips. This apparent age-related trend does not hold for the maxillae, however. In fact, the reverse is true: 42% of the younger adult teeth and 34% of the older adult teeth are chipped. The primary difference between the mandibles and maxillae appears to be the under-representation of chipped teeth in the older adult maxillae. This is contrary to what was expected and may represent age-related tooth use differences. Alternatively, the failure to distinguish location, severity, and specific teeth chipped may be obscuring any underlying age relationship. Further, maxillary and mandibular teeth may be subject to different masticatory stresses.

It is recognized that the causes of dental chipping are multifactored and the result is a wide range of variation in expression of this feature. It is only by well-reasoned arguments supported through and tested by quantified evidence that the complex interaction between all the variables can be elucidated. The Indian Neck skeletal series is clearly not appropriate for such a detailed study. What is of importance here, though, is that all, or nearly all of the adults exhibited at least some form of dental chipping, often times severe. It is not necessary to posit chewing bones as part of the diet as proposed for the Eskimo to explain the Indian Neck data. It would not be unreasonable to suggest, however, that either the teeth were subject to extreme non-dietary activity, or that hard particles such as sand, small gravels, or perhaps fragments of shell were frequently masticated. This amount of dental chipping would not lend support to a hypothesized diet in which ground cereal was a major constituent, although it is possible that only seasonal exposure to large grit and other hard particles in the diet could produce the observed chipping pattern.

## Dental Caries

Caries is one of the primary dental diseases in extant populations. Costa (1980) points out that while census data on caries rates are readily available for many industrialized societies, little is known about the world-wide distribution of caries. Information on the incidence and patterning of caries in past populations is spotty, with the preponderance of studies focusing on North American Indian and Eskimo groups, or European populations. In reviewing any of the literature, it is often observed that there is an increased incidence of dental caries through time. The elevated frequency of caries represents not only greater numbers of individuals with carious lesions, but higher frequencies of carious teeth for any given individual, as well as inclusion of the deciduous dentition in carious attacks (see Brabrant 1967). This increased incidence of caries is associated with greater dietary intake of carbohydrates, and the frequency is elevated even more with consumption of highly refined carbohydrates and sugars.

These findings have been largely corroborated by a recent series of studies by Moore and Corbett (1971, 1973, 1975) and Corbett and Moore (1976). In those studies, the distribution of caries by tooth, location of a lesion on the tooth, and age were examined for a number of British skeletal samples dating from the Iron Age through the 19th century. They found that in the approximate 2000 years from the Iron Age through the late Medieval period, the rate and pattern of caries remained largely unchanged. By the 17th century, however, there is a significant increase in the prevalence of caries as well as a change in the predominate site of carious attack. This secular change in overall prevalence and distribution of caries approximates that observed in modern populations, and the timing and the initiation of that change corresponds to increased consumption of sugar and refined carbohydrates (Corbett and Moore 1976).

The negative impact of consuming a modern diet on dental health has been demonstrated among a number of groups. Costa (1980), citing the work of others, notes that early in this century, the teeth of Eskimo groups were nearly caries-free; increased contact with European groups with concomitant increases in consumption of European foods resulted in precipitous increases in the rate of dental caries (see also Price 1934). In a more recent study of Eskimo groups, Mayhall (1970) compared individuals for which the majority of the diet consisted of native foods (including seal, caribou, fish, and walrus) with those whose diet consisted mainly of purchased food. He found a two- to eight-fold increase in the incidence of caries. Indeed, the deleterious effect due to consumption of highly-refined carbohydrates and sugars has not escaped the attention of dental clinicians today, and there is an enormous and varied body of literature dealing with the etiology of dental caries.

What is less well understood, however, is the etiology of dental caries associated with the change from a diet consisting of hunted and gathered foods to one which incorporates domesticated cereal grains. That there is a correlation between greater reliance on agriculture and increased incidence of dental caries has been demonstrated by numerous studies. Larsen (1980, 1981, 1983, 1984) examined a number of prehistoric skeletal series representing hunting/gathering and agricultural modes of subsistence from coastal Georgia. Among the pre-agricultural groups, dental caries were uncommon. With the adoption of agriculture (presumably maize in this case), there is a marked increase in the frequency of dental caries. This same trend has been observed in the Lower Mississippi Valley and Caddo culture areas (Rose et al. 1984), the Ohio River Valley (Cassidy 1984; Perzigian et al. 1984), Sudanese Nubia (Martin et al 1984), and Central Japan (Turner 1979), to mention only a few studies.

In fact, the positive association between agriculture and relatively high rates of dental caries is so strong that caries rate has been used as a means of testing hypotheses concerning the inclusion of agriculturally-produced carbohydrates in the diet. Turner (1978) examined 7 individuals from a Valdivia Phase occupation in Ecuador to test such a hypothesis. Low numbers of carious teeth (only 2 teeth representing 2.2% of the 90 teeth observed) led Turner to suggest that maize agriculture was not an important dietary constituent. In a more detailed study, Turner (1979) examined 101 crania from the Middle to Late Jomon period in Japan, a period generally considered to represent hunting, gathering, and fishing subsistence economies. High rates of dental crown caries, in addition to other oral pathologies, are used to posit the inclusion of agriculturally-produced carbohydrates in the diet, and support arguments for an early introduction of cultigens in the area.

While agriculturally-produced carbohydrates are generally associated with high caries rates, high caries rate is not necessarily associated with agriculture per se, despite Turner's enthusiasm for and support of the assumption. In fact, in a later study, Turner and Machado (1983) examined 77 individuals from an Archaic Brazilian series with a hunting, gathering and fishing economy. They found that the percentage of carious teeth (10.7%) equalled that of pre-industrial agriculturalists. They suggest the inclusion of manioc or thule roots in the diet as the principal cause. Further, the authors indicate that this rate of dental caries corresponds well with California hunting-gathering groups that relied on ground acorn meal as a dietary constituent (Turner and Machado 1983). A similarly high rate of caries is reported by Costa (1980) for the Ipuitak skeletal series. Compared to the Tigara that succeeded them, the Ipuitak demonstrate nearly 3 times the percent of carious teeth. Costa (1980) indicates that the diet of these two groups was essentially the same with the only significant difference being the protein source, not the relative amounts of protein, carbohydrates, and fats. A plausible explanation is not offered, however, to elucidate the cause of the observed differences in caries rates.

As a further caution in using caries rates alone as a means of dietary reconstruction, it should be noted that all groups which include at least some cultigens in their diet do not have correspondingly high rates of caries. Based on a world-wide survey, Turner (1979) presents data indicating that some groups with an agricultural economy show percent carious teeth as low or lower than some hunter-gatherers. Caries formation depends on a number of factors, including not only the quantity of carbohydrates consumed, but the form of the carbohydrate as well. Further, other dietary constituents and the proportion in which they are consumed are important, as are food preparation techniques, the abrasive quality of foods, types of bacteria present in the mouth, and oral hygiene, (see Powell [1985] for a more detailed discussion).

For the Indian Neck series, all tooth crown and root surfaces of the adult dentitions and isolated teeth were examined for the presence of caries. This was accomplished with the aid of a 10X binocular dissecting microscope. Lesions were scored according to severity and location on the tooth: mesial, distal, buccal, lingual, or occlusal surfaces as well as root surface caries. In the Indian Neck series, all observed caries are essentially incipient; in no cases did cavitation proceed to the point of exposing the pulp cavity with subsequent abscessing or tooth loss. Nonetheless, numerous teeth were observed with very small cavities, generally on the occlusal surface. These small lesions were literally the size of pin points (Figure 2.3), and only in those cases where enamel was very thin due to attrition was dentin exposed. This category of caries was distinguished from pit caries on the basis of size, pit caries being larger. The most extreme carious lesion, a small pit on the occlusal surface of both mandibular first molars of one individual, is shown in Figure 2.4.

The frequency of caries for all teeth observed is presented in Table 2.3. Lesions occurred almost exclusively on the occlusal surface of the teeth, although lesions in the buccal fissure of the molars occasionally did occur. None were observed on the inter-proximal surfaces, or the lingual surface. One mandibular molar may have had a small lesion just beginning to form on the mesial aspect of the cemento-enamel junction, but less than ideal preservation prevented a confident assessment. Because lesions were confined to the occlusal surface and occurred infrequently in the buccal fissures, these two categories were combined. Since caries are uncommon on the anterior teeth, central and lateral incisors, and first and second premolars were combined. Due to the amount of attrition, many of the isolated molars could not be identified with confidence and were therefore combined in a single category as well.

Comparison of the frequency of lesions, whether pin point or small pits, on the maxillary and mandibular teeth shows that the mandibular teeth are more prone to cavitation. Slightly more than 21% of the mandibular teeth demonstrated tiny, pin

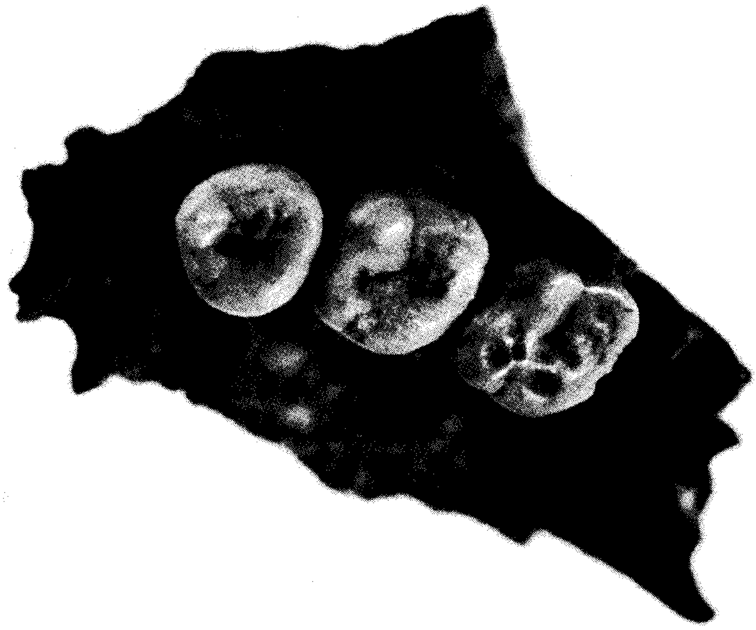

Figure 2.3: Small Occlusal Pit Type Carie on Maxillary Right Third Molar.

Figure 2.4: Largest Carious Lesion Exhibited in the Indian Neck Series; Mandibular Right First Molar.

TABLE 2.3

Prevalence of Dental Caries in the Permanent Teeth*

| Tooth | No. Teeth Observed | Pin-Point Caries N | Pin-Point Caries % | Small Pit Caries N | Small Pit Caries % |
|---|---|---|---|---|---|
| Maxilla: | | | | | |
| Incisors | 28 | 0 | | 0 | |
| Canines | 28 | 0 | | 0 | |
| Premolars | 42 | 2 | 4.8 | 0 | |
| M1 | 32 | 4 | 12.5 | 0 | |
| M2 | 26 | 8 | 30.8 | 0 | |
| M3 | 22 | 3 | 13.6 | 3 | 13.6 |
| Isolated Molars | 12 | 5 | 41.7 | 0 | ____ |
| Total | 190 | 27 | 14.2 | 3 | 1.6 |
| Mandible: | | | | | |
| Incisors | 28 | 0 | | 0 | |
| Canines | 10 | 0 | | 0 | |
| Premolars | 45 | 10 | 22.2 | 1 | 2.2 |
| M1 | 29 | 8 | 27.6 | 6 | 20.7 |
| M2 | 29 | 5 | 17.2 | 5 | 17.2 |
| M3 | 23 | 10 | 43.5 | 1 | 4.3 |
| Isolated Molars | 24 | 7 | 29.2 | 2 | 8.3 |
| Total | 188 | 40 | 21.3 | 15 | 8.0 |
| Grand Total | 378 | 67 | 17.7 | 18 | 4.8 |

* Includes all tooth surfaces. No caries observed on interproximal surfaces or roots.

point sized-caries while 8% had a small pit. Correspondingly, in the maxillary dentition, 14.2% and 1.6% of the teeth demonstrated pin point and small pit caries respectively. Considering only the pit caries, the order of caries susceptible teeth are mandibular first molars, mandibular second molars, maxillary third molars, and finally, mandibular third molars. No maxillary first or second molars demonstrated the presence of caries.

As a means of assessing whether the caries frequency of the Indian Neck series is suggestive of diet consisting primarily of resources obtained by hunting, gathering, and fishing or one in which cultigens were a major constituent, comparisons can be made with frequencies of dental caries reported in other studies. Turner (1979) presents data from a world-wide survey of reported caries frequency based on studies of living and skeletal populations with differing subsistence economies. For purposes of comparison, a few studies were selected from Turner (1979:625) which show the minimum and maximum frequency of caries reported for hunter-gatherers and agriculturalists. Since 1979, numerous studies of caries have been conducted but only a few have been selected for comparison here. Because many researchers present lesion data as percentage of individuals with at least one carious tooth, this survey is biased in favor of those that report their data as percent of teeth with caries. Frequency of carious teeth of selected hunter-gatherer and agricultural groups as reported in the literature is presented in Table 2.4. Since no consideration is given to the severity or location of lesions on teeth, this comparion is both conservative and somewhat crude.

For the Indian Neck series, a caries frequency of 4.8% suggests closer affinities with other hunter-gatherer groups than with agriculturalists. The relatively low frequency of caries from Dynastic Period agriculturalists in Egypt should not go unnoticed, however. Turner (1979) also reports data from groups with mixed subsistence strategies which include agriculture with hunting, gathering, and/or fishing. Reported frequencies range from 1.0%-10.3% carious teeth. Clearly, then, the Indian Neck ossuary caries frequency falls easily within the range reported for a mixed subsistence strategy. As pointed out, however, frequency of caries alone may not be the best indicator of relative amount of cultigens in the diet. Location and severity of lesions have also been shown to change with increased consumption of carbohydrates (Corbett and Moore 1976). In fact, prior to the incorporation of highly refined carbohydrates and sugars in the diet, in all the British series the most common site of carious attack is at the cemento-enamel junction (Corbett and Moore 1976; Moore and Corbett 1971, 1973, 1975). In the Indian Neck series, with one possible exception, no lesions were observed at the cemento-enamel junction,

TABLE 2.4

Prevalence of Caries in Selected Samples of Hunter-Gatherer and Agricultural Subsistence Economies

| Hunter-Gatherer % Caries[1] | Agricultural % Caries[1] | Location | Source |
|---|---|---|---|
| 1.0 | 18.0 | Nubia | Martin et al. (1984) |
| 2.5 | 13.0-24.8 | Ohio | Persigian et al. (1984) |
| 1.5 | 15.6 | Georgia | Larsen (1984) |
| 3.5-14.1 | | Alaska | Costa (1980) |
| 1.6-5.3 | | Australia | Cited in Turner (1979) |
| 0-0.4 | | N.W. Coast | Cited in Turner (1979) |
| | 4.9-15.2 | American S.W. | Cited in Turner (1979) |
| | 2.3-4.4 | Egypt | Cited in Turned (1979) |

1 Prevalence calculated as percentage of observed teeth with caries

suggesting that sticky carbohydrates were not a major dietary constituent. Further, no caries were larger than a small pit, and lack of dentin exposure in many of the pits was common. The vast majority of the caries occurred on teeth exhibiting little or no attrition. Since all observed caries were small or tiny and occurred on teeth with little attrition, caries are being eroded away before they have a chance to enlarge and invade the pulp cavity. This pattern also fails to support an hypothesis of a diet with an abundance of sticky carbohydrates. The relatively low frequency of dental caries, lack of lesions on interstitial surfaces, at the cemento-enamel junction and root surfaces, lack of cavities larger than a small pit, combined with a high frequency of chipped and crushed teeth does not suggest consumption of sticky carbohydrates in any significant quantity. Taken together, the dental data instead suggest a subsistence strategy largely based on hunting, gathering, and probably fishing.

## Nutritional Adequacy and Health

### Enamel Hypoplasias

During dental development, a variety of systemic stressors, especially under- or malnutrition and infectious disease, can produce abnormal enamel growth patterns. Current research has demonstrated that the frequency of developmental disturbances is greatly influenced by quality and quantity of diet. Teeth are ideally suited for analyses of systemic metabolic insults, for unlike bone, once dental enamel is formed, it remains largely unaltered. Thus, disturbances in enamel formation provide an indelible record of stress episodes. Because enamel defects are relatively permanent, adult dentitions can be used to provide a measure of environmental insults which occurred during childhood, since it is possible to determine the developmental age at which stressful events occurred (Goodman et al. 1980; Rose et al. 1985).

Enamel hypoplasias, one type of dental defect, are commonly used to provide a measure of dietary adequacy. Enamel hypoplasias are defined as transverse lines, bands, or pits of decreased enamel thickness which are visible on tooth crown surfaces (Goodman et al. 1980, 1984; Sarnat and Schour 1941). Such decreases in enamel thickness result from a temporary disruption of enamel matrix formation (see Rose et al. 1985 for a review of this process.) Epidemiological, clinical, and experimental studies have demonstrated statistical associations between enamel hypoplasias and a variety of disease and nutrition-related disorders (reviewed in Rose et al. 1985).

Because of the wide spectrum of metabolic insults associated with enamel hypoplasias, their precise etiology remains unknown, and as such, these developmetal dental defects are generally non-specific in nature. When evaluated in conjunction with other skeletal indicators, however, enamel hypoplasias can effectively be used as a measure of nutritional adequacy and disease insults.

In recent years, paleopathologists have increasingly relied on enamel hypoplasias as an indicator of generalized stress and dietary adequacy. Goodman and Armelagos (1985a) point out that the popularity of this indicator is likely related to the clear clinical and experimental evidence for their use as stress indicators, their relative permanence, and the ability to determine the age at which environmental insult occurred. As one of the first to study hypoplasia patterns in an archeological sample, Swardsted (1966) demonstrated an inverse correlation between frequency of hypoplasias and social status in a Swedish Medieval population. In an analysis of the Dickson Mounds skeletal series, Goodman and co-workers (1980, 1984) found a statistically significant association between increased frequency of hypoplasias in the transition from hunting and gathering to predominately agricultural subsistence strategies. This same phenomenon has been observed in a number of other prehistoric North American skeletal samples (see several studies in Cohen and Armelagos 1984).

A number of methodological differences in the analysis and interpretation of hypoplasias make comparison of growth disruption events between populations difficult. One problem is that researchers frequently do not examine the same tooth or teeth. In addition, different standards for tooth crown development are used, and standards for minimal severity of hypoplastic lines are not universally agreed upon. Further, total frequencies of hypoplasias are often presented without regard to the developmental age at which the defect occurred, or the mortality structure of the population being examined. Hence, interpretation of these data is difficult. Goodman and co-workers (1980) suggest a standardized method that minimizes some of these problems. Commonly, it is assumed that all teeth are equally susceptible to the formation of enamel defects. El-Najjar et al. (1978), however, found the frequency of defects to be greater on the anterior teeth. Focusing on those individuals from the Dickson Mounds with the most complete dentitions, Goodman et al. (1980) also found that certain teeth are more likly to demonstrate a hypoplasia. In particular, the canines provide a more sensitive measure of stress between the ages of 3 an 6.5 while the maxillary central incisors are the most susceptible to enamel defects between birth and 3 years of age. Goodman and co-workers also found that when the maxillary central incisor and mandibular canine were considered together, over 95% of total growth disruptions were observed on at least one of these teeth. They conclude that these provide the two "best teeth" for analyis resulting in a great time savings with minimal loss of information.

In order to determine when stressful events occurred, Goodman et al. (1980) propose converting hypoplasias to the developmental age at which they occurred. The standards for enamel crown development provided by Massler et al. (1941) are used. These standards are modified for metric analysis by Swardsted (1966) and a similar version of this chart is presented by Goodman et al. (1980). While the use of dental developmental standards based on a small sample of American Whites is frequently criticized, the lack of suitable alternatives leaves little choice. Despite these problems, Rose et al. (1985) suggest that the chronologies are accurate to a 6-month interval.

For the analysis of the Indian Neck series, enamel hypoplasias were observed and recorded for all permanent maxillary central incisors and canines, and mandibular canines. Age at death of the sample ranges from 6 to 50+ years and includes both sexes. Of the 11 maxillary central incisors, 4 are associated with individuals that died between the age of 6 and 15, while 5 of the 26 maxillary canines represent individuals in that same age group. Because only 8 mandibular canines could be identified, those data are not presented here, despite the fact that this tooth has been shown to be one of the two "best teeth" for hypoplasia analysis (Goodman et al. (1980).

All teeth were throroughly cleaned in order to remove any calculus or foreign substances adhering to the crown. Each tooth was observed for the presence of hypoplasias, defined here as a transverse line, band, or pits of decreased enamel thickness (Figure 2.5). The presence of enamel defects was confirmed with the aid of a binocular dissecting microscope with a magnification of 10X. Initially, the amount of enamel loss due to attrition was estimated and height of the tooth crown was measured. The position of each hypoplasia was determined by measuring from the center of the defect to the cemento-enamel junction. All measurements were taken with a Helios needle-point caliper to the nearest tenth of a millimeter. Measurements were then converted to each half-year period in which a hypoplasia developed from birth to approximately 6.5 years of age by using the chart presented by Goodman and co-workers (1980).

Only 1 of the 26 maxillary canines examined lacked a hypoplasia. More than half of the teeth had 2-3 defects (Table 2.5). Like that shown for the canine, the vast majority of the maxillary central incisors demonstrated 2-3 hypoplastic lines. The chronological distribution of hypoplasias by half-year

Figure 2.5: Enamel Hypoplasias; Mandibular Left Canine.

TABLE 2.5

Number of Hypoplasias per Tooth

| | Number of Hypoplasias | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | 1 | | 2-3 | | 3 | | |
| | N | (%) | N | (%) | N | (%) | N | (%) | Total N |
| Maxillary Incisor | 0 | - | 1 | ( 9.1) | 9 | (81.8) | 1 | ( 9.1) | 11 |
| Maxillary Canine | 1 | (3.8) | 6 | (23.1) | 15 | (57.7) | 4 | (15.4) | 26 |

developmental intervals for these two teeth is presented in Table 2.6 and graphically represented in Figure 2.6. The peak frequency of enamel defects occurs on the central incisor between 2.5 and 3 years of age (90%) with a decline to 70% and 63.6% at 3-3.5 and 3.5-4.0 years respectively. In contrast, the maxillary canine shows relatively low frequencies of hypoplastic lines until the age of 3.5-4, where there is a sharp increase to 50%. There is a slight decrease in this frequency between the age of 5-5.5 declining to 7.7% by the age of 5.6-6 years of age. Of all the enamel defects observed on the canines, fully 81% occur between the ages of 3.5 and 5.5. For the incisor, however, nearly 74% of all defects occur between 2.5 and 4 years of age.

The shape of the chronological distribution curves for the Indian Neck incisors and canines compares reasonably well with those presented for Dickson Mounds (Goodman and Armelagos 1985a, 1985b), although there are some differences. In the Dickson Mounds sample, the peak frequency of incisor hypoplasias occurs between the ages of 2-2.5 while it occurs 6 months later for the Indian Neck sample. The peak frequency of canine hypoplasias occurs at the same age for both series although Dickson Mounds demonstrates a marked decline in hypoplasias after the age of 4. The relatively high frequency of hypoplasias in the Indian Neck sample is maintained until the age of 5. Comparison of the Indian Neck hypoplasia curves with those derived from Black Mesa (Magennis and Martin 1985) show marked similarities for the central incisor while the canine curve is very similar to the slightly later developing mandibular canine for the Black Mesa series.

Although the shape of the hypoplasia chronology curves for Dickson Mounds and the Indian Neck sample are similar, the magnitude of the difference is marked. In the Indian Neck series, 50% of the canines demonstrate an enamel defect at 3.5-4.0 years of age, compared to about 32% for the mandibular canines at Dickson Mounds. For the central incisor, the Indian Neck hypoplasia frequency exceeds the Dickson Mounds sample by a factor only slightly less than 2. Comparing the Indian Neck incisor values to those from Black Mesa, however, reveals only small differences. The canines from the Black Mesa series also show peak values of nearly 50% at 4-4.5 years of age although these values are for the mandibular canine, a tooth which Goodman et al. (1980) suggest is slightly more susceptible to enamel defects than the maxillary canine.

It is not certain whether the large differences in frequencies of hypoplasias between the Dickson Mounds series and the Indian Neck sample is primarily a reflection of greater amounts of stress experienced by the Indian Neck subadults or to what extent methodological differences account for the discrepancy. As noted previously, Goodman and co-workers

TABLE 2.6

Distribution of Hypoplasias by Developmental Age:
Maxillary Central Incisor and Canine

| Age | Incisor | | | Canine | | |
|---|---|---|---|---|---|---|
| | N[1] | N[2] | % | N[1] | N[2] | % |
| 0-0.5 | 5 | 0 | - | 6 | 1 | 16.7 |
| 0.5-1.0 | 5 | 0 | - | 10 | 1 | 10.0 |
| 1.0-1.5 | 5 | 0 | - | 13 | 1 | 7.7 |
| 1.5-2.0 | 8 | 2 | 25.0 | 15 | 1 | 6.7 |
| 2.0-2.5 | 9 | 3 | 33.3 | 16 | 0 | - |
| 2.5-3.0 | 10 | 9 | 90.0 | 18 | 2 | 11.1 |
| 3.0-3.5 | 10 | 7 | 70.0 | 23 | 3 | 13.0 |
| 3.5-4.0 | 11 | 7 | 63.6 | 26 | 13 | 50.0 |
| 4.0-4.5 | 11 | 3 | 27.3 | 26 | 13 | 50.0 |
| 4.5-5.0 | | | | 26 | 12 | 46.2 |
| 5.0-5.5 | | | | 26 | 9 | 34.6 |
| 5.5-6.0 | | | | 26 | 2 | 7.7 |

1 Number of observations in developmental age period
2 Number of hypoplasias in that developmental age period

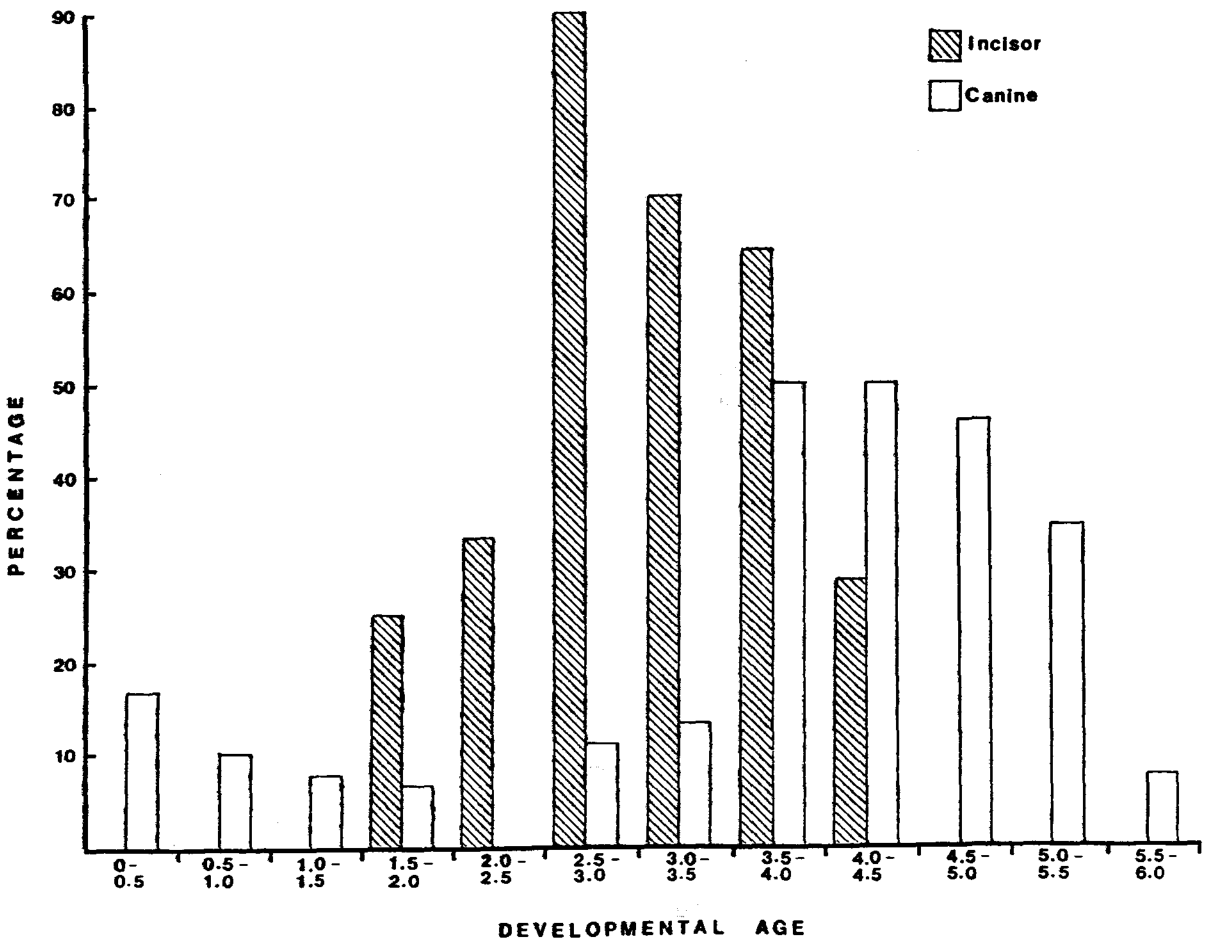


Figure 2.6: Chronological Distribution of Enamel Hypoplasias.

(1980) point out that one of the difficulties in comparing hypoplasia studies is the lack of consensus in the criterion of minimal severity of a hypoplastic defect. For this study, all hypoplasias were counted, including those which had to be confirmed with the aid of the binocular microscope. Thus, many thin, shallow defects undoubtedly contribute to the elevated hypoplasia frequencies in the Indian Neck series. This is an important methodological issue which needs to be resolved. This author is unaware of any studies that address questions of the relationship of the duration, severity, and timing of a metabolic insult to the severity and location of an enamel hypoplasia. An underlying assumption of most studies is that only moderate to severe hypoplastic lines reflect significant stressful episodes, and/or that shallow lines only reflect developmental "noise".

Another important problem with interpreting the differences in hypoplasia frequencies is that of mortality selection. Studies have shown that individuals with hypoplasias have a lower mean age at death than those without (Cook and Buikstra 1979; Rose et al. 1985). Therefore, frequencies of hypoplasias could differ significantly because of differences in the mortality structure of the samples. As a partial solution to this problem, Rose and co-workers (1985) suggest focusing on age-specific rates of dental defects. Unfortunately, the small sample size of the Indian Neck series does not lend itself to this type of analysis. In fact, at least 20% of the dental sample consists of subadults in the 6 to 15 year age group, and Cook and Buikstra (1979) carefully argue that children with enamel defects have experienced metabolic insults that render them less able to cope with nutritional and disease insults. These individuals are more likely to be included in the mortality sample than those without enamel defects. Thus the inclusion of the subadults in this study may be contributing to the high rates of hypoplasias reported here.

Despite the observed differences in hypoplasia frequencies, the chronological distribution of enamel defects demonstrated in the Indian Neck series is similar to other prehistoric skeletal series. The peak frequency of hypoplasias in the central incisor occurs at 2.5-3, the same peak as that demonstrated for the Black Mesa series. This is 6 months later than the peak observed in the Dickson Mounds samples. The 6 month delay in peak frequency of canine enamel defects is evident as well, but corresponds to peak ages in the Black Mesa series (Magennis and Martin 1985), and prehistoric California series reported by Schulz and McHenry (1975). It is suggested that this pattern is indicative of increased nutritional and disease stress in the post-weaning period. This will be discussed in greater detail when summarizing patterns of the other indicators of nutritional and disease stress included in this analysis.

## Bone Growth and Maintenance

Growth, a sensitive indicator of nutritional disturbances, is the most widely used measure of nutritional status in children. There is a voluminous literature documenting the deleterious effects of under- and malnutrition including, among other things, a slowed rate of growth and smaller achieved body size and stature. What is less well documented and more poorly understood, however, is the relationship between nutritional disturbances and cortical bone growth and maintenance.

Numerous experimental studies of severe protein-calorie malnutrition in laboratory animals show that the primary effect is a retardation or cessation of growth. Not only is growth in bone length slowed and stunted, but bone widths are smaller, the bone is poorly mineralized, and new bone is formed at a slower rate than the resorption of old bone, resulting in a net loss of bone. Further, bone is being resorbed rapidly at the inner, endosteal surface of the bone cortex, resulting in medullary expansion, and thinner bone cortices (Adams 1969; Dickerson and McCance 1961; Huss-Ashmore et al. 1982).

Similar skeletal changes associated with malnutrition have been observed in contemporary human populations. In a study of Guatemalan children hospitalized for severe protein and calorie malnutrition, Garn and co-workers (1964) found that cortical thickness of the second metacarpal is reduced when compared to age-matched village controls. These researchers also observed that some children aged 4-6 years had no more compact bone than a 1-year old, yet demonstrated similar maturational stages of osseous development. They suggest this pattern is indicative of actual bone loss rather than simply a failure to gain bone.

Extreme nutritional deprivation is not a prerequisite for osseous changes. Himes and co-workers (1975) conducted a study of mildly to moderately malnourished Guatemalan children using radiographs of the second metacarpal. They found that when compared to well-nourished American children, Guatemalan children demonstrated a significant retardation in a number of bone dimensions. Not only are these children smaller in stature and body size, but also demonstrate a significant reduction in periosteal diameter, expansion of the medullary cavity, thinner cortices, reduced cortical area, and dramatically lower percent cortical area. They conclude that the skeletal response to malnutrition, even moderate to mild forms, results in deficiencies in bone growth beyond those associated solely with reduced body size.

Among the few studies of prehistoric skeletal series that have been conducted, similar patterns of altered bone growth and maintenance have been demonstrated. Huss-Ashmore (1981) analyzed a large sample of subadults from prehistoric Sudanese Nubian skeletal series. She found that growth in femoral length for age approximates a normal growth curve, although the amount of growth between the ages of 2 and 6 is reduced when compared to contemporary American boys. Growth in bone width also follows a normal pattern. Increase in cortical thickness, however, fails to keep pace with growth in length and width, and demonstrates an actual decline, especially after the age of 10. Reduction in percent cortical area is most dramatic, showing a sharp drop after the age of 2, remaining low throughout childhood. When compared to percent cortical area determined for the second metacarpal of a well-nourished American population (Garn 1970), the slopes of the lines are similar until the age of 2, after which the Nubians demonstrate a radical departure. Huss-Ashmore concludes that the pattern of femoral growth demonstrated for the Nubians approximates that of a population undergoing periodic or chronic mild under-nutrition.

In a similar study, Hummert (1983) examined subadult tibial growth in a large skeletal series from the medieval site of Kulubnarti in Sudanese Nubia. He found that growth in tibial length as well as cortical area is maintained from birth through age 16. Percent cortical area, however, is reduced, reflecting excessive endosteal bone loss. He suggests that the relative reduction in bone is consistent with patterns of cortical bone loss in living malnourished children, providing evidence for dietary stress for this population. Similarly, Cook (1979) found that children 2-3 years of age showed significantly lower values for femoral cortical thickness in a Late Woodland cemetery sample from Illinois when compared to children from an earlier Middle Woodland series. She interprets this pattern of bone loss as an indication of relative protein-calorie malnutrition in the Late Woodland sample.

These studies of skeletal responses to nutritional deficits in living and archeological populations suggest that analyses of bone growth and maintenance would provide a good measure of dietary sufficiency. Patterns of femoral growth in the subadult sample from the Indian Neck ossuary are examined as an indicator of nutritional stress. Although growth in bone length for age has been shown to be a sensitive indicator of nutritional insult, ossuary samples pose certain difficulties since an independent means of age determination (such as the dentition) is lacking. Femoral length is that criterion that must be used to estimate age. There is an obvious circularity here, yet there is justification for including an analysis of femoral growth dynamics. Recall from the discussion of subadult age determination presented in Chapter 2 that the mortality profiles based on dental calcification and femoral length are nearly identical. It is assumed that the dentitions and femora represent the same individuals. Thus, growth in femoral midshaft diameter, cortical thickness, and cortical area are examined in relation to age rather than femoral length. Preliminary results of this analysis have been presented elsewhere (Magennis and Martin 1982; Magennis 1984).

As the first step in the analysis, thick sections were taken from 20 subadult femora, ranging in age from 6 months to 18 years. Cortical thickness is determined by averaging the measurements taken at 8 equidistant sites around the circumference of the bone starting at the linea aspera. Cortical area is determined according to the method presented by Sedlin et al. (1963) and Martin and Armelagos (1979). A transparent grid of known area is superimposed on the bone sections and the number of line intersects occurring over bone are counted. Cortical area is then computed by multiplying the number of intersects over bone by the total grid area and dividing by the total possible line intersects in the grid. This procedure is repeated 3 times for each mid-shaft section and mean values are computed. Percent cortical area is determined by dividing cortical area by total cross-sectional area. Medio-lateral diameter at the midshaft is also recorded. Values for shaft diameter, cortical thickness, and percent cortical area for each individual and means for each age group are presented in Table 2.7.

Considering first growth in total bone width, the Indian Neck subadults demonstrate a generally increasing trend in mid-shaft diameter with age (Figure 2.7). This is most dramatic in the first 4 years with a slowed rate of increase thereafter until the age of 15. Contrary to the growth in bone width, cortical thickness demonstrates a fairly rapid increase in the first 3 years, followed by only a slight but gradual increase (Figure 2.7). In general, these patterns of bone growth suggest that increase in bone width is accompanied by a slow, gradual increase in cortical thickness.

Cortical thickness is not the only dimension to be considered when evaluating bone growth and maintenance. Cortical area, that space within the periosteal envelope actually occupied by bone, is directly related to cortical thickness and bone width, and is a more sensitive indicator of cortical bone change. Periosteal diameter gradually increases with age, but as Martin et al. (1985) point out, it is theoretically possible to maintain cortical area with an actual decrease in cortical thickness. By calculating percent cortical area (the percentage of cross-sectional area occupied by bone) this problem is alleviated.

TABLE 2.7

Subadult Femoral Mid-shaft Diameter, Cortical Thickness, and Percent Cortical Area

| Age | N | M-L Diameter (mm) | | Cortical Thickness (mm) | | Percent Cortical Area | |
|---|---|---|---|---|---|---|---|
| | | | X | | X | | X |
| 0-1 | 2 | 7.9 | | 1.5 | | 75.8 | |
| | | 7.2 | 7.5 | 1.3 | 1.4 | 75.3 | 75.8 |
| 1-2 | 4 | 10.1 | | 1.3 | | 61.9 | |
| | | 9.1 | | 1.3 | | 63.8 | |
| | | 10.1 | 10.2 | 2.2 | 1.8 | 73.9 | 69.3 |
| | | 11.5 | | 2.4 | | 77.9 | |
| 2-3 | 1 | 12.8 | | 2.8 | | 55.5 | |
| 3-4 | 2 | 13.5 | | 2.3 | | 54.5 | |
| | | 14.9 | 14.2 | 2.6 | 2.5 | 63.6 | 59.1 |
| 4-5 | 1 | 12.1 | | 2.7 | | 66.0 | |
| 5-10 | 5 | 15.8 | | 2.5 | | 64.3 | |
| | | 16.6 | | 4.6 | | 83.6 | |
| | | 20.2 | 17.3 | 3.5 | 3.5 | 55.8 | 69.7 |
| | | 17.5 | | 3.8 | | 76.7 | |
| | | 16.4 | | 3.2 | | 68.3 | |
| 10-15 | 3 | 19.2 | | 4.8 | | 77.1 | |
| | | 19.8 | 20.0 | 3.9 | 4.5 | 67.6 | 68.2 |
| | | 21.1 | | 4.7 | | 59.8 | |
| 15-18 | 2 | 23.0 | | 5.2 | | 61.9 | |
| | | 25.9 | 24.5 | 5.7 | 5.5 | 64.0 | 63.0 |

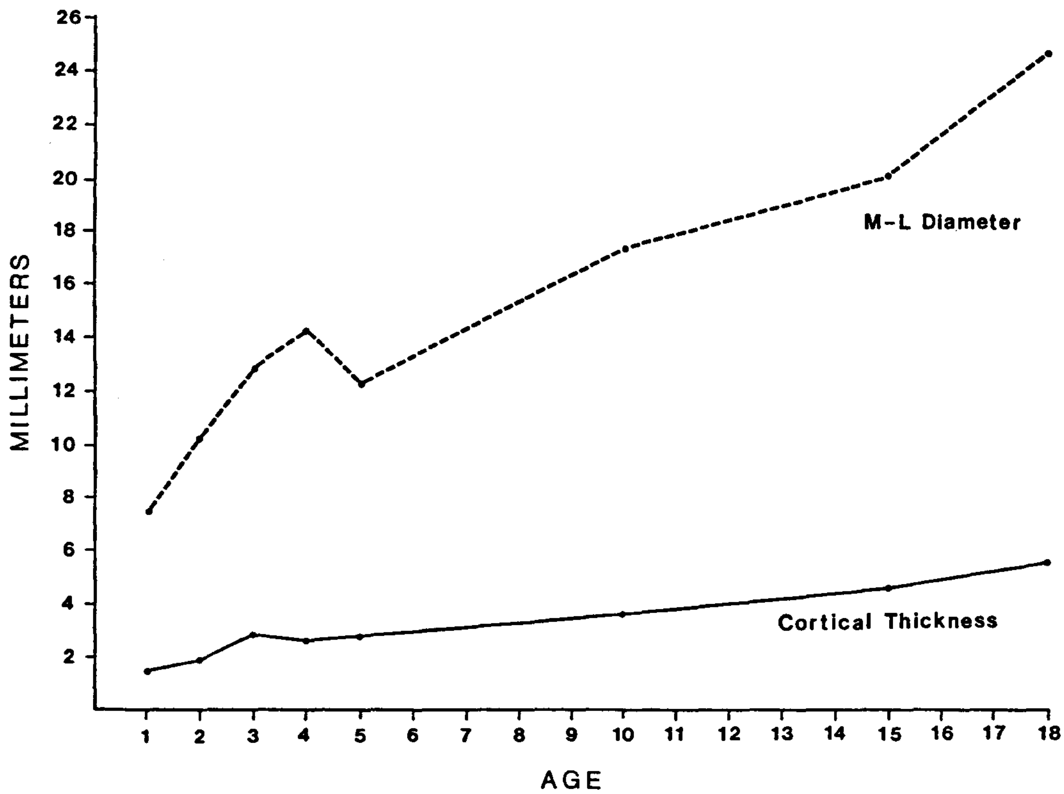


Figure 2.7: Femoral Mid-Shaft Width and Cortical Thickness By Age.

Contrary to the increase in width and cortical thickness observed in the Indian Neck subadults in the first few years of life, percent cortical area demonstrates a sharp decline until the age of 3 (Figure 2.8). This is followed by an apparent recovery, yet percent cortical area remains low throughout childhood. Percent cortical area shows another marked decline after the age of 15.

It is instructive to compare these results with values reported by Garn (1970) for percent cortical area of the second metacarpal of normal children. Absolute values are necessarily different, but the slopes of the lines in the first 3 years of life are markedly different (Figure 2.8). Normal children show a loss of bone after birth, presumably due to the normal process of bone growth and modeling, but this pattern is reversed by 9 months of age (Garn 1970). In contrast, the Indian Neck subadults show a continued decline in percent cortical area until the age of 3 followed by a gradual increase, generally paralleling (but slower than) the curve for normal children. After age 15, the Indian Neck values depart from normals, again indicating relative bone loss.

The values for femoral percent cortical area in the Sudanese Nubian subadults are similar to those from Indian Neck. Unlike the Indian Neck subadults, the Nubians show a slight increase in percent cortical area until the age of 2 (Figure 2.8). After age 2, both series show a decline in percent cortical area until the age of 4, after which there is an increase. The Indian Neck curve is flatter than the Nubian curve because individuals are combined in a single 5-year age category in the former series. This masks subtle, yet probably important, age-specific variation in femoral bone growth. In general, however, the overall shape of the curves is similar, indicating a period of stress for the 2-4 year-olds in particular.

A pattern of bone growth similar to that of the Indian Neck subadults is also demonstrated in the Kulubnarti sample. Hummert (1983) reports a relative reduction in tibial cortical bone from birth until the age of 3. He interprets this continued reduction in cortical bone as evidence of nutritional stress associated with weaning. A relative loss of bone at this same age has been shown for the Late Woodland period children from the Ledders site (Cook 1979) cited earlier. She also argues for nutritional stress associated with weaning as an explanation for the observed bone loss.

The decline in percent cortical area during adolescence for the Indian Neck subadults is more difficult to interpret. While this same trend is shown in the Kulubnarti subadults, Van Gerven and co-workers (1984) point out that periodic reductions in percent cortical area during rapid periods of

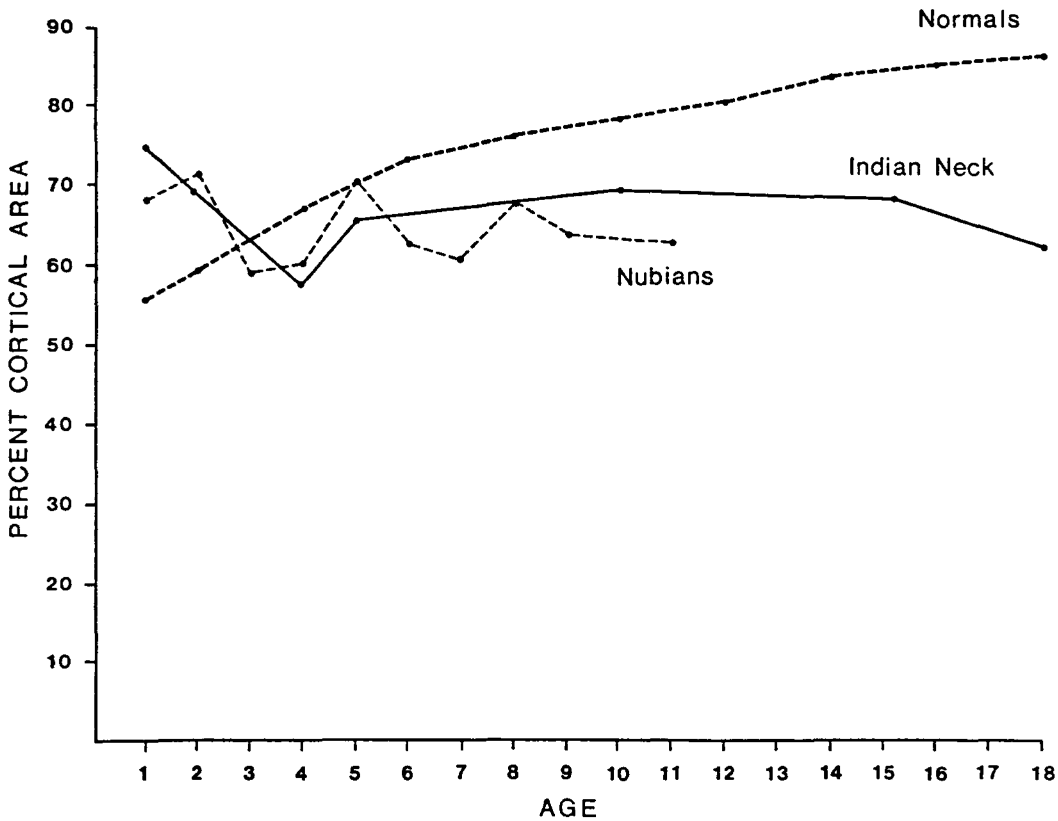


Figure 2.8: Percent Cortical Area of Femoral Mid-Shaft By Age.

growth may be part of the normal bone modeling process. Alternatively, increased demands for nutrient intake during a period of rapid growth are not being met, thus bone reserves are tapped in order to maintain the growth process. These authors contend that lack of comparative data hampers an interpretation of this observed reduction of bone at adolescence.

In general, the overall femoral growth pattern demonstrated for the Indian Neck subadults does not resemble that of a population undergoing chronic, severe protein-energy malnutrition. Bone width and cortical thickness show an increase with age, albeit a slow one. The rapid decline in percent cortical area in the first few years of life followed by a short recovery period with only slight increase in this value for the remainder of the childhood years is suggestive of periodic or mild under- or malnutrition. This is particularly acute at the age traditionally associated with weaning.

## Infectious Disease

One indicator of community health is the prevalence of infectious disease. Osteomylitis and periostitis are commonly observed bony pathologies in prehistoric skeletal remains and result from a host of disease agents which may reflect acute, episodic, or traumatic insults of chronic disease experience. Differential diagnosis is a critical step in distinguishing specific disease entities such as treponemas (syphilis, yaws, etc.), tuberculosis, or leprosy from generalized osteomylitis or periostitis. This is a difficult undertaking and ossuary skeletal series do not lend themselves to differential diagnosis of specific diseases. However, since periostitis is a non-specific indicator of infection, when examined in relation to other stress indicators it can provide a population measure of acute or chronic infectious disease stress without reference to differential diagnosis.

Osteomylitis results from the introduction of pyogenetic bacteria into bone. This may occur by three primary processes; 1) through blood-borne micro-organisms, 2) through contact with adjacent soft-tissue infection, or 3) as a direct result of trauma to the bone itself (Ortner and Putschar 1981). Periostitis, a type of osteomylitis, affects the outer, periosteal layer of bone. Most commonly, periosteal lesions are found on long bone shafts but may occur on the endo- and ectocranial tables. They appear as smooth or irregular lattice-like layers of new bone formed over the cortex, frequently exhibiting a hypervascularized scab-like appearance of variable thickness (Figure 2.9). Periostitis results from an elevation of the periosteum, followed by a subperiosteal hemorrhage which interferes with the blood supply to the

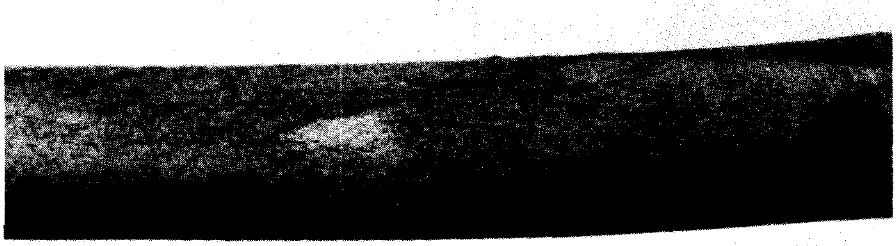

Figure 2.9: Unremodeled Periosteal Reaction on Femoral Diaphysis; 6.5-7.5 Year-Old.

cortex. In turn, this can interfere with normal cortical metabolism resulting in necrosis. If the subperiosteal infection subsides, normal osteoblastic activity is resumed and new subperiosteal bone is produced (Jaffe 1972; Ortner and Putschar 1981; Steinbock 1976).

Periosteal reactions exhibited on the femur and the tibia are used to characterize infectious disease in the Indian Neck population. These two bones were selected because they generally are the most complete and represent the greatest number of individuals. The tibia is also that bone which is most likely to exhibit periostitis and thus may provide some sort of maximum estimate of number of individuals that suffered from infectious disease episodes. Other skeletal elements did, of course, exhibit pathologies but small sample sizes of various bone classes would render their reporting an exercise in clinical description of a particular pathology. By focusing on these two long bones, the prevalence of non-specific indicators of infectious disease and its patterning within the population can be characterized.

Both quantitative and qualitative assessments of periostitis for the femur and tibia are presented (Table 2.8). These data are quantitative in that number of affected bones out of the total sample is reported. It is recognized that the state of a lesion--remodeled or unremodeled--is critical to interpreting the relationship of infectious lesions to morbidity and mortality. Subdividing an already small sample into yet smaller analytical units further precludes making meaningful statements concerning the disease process in this population. Qualitative information is provided in the sense that individuals exhibiting more severe expression of the disease process are reported separately. More severe bony reactions may be indicative of a more severe illness episode, but more likely are an expression of a longer lasting, chronic condition.

Considering first the juvenile portion of the sample, 4 of the 20 femora exhibited a slight periosteal reaction. Only 1 showed a moderate expression, or 25% of those aged 6 months to 18 years demonstrated some form of periostitis. In contrast, the more labile tibia indicates that 40% of the juveniles exhibited periostitis. For both bones, the adults show relatively fewer lesions, 13% and 14% of the adult femora and tibiae as compared to 25% and 40% of these same bones in the juvenile sample. By far, either trace or slight expressions of periostitis predominated, suggesting chronic infections were characteristic of few individuals.

Comparison of the frequency of periostitis in the Indian Neck series with similar analyses of other skeletal series may provide a relative indicator of community health. Comparison

TABLE 2.8

Prevalence of Periostitis: Femur and Tibia

Femur

| Age | Total N | Slight N | Slight % | Moderate N | Moderate % |
|---|---|---|---|---|---|
| Subadult: | | | | | |
| .5-5 | 9 | 2 | (22.2) | - | - |
| 5-10 | 7 | 1 | (14.3) | 1 | (14.3) |
| 10-17 | 4 | 1 | (25.0) | - | - |
| Subtotal | 20 | 4 | (20.0) | 1 | ( 5.0) |
| Adult: | | | | | |
| 18+ | 23 | 3 | (13.0) | - | - |
| Total | 43 | 7 | (16.3) | 1 | ( 2.3) |

Tibia

| Age | Total N | Slight N | Slight % | Moderate N | Moderate % |
|---|---|---|---|---|---|
| Subadult: | | | | | |
| .5-5 | 7 | 2 | (28.6) | - | - |
| 5-10 | 4 | 2 | (50.0) | - | - |
| 10-15 | 4 | 2 | (50.0) | - | - |
| Subtotal | 15 | 6 | (40.0) | - | - |
| Adult: | | | | | |
| 18+ | 14 | 1 | ( 7.1) | 1 | ( 7.1) |
| Total | 29 | 7 | (24.1) | 1 | ( 3.4) |

with skeletal samples derived from similar environmental and social contexts would be most meaningful because of the complex interaction of etiologic factors which can produce infectious disease responses. Conversely, comparison with groups from diverse contexts may suggest factors which could have been important determinants of infectious disease loads for this group.

One of the questions posed to researchers participating in a recent symposium was the relationship of infectious disease loads to changing subsistence patterns from that of hunting-gathering to intensive agriculture (Cohen and Armelagos 1984). Using skeletal series from around the world, many of these researchers report the incidence of infectious disease as reflected in skeletal pathology. A dominant theme in many of these papers is the overriding importance of demographic factors (e.g., population density, distribution, settlement size, and sedentism) rather than agriculture per se in influencing infectious disease loads. Thus, it appears that diet may bear more of an indirect relationship to infectious disease since dietary shifts are most often accompanied by a host of economic, social, and demographic changes.

As expected, the prevalence of periostitis determined for the Indian Neck series when compared to other samples is not unambiguous. For groups with either hunting-gathering or agricultural subsistence economies along the Georgia coast, Larsen (1984) reports a prevalence of 4.5% and 15% respectively for adult tibia and values half that for the femur. While subsistence strategies are indicated, other demographic and social variables are not reported. In the Ohio River Valley, a Late Archaic sample shows 5% and nearly 19% frequency of periostitis for the femur and tibia, 37% and 50% for these bones from a hunting-gathering-fishing subsistence economy Middle Woodland site, and 11% and 24% for the femora and tibiae from Mississippian Period Fort Ancient sites (Perzigian et al. 1984). The Dickson Mounds, mortuary sites associated with large, nucleated settled villages and agricultural subsistence economies, demonstrate much higher percentages of individuals with periostitis than in the Ohio Valley samples. Goodman and co-workers (1984) report an increase from 31% to 67% from the earlier periods to the intensive agriculture Middle Mississippian period. These values are at least twice that observed for the Indian Neck series. Finally, the 24% incidence of tibial periostitis for combined ages in the Indian Neck series is nearly identical to the 25% reported for adults from the Kane Mounds in the American Bottom (Milner 1983). The Kane Mounds are a Mississippian Period mortuary site associated with dispersed, small, farmstead settlements, occupied for a few years and then abandoned. In that study, Milner (1983) compares the percentage of tibiae with periostitis to the 85% reported for the Dickson Mounds samples from the same time period. He argues that the exceedingly high infectious disease experience at Dickson Mounds cannot be explained solely as the result of nutritional factors, since subsistence regimes for these two sites are similar. Instead, he posits that the dispersed, small settlements associated with the Kane Mounds resulted in a relatively contamination-free environment compared to the large, consolidated hamlets characteristic of the Illinois River Valley, resulting in lower rates of infectious disease in the American Bottom.

It is apparent from the few comparisons made that the Indian Neck series falls between the extremes reported for prevalence of infectious disease. The 14% tibial periostitis shown for the Indian Neck adults is a little more than twice that reported for the Georgia Coast hunter-gatherers but slightly less than half that reported for the dispersed farmstead American Bottom agriculturalists. It seems clear that density-dependent variables shape the disease profile in addition to diet and nutritional adequacy. Carefully controlled archeological excavation of settlements affiliated with the ossuary will be necessary to address these issues adequately.

## Porotic Hyperostosis

The use of porotic hyperostosis as an indicator of health in prehistoric populations is becoming increasingly common. It is perhaps one of the best studied markers of nutritional stress and evidence overwhelmingly points to iron-deficiency anemia as the cause. Many of the earlier studies of Old World skeletal series emphasize the hereditary anemias such as thalassemia or sickle-cell anemia as the primary cause of porotic hyperostosis. While well-reasoned, careful diagnoses do isolate hereditary anemias as the most likely cause of this lesion in some cases (e.g., Angel 1967), the lack of thalassemia and sickle-cell anemia in the New World necessitated alternative explanations for this condition.

Porotic hyperostosis is a descriptive term applied to lesions on the skull characteristic of anemia. Particularly affected are the frontal, parietal, and occipital bones of the cranial vault as well as the anterior portion of the orbital roof. Anemia results in increased red blood cell production and is often accompanied by expansion of the marrow spaces of the thin bones of the skeleton. Bones of the skull become thickened with a significant expansion of the diploic space. As the marrow space expands, the outer surface becomes thinner, often exposing the diploe. The lesions characteristically exhibit a coral-like or sieve-like porosity (Angel 1967; Huss-Ashmore et al. 1982; Mensforth et al. 1978; Ortner and Putschar 1981; Steinbock 1976).

By itself, porotic hyperostosis is not diagnostic of a particular anemia, but Huss-Ashmore and co-workers (1982) point to its value as a tool for investigating nutritional adequacy in prehistoric populations. They further stress that in order to use this as an indicator of nutritional stress, it is essential to examine the patterning of the lesion within the ecological context of the group. This involves examining the distribution and severity of the lesion within individuals and the age- and sex-specific occurrence of porotic hyperostosis within the population. Of crucial importance is a reconstruction of the group's subsistence pattern to aid in the identification of the role of diet as an underlying cause of anemia.

In the past 10 years, numerous paleoepidemiological studies of porotic hyperostosis have been undertaken. In an analysis of prehistoric Sudanese Nubians, Carlson et al. (1974) found that 32% of the 0-6 year-olds demonstrated orbital lesions, a frequency significantly higher than that of the population as a whole. The age distribution and mild expression of the pathology argues against one of the hereditary anemias as the cause. Instead, they point to the reliance on millet and wheat, cereal grains which are poor sources of iron, in conjunction with weaning stress and parasitic infection as the most likely cause of porotic hyperostosis in this case.

Similarly, El-Najjar and co-workers (1976) investigated this condition in prehistoric Amerindian groups from the Southwest. They suggest that reliance on maize predisposes these groups to anemia. Maize is a poor dietary source of iron, processing methods frequently reduce the bioavailability of iron, weanling diarrhea, and infectious diseases which promote malabsorption of iron all contribute to the high prevalence of iron-deficiency anemia. From a recent analysis of this condition in the juveniles from the Arroyo Hondo site, Palkovich (1985) suggests that endemic malnutrition, particularly affecting pregnant females and their fetuses, acted synergistically with immediately acquired infections in infants to constitute the probable underlying cause for iron-deficiency anemia in this population.

Analysis of the Dickson Mounds skeletal series by Lallo et al. (1977) also demonstrates the synergistic relationship between porotic hyperostosis and infectious disease. They suggest that the condition is precipitated by insufficient intake of dietary iron and protein coincident with weanling diarrhea. In that population, these researchers found that the prevalence of porotic hyperostosis nearly quadrupled (from 14%-52%) with the population's increased reliance on maize.

So common is the association between diets high in cereal grains and porotic hyperostosis that maize-based diets are frequently cited as the primary underlying cause of this condition. A detailed study by Mensforth and co-workers (1978), however, emphasizes the necessity for examining porotic hyperostosis within the total biological, cultural, and archeological context. They demonstrate the synergism between infection, increased nutrient demands during rapid growth and porotic hyperostosis. By carefully examining remodeled and unremodeled states of this lesion, these researchers make a strong argument for an early age of onset of infections which precipitates iron-deficiency anemia. Subsistence reconstruction indicates that maize was not cultivated and protein and iron were readily available to residents of the Libben site. Thus, diet is not the primary etiologic factor underlying porotic hyperostosis. Instead, they suggest that the interaction of infection, malabsorption of nutrients due to diarrhea, and increased nutrient demands during periods of rapid growth are the causes of porotic hyperostosis in the Libben population.

Walker (1985) re-emphasizes that maize-dependent diets are not necessarily the most important factor in precipitating porotic hyperostosis. In an analysis of a large skeletal series from the Channel Islands area of southern California, he found the prevelance of porotic hyperostosis among these fisher-people to be as common as that demonstrated for maize-dependent agriculturalists. He points out that a diet rich in iron and high in protein consisting of fish, shellfish, and sea mammals is clear evidence that porotic hyperostosis is not necessarily associated with a subsistence strategy which limits the dietary availability of these nutrients. In the Channel Island series, he found that 50% of the 0-10 years-olds exhibited orbital lesions, but that none of those greater than 3-4 years of age demonstrated unremodeled lesions. This suggests a pattern of acute episodes of anemia experienced during the first few years of life. He points out that infants are highly prone to anemia because of diarrheal infections, and nutrient loss associated with diarrhea and malabsorption. Walker posits that the underlying etiologic factors associated with porotic hyperostosis in the Channel Islands populations is due to diarrheal infections precipitated by consumption of contaminated fresh water supplies. This is exacerbated by increased exposure to parasitic infections from eating raw fish and sea mammals, and protein-energy malnutrition during periods of low marine productivity.

The success of these few studies mentioned lies in the rigorous application of an epidemiological approach to the study of the underlying causes of porotic hyperostosis. All point to the importance of considering the state of porotic lesions (remodeled vs. unremodeled), narrowly defined age classes, and patterning of the lesions evaluated in conjunction with infectious disease episodes manifested by periosteal reactions. Reconstruction of subsistence is also critical for determining whether a diet insufficient in the essential nutrients is the primary predisposing etiologic factor in porotic hyperostosis. Despite the limitations inherent in the Indian Neck ossuary sample, an anlysis of patterning of porotic hyperostosis can provide some measure of nutritional adequacy for this population.

In the analysis of the Indian Neck series, juvenile and adult crania were examined for evidence of porotic hyperostosis. Lesions were evaluated according to whether they were remodeled or active at the time of death. Mensforth et al. (1978:23) describe unremodeled lesions as those which "usually exhibit sharp and clearly defined margins in the cribriform structure of the hyperostotic bone. The cribriform mesh characteristically displays a microporosity visible upon close macroscopic examination". Remodeled lesions "typically display a smooth lamellar texture with bone filling of the peripheral pores. The microporosity so characteristic of the unremodeled lesion is always absent in the cribriform mesh of the remodeled lesion" (Mensforth et al. 1978:23). A remodeled porotic lesion of the orbit is shown in Figure 2.10. As described above, porotic hyperostosis also appears on the cranial vault, most typically affecting the frontal, parietals, and occipital bone above the nuchal line (Figure 2.11). Hill (1985) posits that there are distinctive patterns of porotic pitting on the cranial vault and suggests these patterns may be indicative of distinctly different age of onset of anemia. She notes that the severity of the lesions ranges from small pin-point porosities to areas exhibiting large blastic resorptive spaces. The presence of these small pin-point porosities has been noted by numerous researchers but they are usually attributed to osteoporosis. The remodeling processes associated with osteoporosis and its manifestation on the thin bones of the skeleton are not clearly documented, however. Hill (1985) maintains that they are the result of bony changes associated with anemia rather than osteoporosis. Further research is obviously needed to clarify this issue.

For this analysis, occurrence of porotic hyperostosis was recorded separately for the orbits and the vault. Fragmented as well as relatively complete crania were scored. Thus, the sample of observable orbits is not necessarily the same as the sample of observable vaults. The supraorbital margin is dense bone, readily preserved, and easily recognizable, and hence the sample of orbits is larger than that of cranial vaults. Numerous vault fragments with evidence of porotic hyperostosis were observed but because there is no reasonable way to quantify them, these fragments were not included in the analysis. The pin-point porosities are exceedingly common on

Figure 2.10: Remodeled Cribra Orbitalia; 4-5 Year-Old.

Figure 2.11: Remodeled Porotic Hyperostosis on the Occipital; Adult.

the adult Indian Neck crania. For purposes of this analysis, these are considered to be indicative of porotic hyperostosis rather than osteoporosis and are included in the counts.

Examination of the prevalence of porotic hyperostosis in the Indian Neck sample (Table 2.9) shows that the majority of subadults exhibited porotic lesions in the orbits, while none demonstrated lesions on the vault. Of the two which did not have orbital lesions, both are approximately 6 months to 2 years of age and both exhibit unremodeled periostitis on the ectocranial table. Of the 8 individuals in the youngest age group, 3 demonstrated unremodeled porotic hyperostosis and all were 1-2 years of age at the time of death. In contrast, all those subadults in the 5-10-year age group demonstrated remodeled lesions. Only one-third of the 21 adults exhibited remodeled porotic hyperostosis in the orbits while 12 out of the 13 vaults which could be assessed exhibited porotic pitting. In general, this was of the small pin-point type which largely accounts for the elevated frequency of porotic hyperostosis on the vaults of adults.

The porotic hyperostosis data suggest that iron-deficiency anemia was a common condition in the Indian Neck population. That at least 33% of the adults demonstrate remodeled lesions indicates that the condition was not sufficiently severe to result in death. Further, the expression of porotic hyperostosis in this series is generally mild, examples of the most extreme manifestation being similar to those shown in Figure 2.10 and 2.11. The greatest period of stress is during the childhood years. Again, while nearly all of the juveniles exhibited porotic hyperostosis, none showed involvement of the cranial vault. Further, only 3 individuals demonstrated unremodeled lesions and all were less than 2 years of age. This pattern would suggest that the period of greatest stress for the Indian Neck population was during the weaning years.

Lack of supporting data from subsistence reconstruction makes it difficult to evaluate the role of diet as the primary etiologic factor underlying porotic hyperostosis in the Indian Neck population. It would seem, however, that the abundant fish, shellfish, and sea mammals in the Wellfleet Harbor and adjacent coastal areas would be heavily exploited, in addition to a variety of birds, land mammals, seeds, nuts, berries and other plants. A diet such as this, rich in available protein and iron, would unlikely be cited as the primary cause in this case. Unremodeled lesions occur only during the first few years of life in this population, possibly suggesting stress associated with weaning.

TABLE 2.9

Prevalence of Porotic Hyperostosis

Orbits

| Age | Total N | Unremodeled N | Unremodeled % | Remodeled N | Remodeled % |
|---|---|---|---|---|---|
| 0.5-5 | 8 | 3 | (37.5) | 3 | (37.5) |
| 5.0-10 | 5 | 0 | - | 5 | (100.0) |
| Subtotal | 13 | 3 | (23.1) | 8 | (61.5) |
| 15+ | 21 | 0 | - | 7 | (33.3) |

Vault

| Age | Total N | Unremodeled N | Unremodeled % | Remodeled N | Remodeled % |
|---|---|---|---|---|---|
| 0.5-5 | 5 | 0 | - | 0 | - |
| 5.0-10 | 4 | 0 | - | 0 | - |
| Subtotal | 9 | 0 | - | 0 | - |
| 15+ | 13 | 0 | - | 12 | (92.3) |

## Summary and Conclusions

The goals of this portion of the analysis of the Indian Neck ossuary skeletal remains are modest. The first was to document the skeletal remains themselves in order to provide a data base which should prove useful to other scholars. Second, particular analyses were undertaken, specifically of dental caries and dental chipping, in order to test hypotheses concerning the diet of the Indian Neck population. Finally, the occurrence of skeletal pathologies has been examined as a means to evaluate the impact of nutritional and disease stress on this group and to provide a measure of overall community health.

A subsistence regime has been suggested for the Indian Neck population focusing on the exploitation of the abundant marine resources in the area of Wellfleet Harbor. In addition to marine resources (fish, shellfish, and marine mammals), migratory birds, land mammals, and a variety of plant resources may have been included in the diet. Corn has been recovered from dated contexts in the region (Ritchie 1969), dates which are roughly contemporaneous with the Indian Neck ossuary. Although the occurrence of corn has been documented, the relative importance of this dietary item during this time period has yet to be demonstrated.

An analysis of dental caries and dental enamel chipping, a particular type of dental wear, was conducted in order to determine whether refined carbohydrates constituted a predominant part of the diet. For these analyses, only the adult dentitons were included. A low frequency of caries (4.2 % of the teeth) is comparable to equally low values reported for a number of other hunter-gatherer groups. Further, the total lack of severe carious lesions coupled with a lack of interproximal lesions and the absence of caries at the cemento-enamel junction is not in keeping with the carious lesion prevalence and distribution for populations in which cereal grains are a prominent dietary item. Although the Indian Neck deciduous teeth were excluded from this analysis, none demonstrated a carious lesion.

Dental enamel chipping and tooth breakage are common features of the Indian Neck adult dentitions. Most adults exhibited at least one tooth that was chipped, but many chipped teeth, often resulting in serious damage to the geometry and structural integrity of the tooth was the more frequent pattern. Diets high in processed food (such as ground cereal grains) tend to result in teeth which are worn due to abrasion rather than chipped enamel. Frequent and often severe dental chipping implies the mastication of very hard objects, perhaps bone, gravel particles, shell, or even the use of teeth for some non-dietary function. This pattern of dental wear alone does not preclude corn as a major dietary constituent. Considered in concert with the low prevalence of caries, however, these data would suggest that cereal grains were not a predominant feature of the diet.

Interpretation of the data on nutritional and disease stress is ambiguous. These analyses have focused on the subadult portion of the Indian Neck population because juvenile morbidity and mortality provide a better reflection of the well-being of the group. Examination of the chronological distribution of enamel hypoplasias demonstrates a pattern similar to that for other prehistoric populations. The maxillary central incisor exhibits a peak percentage of defects (90%) at 2.5-3 years of age, while a peak in maxillary canine defects (50%) occurs between the ages of 3.5 and 4.5. The absolute percentage of defects by age in the Indian Neck series is greater than that demonstrated in other prehistoric groups, notably Dickson Mounds (Goodman and Armelagos 1985a, 1985b; Goodman et al. 1980, 1984), but are similar to values reported for the Black Mesa Anasazi (Magennis and Martin 1985). Inter-observer differences may explain the disparity in these values, but the possibility that a greater number of the Indian Neck juveniles were subject to more frequent, acute episodes of stress cannot be discounted. Patterning of the chronological age distributions are similar, however, and suggest that the period between 2.5 and 4.5 years of age was one of greatest stress. This is the age typically associated with weaning.

A similar peak period of stress is suggested by the pattern of femoral cortical growth and maintenance. These data show that growth in femoral width keeps pace with increasing age, while increase in cortical thickness proceeds much more slowly. Percent cortical area, however, demonstrates a rapid decline from 6 months to the age of 3, with a gradual increase thereafter until the age of 15. After the age of 15, there is another decline in percent cortical area. The greatest relative bone loss at the age of 3 corresponds to the age of peak occurrence of incisor enamel hypoplasias. Together, these data would support an explanation of nutritional and disease stress associated with weaning at this age. The continued decline in percent cortical area after birth, however, may indicate that nutritional and disease insult were significant stressors prior to weaning.

Periostitis, a non-specific bony response to infectious disease is also relatively common in the Indian Neck population. Not unexpectedly, juveniles suffer more from periostitis than adults. The etiologic factors underlying infectious disease, however, are much more difficult to delineate. As indicated previously, nutrition and infection are synergistically related. Demographic factors such as population size, density, distribution, and mobility all act to alter the host, environment, and disease vector interaction. Demographic variables are specifically those for which we have little information. It is not possible here to sort out the relative contribution of density-dependent variables and nutrition to the prevalence of infectious disease loads in the Indian Neck population. When the incidence of periostitis is compared to values reported for other prehistoric Amerindian groups, that for the Indian Neck series is markedly lower than values for sedentary, aggregated agricultural groups but slightly higher than values for hunter-gatherer groups.

Porotic hyperostosis, lesions indicative of iron-deficiency anemia, is also common in the Indian Neck series, particularly among the juveniles. It is argued that a diet low in available iron and protein is not the most parsimonious explanation for the primary underlying causes of this condition in the Indian Neck population. Based on the research of others (Lallo et al. 1977; Mensforth et al. 1978; Palkovich 1985; Walker 1985) however, infectious disease, weanling diarrhea, and malabsorption of iron, especially during the period of rapid growth in infancy is a more plausible explanation in this case. Age-specific incidence of infectious disease in relation to porotic hyperostosis could not be examined in this study for reasons outlined previously. However, stress associated with weaning is a likely explanation, given that no cases of unremodeled porotic lesions were observed in individuals older than 2, combined with peak incidence of hypoplasias beginning at 2.5-3 years of age, and relative bone loss from birth until the age of 3.

Analysis of human skeletal remains can provide valuable insights concerning a population's adaptation to their environment. In addition, skeletal remains can be used to successfully test hypotheses concerning both the kind and the qualilty of aboriginal diet. Ossuary skeletal series are not ideally suited to many of the types of analyses necessary to test hypotheses rigorously concerning the adaptive success of paleopopulations. Because of the nature of the samples, a great deal of precision is sacrificed, yet at the same time, it is possible to make a number of generalizations about the diet and health of these groups.

The Indian Neck ossuary is no exception. Analyses of this skeletal sample should provide a sound, initial step toward reconstructing and interpreting past lifeways in this area. Numerous questions, both implicit and explicit, have been posed which can potentially lead to the generation of testable hypotheses. The strength of an interpretation of these data must lie within an archeological context, a context which at this time is largely lacking. Carefully controlled excavations are essential in order to recover the necessary botanical, faunal, and habitation data necessary to understand settlement and subsistence patterns during this time period. By building on recent research conducted in this area, controlled excavations will provide some of the information necessary for an interpretation of the Indian Neck ossuary.

# CHAPTER 3

# Mortuary Activity At The Indian Neck Ossuary

## Introduction

Ossuary burial is a common form of disposal of the dead during late prehsitoric and early historic periods in certain regions of eastern North America. Hundreds of ossuaries have been noted in southern Ontario and the Upper Great Lakes region (Anderson 1963), and although less abundant, they are still common in the Mid-Atlantic States. While the human remains from a relatively small number of these have been subject to detailed analyses, they have provided a wealth of information, especially regarding the demographic structure of the population in question. What is frequently lacking, however, is a consideration of the behaviors associated with this form of burial, especially the sequence of events related to the construction and form of the burial feature, treatment and preparation of the corpse for burial in the ossuary, and placement of the remains within the burial feature. That these behavioral aspects of ossuary burial have not been emphasized is due to several factors. Among them are that some were excavated earlier in this century when less attention was paid to contextual details while others were salvage operations in which the priority was necessarily given to recovering as much information as possible in a short period of time. In part, however, a reliance on the ethnographic record, particularly accounts of the "Feast of the Dead" among the Huron has acted to obscure variation. To be sure, there are numerous and striking similarities between early historic accounts of this ritual and that which is recovered in the archeological record. At the same time, though, there is undoubtedly a great deal of spatial and temporal variation in the form as well as the behaviors associated with ossuary burial, and it is this variation which is largely undocumented. A case in point is the frequency with which cremations occur in ossuaries. For example, in southern Ontario, Churcher and Kenyon (1960) note pockets of burned bone in the Tabor Hill ossuaries, an undetermined number of individuals included in the Uxbridge ossuary are cremated (Pfeiffer 1984), and in Maryland, burned bone was recovered from the Namjemoy ossuaries (Ubelaker 1974), to mention only a few. Although apparently not uncommon, this form of body processing has received little attention, at best only passing comment in the description of a given ossuary.

The primary goal of this chapter is to examine and document the range of behaviors associated with ossuary burial at Indian Neck, and to identify that segment of the population afforded this type of burial. This is especially important since the Indian Neck ossuary is unique. It is among the earliest examples of this type of mortuary activity in the Northeast, is the only one in New England, and thus is spatially segregated from other known ossuaries. To assume this ossuary is like all others is clearly unwarranted. The major focus of this chapter is on the treatment and preparation of the body for final interment. Two other areas of interest include the manner in which corpses are defleshed and whether all individuals are "processed" in the same way prior to burial in the ossuary. If there are differences in body preparation, then to the extent possible, the goal is to determine which individuals are afforded different treatment. While this information may be useful in making inferences about social organization and regional mortuary practices in southern coastal New England, such an endeavor is beyond the scope of this study. With the presentation of sufficient detail here, the Indian Neck ossuary will provide data for future analyses by others.

It is often assumed that all or nearly all individuals in a group are interred in an ossuary. Through a careful consideration of the demographic profile of the Indian Neck skeletal series, it may be possible to identify gender- or age-related criteria used to exclude some members from the ossuary. Further, certain individuals may be afforded differential body treatment which can be identified on the basis of age or sex. Demographic characteristics of the Indian Neck ossuary have been treated extensively in Chapter 1. For purposes of this chapter, only those aspects of the population's demography relevant to mortuary behavior are reviewed and summarized.

The aspect of mortuary behavior of particular interest here is the manner in which the body was prepared for final interment in the ossuary. That the ossuary represents the disarticulated remains of a number of individuals buried simultaneously minimally suggests that the corpse was disarticulated prior to burial. In most cases, the body was defleshed as well. If the bodies were defleshed, it is of interest whether this was by some mechanical means such as scraping or cutting. Alternatively, the flesh may decompose or dessicate by natural means, such as burial with subsequent disinterment or exposure to the elements on some above-ground structure such as a scaffold, tree, or specialized mortuary structure.

The other form of special pre-interment body treatment to be considered here is cremation. Because analysis of cremated bone is complex and involves a number of steps, and the unburned bone has been treated extensively in the previous two chapters, the cremations will be emphasized here. Admittedly, the amount of biological information that can be extracted from cremated bone is often quite limited. On the other hand, analysis of cremations can provide a great deal of information about mortuary behavior, a point made by Merbs almost 20 years ago (Merbs 1967). Cremations interred in ossuaries apparently are not unusual but most have escaped analysis so we know very little about this form of treatment of the dead. It is important to know whether cremation is a form of pre-interment body treatment reserved for certain group members and (aside from the obvious effects of burning) the way(s) in which it differs from the pre-interment body treatment of those individuals who were not cremated. It is only through a detailed evaluation of the cremated remains that we can begin to address some of these questions.

Similar to the analytical treatment of the unburned portion of the ossuary, the first step is the determination of the number of individuals cremated and the sex and age at death of those individuals. Comparison of the resulting demographic profile can then be made with the unburned portion of the series. Then it is possible to evaluate whether cremation is reserved for particular individuals within the population. From a careful analysis of cremated bone, it is possible to determine whether the bodies were articulated and in the flesh at the time they were burned, or whether the corpse was dismembered and/or defleshed prior to incineration. If there is evidence for pre-incineration defleshing, it may be possible to determine if the bones were still fresh or whether they were dry.

In addition to providing evidence for pre-incineration body condition, analysis of cremated remains provides the potential for elucidating particular aspects of the firing process itself. Patterns of burning on the bones can indicate the relationship of the bodies to the fire. For example, studies of numerous cremated skeletal series suggest that the bodies are frequently placed on or near the ground and the fire built over them. Fire temperature may be estimated through analyses of the bony remains. Other behaviors that can be inferred are whether complete bodies are represented in the cremations or only selected body parts, perhaps parts of those individuals included in the unburned portion of the ossuary.

Finally, the physical remains can potentially provide evidence for post-incineration body manipulation.

This chapter is devoted to gaining a better understanding of the range of behaviors associated with variation in the forms of body preparation prior to interment, and the identification of those individuals who were afforded burial in the ossuary. Burial context and the inferred sequence of events are obviously important to an interpretation of mortuary behavior at the Indian Neck ossuary. This information has been reported in detail elsewhere, however, (see Bradley et al. [1982] and Part I of this volume) and will not be reiterated here. The first section of this chapter outlines the primary questions to be addressed and the evidence needed to answer those questions. Results of the analysis of the human remains from the Indian Neck ossuary are presented in the second section. Finally, explanations and interpretations from the results are offered.

## Demography

Crucial to any mortuary study is the determination of the number of individuals included in the cemetery as well as the determination of age at death and sex. The number of individuals included in the cemetery sample may provide information regarding the size of the social unit participating in that mortuary ritual. Consideration of differences in burial treatment may provide important information about the social organization of past human groups. A careful evaluation of burial context in conjunction with demographic characteristics of the sample may help identify that segment of the population included in the cemetery or whether certain group members are treated differently at death. For example, circumstances of death or social status may structure the way in which the corpse is treated. Alternatively, differential treatment at death may vary according to age or gender. While analysis of the demographic profile of a cemetery sample is a valuable key for inferring social organization, it will also help identify possible biases introduced by burial practices. This information, in turn, is crucial to paleodemographic research directed toward evaluating a population's adaptive success.

## Pre-Interment Body Treatment: Defleshing and Disarticulation

Ossuaries are secondary burials consisting primarily of the disarticulated remains of a number of individuals. Based on ethnographic analogy, it is also assumed that the skeletal remains have been stored elsewhere prior to final interment. Although ethnographic accounts variously report the behaviors associated with the burial ritual, little is known about the way in which the body was prepared prior to this ritual. The means by which a corpse was dismembered or defleshed are largely unknown, and the spatial and temporal variability of these behaviors is not well documented.

### Body Reduction Processes

There are a variety of methods by which a corpse can be dismembered and defleshed. Evidence of only some of these, however, will be preserved in the archeological record. Defleshing as a result of dessication and decomposition by exposure to natural elements such as air, water, heat, insects, bacteria, and scavanging animals could be accomplished by any number of methods. Among them might be laying a corpse out on a scaffold or in a tree, placement of the body in a specialized mortuary structure (e.g., charnel house), or burial in the ground. It is improbable that mortuary features such as scaffolds would be preserved in the archeological record. Specialized mortuary structures may be identifiable, depending on construction materials and methods, location, and innumerable taphonomic processes. Interment in the ground, however, may be the most likely method of body treatment that can be identified. In the process of removing the remains in preparation for secondary burial in an ossuary, it is possible that some bones would be left in the ground, particularly if the soft tissue had decomposed completely. To date, there is no material evidence to support or refute any of these potential means of body processing. Further, the skeletal remains themselves would not provide any additional information if the preferred means of defleshing were by natural means. Decompositon of soft tissue would leave no evidence on the bones. Although taphonomic processes associated with these means of deflesing may vary, it seems unlikely that a unique and predictable pattern could be identified to distinguish between each of the methods.

If defleshing and disarticulation of the corpse occurred by mechanical techniques such as cutting and scraping, however, evidence of this may be observable on the bones. In situations where the soft tissue is still fresh, considerable effort is required to remove it, especially in those areas with heavy or thick tendons and ligaments. One would expect to find evidence of cutting marks or scraping around the joints, particularly the ankle, knee, shoulder, neck, or ribs. If a corpse is at least partially decomposed, however, the soft tissue is much more easily removed and vigorous butchering or scraping may not be necessary, thus leaving no evidence of this activity on the skeleton.

## Cremation

Another form of body reduction at the Indian Neck ossuary was cremation. Other than the obvious fact that the remains were burned, it is unknown whether body treatment prior to incineration differs from the way in which the unburned remains are treated. At Indian Neck, the cremations were disarticulated, fragmented, and confined to a small pit. Had there been clear evidence of in-situ burning, then it would be obvious that the corpse had been disarticulated and at least defleshed (if not dessicated) prior to burning. Since the initial suggestion based on field observations is that the burning had occurred elsewhere, but probably nearby, then an analysis of the human remains is necessary in order to gain insight into pre-incineration body treatment.

Given the assertion that burning occurred elsewhere, it leaves open to question the pre-incineration body condition. Possibly cremation was reserved for those most recently deceased. If the remains are from those recently deceased, then it needs to be determined whether the remains were 1) articulated and fully fleshed, 2) fleshed but disarticulated, or 3) defleshed. If there is evidence to suggest that the remains were dismembered and/or dry at the time of burning, then it needs to be determined how the pre-incineration body reduction process differed from that afforded those individuals who were not cremated. It is also unknown whether complete or nearly complete individuals were burned, or whether there was selective burning of only certain body parts.

In addition to pre-incineration body condition, detailed analyses of the bones can provide information about the burning process itself. It may be possible to ascertain the relationship of the remains to the fire (i.e., whether the fire was constructed over or under the body, or the position of the bones relative to the hottest part of the fire). It also may be possible to determine fire temperature and duration of the burning episode.

Finally, detailed analyses of the remains can provide clues concerning post-incineration body treatment. Is there evidence to suggest that all individuals were burned simultaneously, or does evidence suggest that some were burned before transport to the ossuary and simply interred with those burned just prior to final deposition?

## Pre-incineration Body Condition

Articulated or disarticulated: Clear evidence for articulation during cremation would ideally come from excavation information of *in situ* burning. In the case of redeposition, however, this information would be lost and evidence must be obtained from the bones themselves. A body which is articulated at the time of burning should exhibit characteristic patterns of smoking and/or calcination. A joint surface that is protected from the heat by opposing bone would be burned to a lesser degree than bone which is exposed directly to the heat. Using the hip as an example, one would expect to find portions of the acetabulum and/or femur head to show areas of less burning than surrounding bone. Buikstra illustrates a case of articulation at the time of burning in which the odontoid process of the second cervical vertebra is smoked, while the body is calcined (Buikstra and Goldstein 1973:18). Buikstra further suggests that abrupt changes in the degree of burning on a single bone may be indicative of pre-incineration dismemberment. As soft tissue no longer attached to bone contracts due to heat, the joint is not protected by covering flesh and it will likely be burned more heavily than the remainder of the bone. Alternatively, over-representation of certain body parts may be indicative of pre-incineration dismemberment with selective burning. If there is evidence for the under-enumeration of some body parts, however, it may be due to post-incineration selection and a careful interpretation of the evidence would be necessary.

In-flesh, Green, or Dry Burning: Central to the question of pre-incineration body condition is whether the body was burned in the flesh, recently defleshed but still fresh (green), or dry. Among the first to address this issue was Krogman in his analysis of Adena and Hopewell cremations (Webb and Snow 1945). Krogman indicates that it is very difficult to distinguish between bones that were burned in the flesh and those that are green, but that these two conditions can be distinguished more easily from bones that are burned dry. He observes that when dry bones are completely incinerated not only are they calcined, but show cracking patterns "like the patina of age on an oil painting" (Webb and Snow 1945:188). Krogman concludes that the Hopewell cremated mainly defleshed and dried bones, though fleshed cremations did occasionally occur.

Later, Baby examined the cremated remains of 128 individuals and concludes that Krogman's assessment of Hopewell cremations was incorrect (Baby 1954). By conducting an experiment in which he burned a whole, fleshed cadaver and "green bones", Baby suggests that the Hopewell cremations were burned in-flesh, but dismembered. He posits that the characteristics of bones that are burned dry include "superficial checking, fine longitudinal striae, deep longitudinal fracturing, or splintering, and no warping" (Baby 1954:4). Baby did not explicitly present the results of the experimental burning nor did he clearly distinguish between fleshed and green bone-burning. Thurman and Willmore (1980-81) suggest that Baby's classification of burning into three types based on color and cracking patterns applies to fleshed cremations: 1)completely incinerated, or calcined, 2) incompletely incinerated or smoked, and 3)unburned. The description of these categories is summarized in Table 3.1. Essentially, it seems that Baby only distinguished between bones which are fleshed vs. bones which are dry at the time of incineration.

Before proceeding with his analysis of Late Archaic cremations from Michigan, Binford sought to resolve the controversy between Baby and Krogman by conducting a replicative burning experiment of his own (Binford 1972). For the dry bone specimens, he included an approximately 1500 year-old burial and recently macerated bones from the Anatomy Department. For the fleshed specimen he burned a partially dissected green monkey cadaver, but thereafter refers to the bones as fresh or green, never making clear whether any of the monkey remains had been defleshed prior to burning. The difficulty in interpreting Binford's study is his apparent lack of distinction between fleshed and green bones; it appears that he combined these two states in a single category he calls "fresh." To further complicate matters, he included a recently macerated specimen with the archaeological bone in his "dry" category. It appears that Binford may have included remains in that category which Baby would characterize as "green." According to the way he categorized bone condition, Binford found that fresh bones which are calcined exhibit deep longitudinal and transverse fractures, deep angular and curved checking (frequently extending through the bone), and warping. Calcined bone which is burned dry exhibits superficial checking, deep longitudinal fractures, and no warping (Binford 1972). Despite the problems with his categorization of pre-incineration bone condition, Binford's results largely corroborate those of Baby. Binford's findings are also summarized in Table 3.1.

The lack of distinction between fleshed and recently defleshed specimens in previous studies led Buikstra (Buikstra and Goldstein 1973) to consider these two categories together in her analysis of Illinois Late Woodland cremations. She notes that no differences in calcination have been reported between fleshed and green cremated bone by either Baby or Binford, and hence she refers to both fleshed and recently defleshed bone as "green", contrasting those with dry bone burning. She concludes that "the only means available for making this distinction (between fleshed and recently defleshed) appears to be variations in degree of burning in the fleshed specimen due to variant shielding by the soft tissue" (Buikstra and Goldstein 1973:21).

There is a lack of explicit reporting of the differences between cremation of in-flesh and green bones which led Thurman and Willmore (1980-81) to conduct a replicative experiment. They burned 4 fleshed upper arms and 4 which had been defleshed by caustic methods. (It would appear that "defleshing by caustic methods" is the same as maceration as reported by Binford. Binford, however, included these in his "dry" category.) All 8 specimens were placed on an oak fire. In their descriptions, these researchers concentrate on cracking and checking patterns and find areas of agreement and disagreement with results of previous experimental studies. They found that the fleshed bone demonstrates little surface checking in contrast to the green bone. They suggest that green and fleshed bone can further be distinguished by the amount of warping; fleshed bone exhibits more extensive warping, especially of the fracture edges, than green bone. Further, fleshed specimens tended to demonstrate diagonal fractures while green bone exhibited more transverse fractures (see Table 3.1) Given their results, these researchers conclude that in-flesh, green-, and dry-bone cremations from archeological contexts can be differentiated. They do concede, however, that length of time in the fire, temperature of the fire, type of wood used, proximity of the bones to the center of the fire, and the manner in which the bones are cooled are all factors which would contribute to the nature and pattern of fractures exhibited on cremated bones (Thurman and Willmore 1980-81).

One other experimental study has been conducted by Buikstra and Swegle (n.d.) in which they burned in-flesh, green, and dry bone. Results of that study suggest that many of the distinctions made between the three types of bone are not as clear-cut as we would like to believe. One goal of that study was to address the extent to which experimental results can be generalized, especially in light of the multiple factors noted above which determine the observed bone condition. In addition to bone shrinkage induced by firing (discussed in Chapter 1), Buikstra and Swegle are concerned with our ability to precisely estimate pre-incineration body condition. Their sample consisted of fleshed, green and dry bones from humans, dogs, and/or cows and were burned in a gas incinerator and/or a wood fire.

TABLE 3.1

Characteristics of In-Flesh, Green, and Dry Bone Burning Reported by Various Researchers

| | Pre-Incineration Bone Condition | | |
|---|---|---|---|
| Researcher | In-Flesh | Green | Dry |
| Baby (1954) | Cracking: deep checking, diagonal transverse fracturing, warping, primary evidence for pre-incineration condition from patterns of burning on the bones | Cracking: not clearly distinguished from in-flesh burning | Cracking: superficial checking, fine longitudinal striae, deep longitudinal fracturing or splintering, and no warping |
| | Color: 1) Completely Incinerated; light gray to blue-gray, to buff 2) Incompletely incinerated, Smoked; blackened 3) Unburned; unaltered | Color: not addressed, assume similar to in-flesh categories | Color: not addressed, assume similar to in-flesh categories |
| Binford (1972) | Cracking: angular and curved checking, frequently extending through the bone; deep longitudinal and transverse fracturing with warping along the edges of the fractures; transverse fractures tend to be curved and serrated | Cracking: Not clearly distinguished from in-flesh burning; checking extending through the bone, marked warping, deep transverse fractures | Cracking: Superficial checking, fine longitudinal striae, deep longitudinal fracturing with no warping, cracks tend to be straight sided, no curved cracks, spongy bone shows almost no checking |
| | Color: same categories as Baby | Color: assume same as in-flesh | Color: assume same as in-flesh |
| Thurman and Willmore (1980-81) | Cracking: diagonal fractures accompanied by warping, serrated transverse fractures totally through the bone | Cracking: checking frequently extending through the bone, serrated fractures near epiphyses but otherwise parallel sided fractures, less pronounced warping than in-flesh cremations | Cracking: did not replicate dry burning. See descriptions by other researchers |
| | Color: did not address specifically | Color: did not address specifically | Color: did not replicate dry burning |

TABLE 3.1

(continued)

| Researcher | In-Flesh | Green | Dry |
|---|---|---|---|
| Buikstra and Swegle (n.d.) | Color: Calcined; cannot distinguish from green bone burning; areas of white, gray, and blue with white predominating | Color: Calcined; cannot distinguish from in-flesh burning on the basis of color, areas of white, gray, and blue with white predominating | Color: Calcined; light brown or tan color on outermost cortex, deep to this, cortex or trabeculae black to gray or white, distinct from in-flesh and green bone burning |
| | Cracking: deep longitudinal cracks nearly entire length of long bone shaft, frequent transverse cracks which are more common than in green bone, small and large flakes of cortex exfoliated from shaft, concentric pattern of curved cracks in popliteal region of femur; difficult to distinguish from green bone on the basis of cracking | Cracking: deep longitudinal cracks nearly entire length of long bone shaft, frequent transverse cracks, less common than in-flesh, curved cracks rare, small and large flakes of cortex exfoliated from shaft more common than in-flesh, lack of concentric pattern of curved cracks in popliteal region of femur | Cracking: shallow longitudinal cracks running entire length of shaft, few transverse cracks, most cracks shallow and far fewer than either in-flesh or green bone |
| | Color: Smoked; bone not uniformly smoked, areas of calcination | Color: Smoked; possible to achieve unifrom black color | Color: Smoked; black color not uniform or as deep as other two categories, likely to retain unburned areas |
| | Cracking: pattern not distinctive | Cracking: pattern not distinctive | Cracking: pattern not distinctive |

They elected to characterize burning on the three bone conditions according to color and degree of burning as well as cracking patterns. Results of their study suggest that in general, it is difficult to distinguish between fleshed and green bones, but that dry bones frequently exhibit distinctive color and cracking patterns. For bones which are smoked, it is not possible to distinguish between fleshed and green bone on the basis of color. Dry bone, however, fails to achieve a uniform black color, but retains areas of unburned bone, apparently indicating a lack of significant amounts of organic material remaining in dry bones. Cracking patterns of smoked bone failed to discriminate bone condition. It is noteworthy, however, that only on green bone was it possible to achieve a uniform smoked appearance. In the fleshed specimens, some areas calcined before other areas became smoked.

Once a bone calcined, it was not possible to distinguish fleshed and green bones on the basis of color. Both exhibited areas of white, gray, and blue, although white predominated. The color of dry calcined bone, however, was distinctly different in that the outer surface tended to be tan or light brown while only the inner cortex became white, gray, or black. Differences in cracking patterns on fleshed, green, and dry bone which are calcined is more a matter of degree than any absolute difference. Fleshed and green bone are virtually indistinguishable except for an unusual pattern of concentric cracks in the popliteal region of the fleshed human femora. The results of this study are summarized in Table 3.1.

Buikstra and Swegle conclude that the results of their experimental study tend to confirm the conclusions of other researchers; it is easier to distinguish dry burned bone from fleshed or green bone than it is to differentiate the two latter categories. It should be cautioned, however, that they also note those characteristics of dry burned bone reported by Baby (1954) also apply to many of their green and fleshed bones as well. Further, the presence of deep, transverse cracks, often used to characterize bones burned in the flesh, occurred on dry bones burned in the oak fire. Finally, previous researchers suggest that dry bones do not warp. The findings of Buikstra and Swegle contradict this, for they found that dry bones burned in the oak fire did warp, although to varying degrees.

Results of all these experimental studies underscore the tremendous variability evident in cremated bone, regardless of pre-incineration condition. Binford (1972), Thurman and Willmore (1980-81), and Buikstra and Swegle (n.d.) all emphasize myriad factors which can interact and contribute to the color and surface characteristic patterns observed on cremated bone in a given archeological series. Among these factors are length of time in the fire, temperature of the fire, type of wood used, position of the bodies relative to the fire, relationship of the bones to the oxidizing flame, air temperature, manner of cooling after firing, and post-incineration treatment of the remains. The researcher investigating prehistoric cremations with an aim toward inferring pre-incineration body condition obviously faces a difficult task and must proceed with caution.

Selective Representation of Body Parts: The over- or under-enumeration of certain bony elements suggests the possibility of selection of body parts for cremation and inclusion in the burial. Whether this occurred before of after incineration may be difficult to ascertain, especially if contextual information is ambiguous. In the case of the Indian Neck ossuary, it is possible that only certain body parts were reserved for cremation, the rest being interred with the unburned remains. In such a case, over-representation of some elements would be expected in the cremations while these elements would be underrepresented in the unburned portion of the burial feature. Alternatively, equal, or nearly equal, representation of body parts would argue for the incineration of complete bodies.

## Reconstructing the Burning Event

Relationship of the Body to the Fire: In general, contextual information provides the best evidence for the relationship of the body to the fire. In many cases, charcoal or ash is found on the bones, suggesting the position of the body relative to the fire. When such evidence is lacking, as it is for the Indian Neck ossuary, it may be possible to suggest positioning by examining changes in the degree of burning and patterns of burning on the bones. It would be expected that those bones closest to the hottest part of the fire would be burned to a greater degree than those at the periphery. If the fire is constructed over the bones, those surfaces lying close to or directly on the ground would be burned to a lesser degree than those immediately exposed to the intense heat. This phenomenon is observed in modern gas-fired crematoria where Wells (1960) observes that when the corpse (in the coffin) is lying on the floor, those bones on the dorsal surface are burned to a lesser degree than those on the upper portions of the body. In contrast, when the body is placed on a grate above the floor, the bones become completely incinerated. Based on these observations, Wells convincingly argues the case of the fire built on top of the body in the Early Saxon cremations he analyzed. In that case, the spinous processes of the vertebrae, the sacrum, and the occiput were incompletely incinerated while the remainder of the bones were completely calcined. Thus, even though the bones had been collected and placed in urns for burial, distinctive patterns of calcined and smoked areas on the bones are suggestive of the relationship of the body to the consuming flames.

In-Situ Burning and Post-incineration Redeposition: The most definitive evidence for in-situ burning would be derived from observations in the field. Such things as remains of charred logs, ash and charcoal associated with evidence for burned soil around the remains would suggest in-situ cremation. Additionally, the position of the bones, particularly if they are articulated, would suggest in-situ burning. Disarticulated remains, however, do not necessarily imply that burning occurred elsewhere since disarticulation may have occurred prior to incineration.

Post-incineration treatment of the bones may be implied, not only from the context in which they are found, but from the size and condition of the bone fragments. Very small fragments would imply intentional post-incineration breakage, or at the very least, a great deal of post-incineration movement from sweeping or raking the bones around, especially if they are still hot. Both Wells (1960) and Lisowski (1968) note the small size of bone fragments from cremations in England, Scotland and Wales (generally less than 25 mm), and both suggest deliberate breakage after cremation. Following his experimental study, Binford (1972) observed that if a bone were allowed to cool naturally it remained largely intact, whereas rapid cooling caused the bones to break, particularly along heat-produced fractures. Alternatively, Shipman et al. (1984) point out that when heating is of relatively short duration, the bones are likely to survive intact. A situation, then, characterized by large bone fragments would suggest that there was little post-incineration manipulation of the bones, or that the bones were allowed to cool sufficiently before collecting them for redeposition.

Fire Temperature: Inferring temperature of a crematory fire based on evidence from surface characteristics and burning patterns on bones in not entirely straightforward. That a bone is calcined does not necessarily imply that the fire was especially hot, nor does a bone which is only smoked suggest that the remains were not exposed to high heat. The length of time that the bones are exposed to heat as well as amount of oxygen available can both play a role in determining the degree to which a bone is burned. Tooth crowns infrequently survive incineration and at temperatures above 500°C, the tooth enamel will exfoliate from the surrounding dentine (Furuhata and Yamamoto 1967). Evidence such as this, however, can only provide a minimum estimate of fire temperature.

In a recent experimental study, Shipman and co-workers (1984) burned sheep or goat mandibles and astragli in a kiln under controlled conditions. This experiment was conducted in order to examine changes in color, microscopic morphology, crystalline structure, and bone shrinkage in relation to differing temperature. The color of bone burned at temperatures ranging from 185-940$^{o}$ C was recorded using a Munsell Soil Color Chart. They found that with increasing temperature, all three components of color--value, chroma, and hue--show "...progressive diversification with heating." They conclude that "...color alone is insufficient to identify precisely the temperature to which a tooth or bone has been heated, but can be useful to deduce a range of temperatures" (Shipman et al. 1985:313). Changes in crystalline size due to heating as measured by X-ray diffraction suggest this technique is useful only as a means of establishing whether the bones were heated to temperatures less than or greater than about 600$^{o}$C. Slightly better results for estimating temperature were obtained through the use of SEM inspection of bone. They were able to distinguish five distinct stages of microscopically observable change that correlated well with increasing temperature. At the present time, however, access to and training for the use of an SEM are not readily available.

In sum, macroscopically observable changes in bone texture and color patterns are useful only for providing broad estimates of the temperature to which a bone was heated. The length of time that the bone is exposed to the heat confounds this issue, however, for the fire may well have achieved higher temperatures. Shipman et al. (1984) found that the sheep and goat bones would calcine when heated to a temperature of less than 250$^{o}$ C, temperatures less than that obtainable from an open-air wood fire.

## Analysis of the Indian Neck Ossuary

A variety of quantitative and qualitative techniques have been developed by various researchers for analysis of cremated human remains. Metrics have proven useful in certain situations for sex determination. Bone weight has been used to estimate representation of skeletal elements and to infer body part selection for burning. Visual inspection of the remains, focusing on degree of burning and surface characteristics exhibited on the bones, is essential for inferring pre-incineration body condition and the relationship of the bodies to the fire.

There is not a single, best method for the analysis of all cremations. Techniques must be adopted which are most appropriate for the questions to be addressed in each situation. The Indian Neck ossuary cremations appear to represent a discrete, "one-time event" in which all the individuals were burned simultaneously and contained in a single pit. Thus there is confidence that the number of individuals established on the basis of counts for each skeletal element provides an accurate reflection of those individuals included in this form of mortuary activity. These cremated remains look different in some regards than any other cremations this author has analyzed, however. The degree of burning exhibited by the bones is strikingly uniform, with complete calcination the general rule rather than the exception. Given the complete incineration of the remains and the hypothesized post-incineration redeposition, the expectation is that few of the bones would have survived intact, yet this is not the case. While there were numerous small, unidentifiable fragments, the number of large and partially complete or complete bones allowed this to be the primary unit of analysis rather than fragments. Because of these characteristics of the Indian Neck cremations, the analytical techniques had to be tailored to address the questions outlined above. The results of the analysis of the Indian Neck skeletal remains are presented below.

## Demography

The demography of the ossuary has been examined in detail in Chapter 1, so only those results relevant to mortuary behavior will be summarized here. At least 56 individuals are represented in the ossuary; 47 in the unburned portion and 9 from the cremations. Of those individuals which were not burned, 25 are adult and 22 are subadult, representing nearly the entire age range. The exception to this is the apparent exclusion of infants in their first 6 months of life; no individuals representing that age group were recovered in the unburned bone sample. Determination of sex of the adults based on various visual and metric sexing techniques indicates there are only slightly fewer females than males represented in the sample. These data suggest that inclusion in the unburned portion of the ossuary was not restricted according to gender or age, with the exception of exclusion of infants in their first 6 months of life. The exclusion of infants under about 6 months of age from ossuary burial was also observed among the early historic period Huron (Tooker 1964).

Cremation is a special form of body treatment afforded to only certain members of the group. In the case of the Indian Neck ossuary, 9 individuals were cremated--6 adults and 3 subadults. Of the adults, at least 1 individual is approximately 18-20 years of age. At least 2 individuals are older adults, or 45+ years of age. The other 3 adults are between 20 and 45+ years of age. Two of the subadults are 7-10 years of age at death, while the third represents a newborn or late-term fetus. Pelvic morphology indicates that at least 2 of the 6 adults are female, while mandibular morphology suggest that 3 of the adults are male.

Although 9 individuals is an admittedly small sample, the demographic profile of the cremations is similar in some respects to the unburned portion of the ossuary sample. The most apparent differences are in the subadult age groups. In the unburned sample, slightly less than one third of all individuals are between the ages of 6 months and 7 years of age at death, while in the cremated sample, there are no subadults within this age range. Cremation may be reserved for a particular portion of the group, in this case excluding those who are less than 6 years of age. The recovery of fragments of a newborn or late-term infant in the cremated sample stands in marked contrast to their total absence in the unburned portion of the ossuary. It is possible that this young individual is an accidental inclusion, since it is represented only by a small fragment of the proximal end of the left ulna, the petrous portion of the temporal, and one occipital condyle. It may have been "processed" nearby another, older individual and when those remains were collected for reburial, portions of the newborn were accidentally picked up as well. At the same time, the bones are so small that they may represent a late-term infant, and it is possible that one of the cremated females was pregnant at the time of death. Finally, the possibility that this infant was included intentionally cannot be ruled out entirely. Small bones more often suffer destruction due to burning than do large bones, and all the bones recovered from this infant are dense and likely to preserve. Age at death is a distinguishing criterion for this type of body treatment, since infants and children less than 6 years of age are not represented in the cremations (with the single exception noted above). It is entirely possible that affiliation with some other group, perhaps kin-based, irrespective of age is the critical consideration. Due to chance alone, no infants or young children in that group may have died during the period when the ossuary was used.

The demographic profile of the unburned smaple from the Indian Neck ossuary suggests that this form of burial is afforded all members of the group older than 6 months of age. Cremation, however, may be reserved for a portion of the social group whose membership excludes infants and young children. Gender, however, does not appear to restrict access to this form of mortuary treatment.

## Body Processing: Dismemberment

In order to make inferences about the method of pre-interment dismemberment, all bones, burned and unburned, were examined for evidence of cut marks or scraping, particularly around the joints. There is no clear evidence to suggest that the bodies were dismembered mechanically as the preferred method of body-reduction treatment. There was, however, evidence of cutting on the skulls of two individuals: both adult males, one 50+ years of age and the other 25-30 years of age at death. In both cases, cut marks are observable in the temporal fossa immediately posterior to the zygomatico-frontal suture, on the malar just below the orbit, at the lateral margins of the orbits. In the case of the older adult male, cut marks are observable on the forehead near glabella (see Figure 3.1). This suggests that in at least two cases, mechanical means of removing soft tissue from the face occurred. Lack of evidence for mechanical dismemberment and defleshing for the majority of the skeletal remains, however, would suggest that decomposition and dessication by natural means (probably burial) was the primary form of body treatment prior to interment in the ossuary. Anderson (1963) notes that during the Feast of the Dead, primary burials were exhumed and transferred to large, common pits. Churcher and Kenyon (1960) specifically note that there is no evidence of working on any of the bones from the Tabor Hill ossuaries. In the Indian Neck ossuary, those cases where cut marks are evident might suggest that these individuals were recently deceased at the time of the time of the burial event, necessitating removal of the remaining soft tissue prior to final interment. Lack of evidence for cut marks on the vast majority of the remains would imply that this was not the preferred means of body reduction.

## Representation of Body Parts

A detailed count of the bone elements represented not only provides information essential for inferring the number of individuals interred in the ossuary, but it can also be used to determine relative representation of body parts. Differences in the numbers of various bones can be indicative of variability in bone preservation, but may also be indicative of mortuary behavior. Over- or underrepresentation of certain bony elements could suggest their intentional inclusion or exclusion from burial. If selective representation of bones can be ruled out, then comparisons between the numbers of bones in each category can be used to assess loss of body parts, whether due to differential preservation or loss of bones during the curation period prior to burial.

Figure 3.1: Adult Male with Cut Marks.

After the minimum number count for each bone was established, the counts were ranked. Then the percentage of the total number of individuals represented by each bone was calculated. Adults and subadults for the unburned and cremated samples were counted separately. The rank order of bones in the unburned and cremated portions of the sample are presented in Tables 3.2 and 3.3 respectively.

In the unburned sample, 25 adults are represented by the mandible. This number is followed closely by the temporal which represents at least 24 individuals. Femora and humeri, the next most frequently occurring bone, represent only 80 percent of the total minimum number of adults, while the tibia accounts for only 56 percent. With the exception of the tibia, radius, and perhaps fibula, decreasing rank order generally corresponds to decreasing bone size, with the small bones of the hands representing the fewest number of individuals. A pattern such as this is most indicative of sampling error rather than intentional selection of body parts for interment or curation elsewhere. Most likely, the lower numbers of these small bony elements exemplify differential preservation during the period of ossuary burial or their accidental loss at some time prior to final interment rather than their purposeful exclusion. Recall that an estimated one-quarter to one-half of the unburned sample was not recovered. Some of the larger bones underrepresented in the unburned sample may have been in the part of the backdirt pile which was not screened, thus creating an additional, archeological, sampling bias.

The same pattern of bone representation appears to hold for the subadult sample. The larger and/or more dense bones occur more frequently than the smaller, more fragile elements. It appears that the differential representation of body parts for both adults and subadults is most reasonably explained as sampling error rather than as the intentional selection of body parts for burial in the ossuary.

The counts of cremated bones were analyzed in the same manner as the unburned sample. The minimum number of each element is rank ordered for adults and subadults separately and is presented in Table 3.3. As was the case for the adults in the unburned sample, those bones which are most dense and/or large are represented most commonly in the cremations. The possible exception is the relatively smaller number of adult femora, but this could well be due to this researcher's waning enthusiasm for reconstructing femora from piles of fragments. In contrast to the unburned sample, even some of the hand and foot bones are as common as the larger, more dense bones.

All elements of the subadult cremations are reasonably well represented. Small sample size and the greater likelihood that subadult bones would be destroyed by burning are

TABLE 3.2

Rank Order Representation of Skeletal Elements: Unburned Sample

| Adults: Bone | n | (%) | Subadults | n | (%) |
|---|---|---|---|---|---|
| Mandible | 25 | (100) | Femur | 20 | (100) |
| Temporal | 24 | (96) | Humerus | 17 | (85) |
| Femur, Humerus | 20 | (80) | Mandible, Tibia | 16 | (80) |
| Occipital, Maxilla | 19 | (76) | Temporal | 15 | (75) |
| Ulna | 18 | (72) | Occipital, Ulna, Innominate | 14 | (70) |
| Frontal, Calcaneus | 16 | (64) | Scapula, Frontal | 13 | (65) |
| Innominate | 15 | (60) | Maxilla | 11 | (55) |
| Tibia, Scapula, Talus | 14 | (56) | Radius | 9 | (45) |
| Clavicle, Foot Navicular | 12 | (48) | Axis | 8 | (40) |
| Radius | 10 | (40) | Fibula, Clavicle | 7 | (35) |
| Atlas, 2nd Cuneiform, 1st, 5th Metatarsal | 9 | (36) | Atlas, Talus | 6 | (30) |
| Axis, Sacrum, Patella, 1st Cuneiform, 1st and 5th Metatarsal | 8 | (32) | Calcaneus | 5 | (25) |
| Fibula, Cuboid, 2nd, 3rd Metatarsal, 5th Metacarpal | 7 | (28) | Sacrum | 4 | (20) |
| 12th Thoracic Vertebra, 3rd Cuneiform, 2nd Metacarpal | 6 | (24) | 12th Thoracic Vertebra | 3 | (15) |
| Hand Navicular, 1st and 3rd Metacarpal | 5 | (20) | Foot Navicular, 1st Metacarpal | 2 | (10) |
| Greater Multangular, 4th Metacarpal | 4 | (16) | Patella, Cuboid, Cuneiform, 5th Metacarpal | 1 | ( 5) |
| Capitate, Lunate, Lesser Multangular | 2 | ( 8) | | | |
| Hamate | 1 | ( 4) | | | |

TABLE 3.3

Rank Order Representation of Skeletal Elements: Cremated Sample

| Adult Bone | n | (%) | Subadult | n | (%) |
| --- | --- | --- | --- | --- | --- |
| Temporal, Mandible, Scapula, 1st Metatarsal | 6 | (100) | Occipital, Ulna | 3 | (100) |
| Frontal, Maxilla, Atlas, Axis, Humerus, Radius, Ulna, Tibia, Clavicle, Innominate, Calcaneus, Talus, Navicular, 2nd and 4th Metatarsal, 2nd Metacarpal | 5 | (83) | Frontal, Mandible, Axis, 12th Thoracic, Femur, Tibia, Clavicle, Scapula, Innominate, Talus | 2 | (68) |
| Femur, Fibula, Cuboid, 1st and 3rd Cuneiform, 3rd and 5th Metatarsal, 1st, 3rd, and 5th Metacarpal | 4 | (67) | Maxilla, Atlas, Sacrum, Fibula, Humerus, Radius, Calcaneous, Cuboid | 1 | (33) |
| Sacrum | 3 | (50) | | | |
| Patella, 2nd Cuneifrom, Capitate, 4th Metacarpal | 2 | (33) | | | |
| 12th Thoracic Vertebra, Lunate, Lesser Multangular, Hand Navicular | 1 | (17) | | | |

reasonable explanations for the differential representation of bone elements in the subadult cremations.

It can be inferred from these data that relatively complete skeletons were buried in the ossuary. This pertains to those individuals who were cremated as well as those who were not burned. The underrepresentation of some elements generally corresponds to decreasing bone size and density. This pattern is indicative of sampling bias due to bone recovery and/or preservation rather than culturally-motivated selection of particular bones for inclusion or exclusion from burial. An indeterminate amount of the unburned portion of the sample was not recovered, and all dirt was not screened (see the discussion of this in Chapter 1), so a loss of small bones is not unexpected. The relatively common occurrence of hand and foot bones in the cremated sample may be due to any of several factors. Burned bone preserves better than unburned bone. (Merbs 1967). The burned sample was undisturbed and completely recovered. As will be disussed in the subsequent section, evidence suggests that the corpse was disarticulated and defleshed prior to burning, and only 2 individuals appear to be fairly fresh when burned. The others were dry. It is entirely possible that the method of post-mortem defleshing differs between individuals who were burned and those who were not, such that more of the small bones would have been retained. Alternatively, method of curation or storage of the bones of those individuals to be cremated may have differed in such a way that the loss of small bones was less likely. Thus, evidence to suggest that certain body parts were selected for inclusion in or exclusion from burial is lacking.

## Inferring Pre-incineration Body Condition

Articulated or Disarticulated: As discussed previously, when a body is articulated at the time of incineration, it would be expected that joint surfaces protected from the heat by opposing bone would be burned to lesser degree than the surrounding bone. All joint surfaces from the cremated sample were examined for degree of burning. It was found that joint surfaces were burned to the same degree as the rest of the bone. For example, the vertebrae would be expected to demonstrate different degrees of burning if articulated bodies had been burned. Surprisingly, the vertebrae survived the burning largely intact. Given a minimum of 6 adults, of the 144 vertebrae expected at least 102 were identified, and virtually all were calcined, generally demonstrating a uniform gray-white or gray-tan color (Figure 3.2). Burning patterns evident on the crania indicate that at least some were whole and intact at the time of burning. In two cases, portions of the parietal at the squamosal suture were only smoked, due to the shielding offered by the squamous portion of the temporal.

The lack of evidence for differential burning on joint surfaces suggests that the remains were not articulated at the time of burning. Since not every joint surface for each individual was preserved, it is possible that the evidence indicative of articulated bodies was not recovered. All of the articular surfaces recovered, however, support the conclusion that the remains were disarticulated at the time of cremation. The next question to be addressed, then, is whether the bodies were in the flesh or defleshed at the time of cremation.

<u>In-flesh, Defleshed, or Dry Burning:</u> Examination of all the bones and fragments indicates that the majority of the remains were calcined. The color of the calcined bones was variable including white, buff, gray-tan, blue-gray, and light gray. Smoked bone also exhibited variation in color, including charcoal gray, brown-black, and black (Figure 3.3). An attempt was made to sort fragments into categories depending on the relative amount of each type of burning--calcined, smoked, or unburned. The intention was to count and weigh the bones in each category as a means of quantifying the amount of each type of burning exhibited in this series. This strategy ultimately was abandoned, since the variability exhibited by the sample was so great that it was difficult to reduce it to a manageable number of discrete categories. For example, when attempting to categorize a long bone fragment by relative amount of each type of burning, it was possible for both the outer cortex and medullary surface to be calcined while the inner cortex was incompletely calcined. Since it is possible to see the inner cortex only along the broken edges, it would have to be assumed that the entire cortex was burned to the same degree as the visible portion. Obviously, this assumption would not always hold, for it was possible to find fragments in which the cortex on one end was totally calcined while the cortex at the other end demonstrated areas of dark gray or black. Alternatively, it was possible to find examples on which the outer cortex was calcined incompletely and the medullary surface and inner cortex were calcined completely. Because of the great variation exhibited, it did not seem that there was a reasonable way to quantify the amount of each color. Instead, a qualitative assessment was made of the relative amount of each color indicating various degrees of burning, recognizing, however, that this is a very subjective measure.

Rather then spend time sorting bone in the manner just described, effort was put into reconstructing portions of the bones. This strategy would afford a more complete picture of the color patterns and variation in degrees of burning on a given bone and allow a more reliable assessment of pre-incineration body condition. As discussed previously, bones in the flesh at the time of burning generally fail to achieve a uniform color. While some areas of the bone calcine, other areas still protected by flesh will only become smoked.

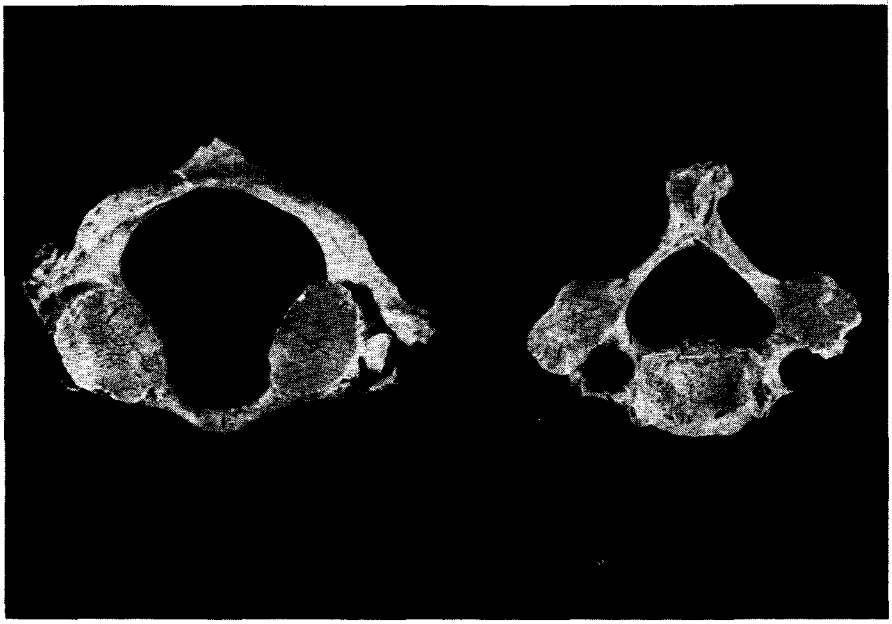

Figure 3.2: Cervical Vertebrae Showing Uniform Calcination.

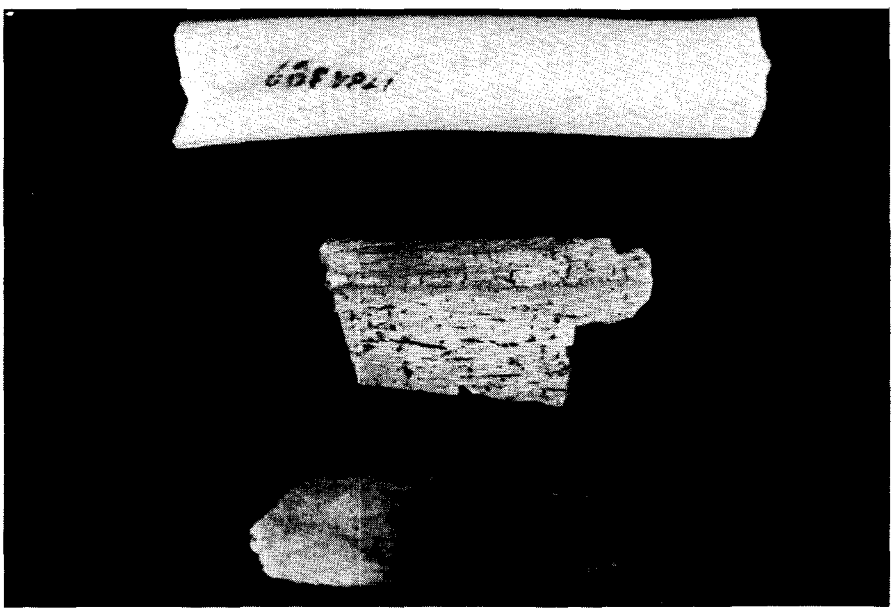

Figure 3.3: Color Variation in Burned Bone.
(Calcined white [top]; calcined gray [middle]; and gray/black of calcined/smoked bone [bottom])

Results of experimental studies suggest that when bones burned in the flesh become calcined, color and surface cracking patterns are difficult to distinguish from green burning; these differences are more a matter of degree than kind. In-flesh and green burned bone which is only smoked can not be distinguished from one another. Dry bone burning, however, is more readily distinguished from green and in-flesh burning. Since patterns of differential smoking and calcination on a single bone appear to be the most distinctive criterion for establishing in-flesh burning, color patterns were weighted most heavily in this analysis.

None of the bones in the Indian Neck series demonstrated the extreme warping, cracking, and splitting frequently characteristic of in-flesh burning. Further, evidence for abrupt changes from one degree of burning to another on a single bone (the pattern most indicative of in-flesh burning) was lacking. In support of this observation, Thurman and Willmore (1980-81), in burning their in-flesh specimens, found that the articular ends of the bones were completely consumed before portions of the shafts even became calcined. In the Indian Neck series, the majority of the remains were completely calcined and articular ends were commonly preserved. The uniform pattern of calcination, combined with the lack of extreme warping, deep longitudinal splitting, transverse cracking, and the frequency of largely intact bones strongly suggest that the Indian Neck cremations were not burned in the flesh.

This observation might not hold true if the fire temperature was relatively low and the bones were burned for a longer period of time. Neither of these variables were sufficiently controlled in any of the experimental studies cited. In their study of the effects of burning temperature on the color of calcined bone, Shipman et al. (1984) noted that bones burned for four hours in a kiln were uniformly calcined, even at low temperatures. In those experiments, the bones were fresh, but defleshed, so the effect of soft tissue on the bones at the time of burning, even at low temperatures, would be unknown.

Thus far the pattern of burning on the Indian Neck cremations suggests that the bones were defleshed and disarticulated at the time of burning. The question remains, however, whether the bones were green or dry at the time of burning. This question was addressed by looking at each fragment and categorizing it according to the degree of burning and the pattern of surface characteristics indicative of green vs. dry burning. This process was initiated by sorting long bone fragments into categories based on color, and then into green- or dry-burned. The next step was to quantify each of these categories by counting the number of fragments and weighing them in order to estimate the relative amount of dry or green burning. This was used as a proxy estimate of the proportion of individuals that were green or dry at the time of burning. During this process, a fragment from the proximal end of a tibia was classified as dry-burned and later, a piece from the distal end of the same tibia had been classified as characteristic of green burning. Finding fragments from the same bone that had been placed in different categories seriously undermined confidence in the results obtained using this particular anaytical procedure and it was abandoned. The alternate strategy that was adopted was to invest the time that would have been spent sorting fragments into reconstructing, insofar as possible, parts of bones, concentrating particularly on crania and tibiae. These two skeletal elements received more attention only because they are easily identifiable. When portions of the elements were reconstructed, it provided a clearer picture of the pattern of coloration, cracking, and warping on more nearly complete bones. The reconstructed bones were then used to estimate the condition of a complete individual at the time of burning.

Rather than focus on bone fragments as the unit of measure, then, this procedure focuses on partially reconstructed skeletal elements. This method of analysis may introduce a bias, in that the heaviest and most dense bones are more likely to survive burning intact and are thus more likely to be identified subsequently. These same elements are also less likely to demonstrate the warping and distortion characteristic of in-flesh and green burning.

Even with this method of analysis, it was difficult to determine pre-incineration body condition. Examination of one skeletal element (say the ulna) would suggest that 4 of the 6 adults were burned dry. Alternatively, evidence from crania would suggest that only 3 of the 5 individuals were burned dry, while only 2 of the 4 femora were clearly indicative of dry burning. To further compound this problem, some skeletal elements demonstrated characteristics that would imply either green or dry burning. In the discussion of the experimental evidence obtained from in-flesh, green, and dry burning, Buikstra and Swegle (n.d.) caution that longitudinal striae, longitudinal splitting, and no warping (characteristics usually displayed by dry-burned bone) were also demonstrated by some of their green-burned specimens. Conversely, other researchers point to a lack of warping as a characteristic of dry burning, yet Buikstra and Swegle found that dry bone did, in fact, warp.

In the Indian Neck cremations, the observed pattern of surface features characteristic of dry burning but accompanied by some warping could imply at least 3 possible scenarios. One, the bones were green, but the fire temperature was not excessive, and/or the bones were heated slowly such that cracking and warping were not extreme. Alternatively, the fire temperature could have been sufficiently intense to warp many of the dry bones. The preponderance of calcined bone with lack of differential burning patterns suggests that these individuals were at least defleshed prior to burning (as discussed above), and there is evidence to suggest that at least two were green (Figure 3.4). Experimental burning studies carefully dichotomize the bone categories. Either the bones are in-flesh or stripped immediately prior to burning. The dry bone has been stripped of the flesh and dry for extended periods of time (i.e., a 1500 year-old burial that has been housed in a museum or laboratory--conditions where most of the water in the bone has been lost). What is unknown, however, is the variability expected in bones that are differentially dessicated when burned. Some bones of an individual, or segments of bones, could retain more grease and water than others, depending on the manner of defleshing, length of time the bones were defleshed prior to burning, and the manner in which the bones were curated prior to burning. In reality, green and dry bone are probably a continuum. The question is, how green is "green", and how dry is "dry"? The third possibiity, then, is that the disparate patterns of color, cracking, checking, and warping, may be due to differing amounts of pre-incineration drying.

All three possibilities have their merits. The size of the fragments suggests that the fire was not intense for a long period of time or, that many of the bones escaped the intense heat if they had been burned green. With intense heat, green bones would be expected to crack and break into many more fragments than was the case for the Indian Neck sample. The fire had to be hot or of long duration since the vast majority of the bones are calcined. That the bones were dry but had been subject to sufficient heat to warp them also could be supported.

Based on the observations of each skeletal element, the color, cracking patterns, and warping strongly suggest that at least 3, and probably 4 of the adults were burned dry. At least 1 of the 7-10 year-old subadults and 1 of the other adults were likely quite fresh at the time of burning. It seems that the characteristics observed on the Indian Neck cremations represent individuals who were not all recently deceased, but rather were individuals who had died at varying lengths of time prior to incineration. All were defleshed, however.

## Reconstructing the Burning Event

Placement of the Remains Relative to the Fire: Determining the relationship of the bodies to the fire is best accomplished

Figure 3.4: Distal Humerus of 7-10 Year-Old Exhibiting Cracking and Warping Indicative of Green Burning.

using both contextual information and the patterns of burning evident on the bones. In cases of redeposition after the burning event, evidence must be obtained solely from the bones. Because the majority of the bones are completely calcined, evidence from distinct color changes is not available. Other lines of evidence used to infer pre-incineration body condition all suggest that the bodies were defleshed, and many of them dry, at the time of the burning. Thus, a pattern of burning indicative of completely articulated, in-flesh bodies with the fire built over them would not be expected. Neither was there evidence to suggest some regular pattern of stacking or placement of the bones during the burning event. Unfortunately, in the case of the Indian Neck ossuary, little information could be gleaned either from the excavation records or the examination of the bones that would aid in suggesting the way in which the bones were placed nor the way in which the fire was constructed.

Fire Temperature: Fire temperature is also difficult to establish on the basis of the evidence available here. As Shipman et al. (1984) point out, color of calcined bone is not a sufficient criterion to determine precise fire temperature. Additionally, Shipman and co-workers burned green bone whereas many of the Indian Neck individuals were burned dry. Buikstra and Swegle (n.d.) point out that dry bone which is calcined differs in color from green bone. There is a lack of experimental evidence to suggest temperature-related color differences in dry-burned bone. Tooth crowns in the Indian Neck series did not preserve, suggesting that the bones reached temperatures at least as high as $500^{\circ}$ C. This is not particularly informative since studies have documented the maximum temperature reached by various types of fires using a variety of different woods (see references cited in Shipman et al. [1984]). Many of these types of fires are capable of sustaining temperatures in excess of $500^{\circ}$C, and at Indian Neck this seems to be the case.

## In-Situ Burning and Post-Incineration Redeposition

The sequence of events inferred from excavation of the cremations is that the burning did not occur *in situ* but rather took place nearby, and that the still hot remains were redeposited in a pit at the bottom of the ossuary feature. The primary lines of evidence used to support this position were that the soil under and around the cremated bones was not sufficiently reddened to indicate *in-situ* burning and that there was a lack of charcoal (see Bradley et al. [1982] and Part I of this volume). Despite these observations, it seems that *in-situ* burning is still a likely possibility. Even if the bones were burned nearby, it is probable that charcoal would have been scooped up with the bones when they were collected for redeposition. The lack of discernible charcoal may be due to complete, or near-complete combustion of the wood used in the fire. Buikstra and Swegle (n.d.) note that fires constructed out of juniper leave little charcoal when compared to a fire fueled by oak. Further, these same researchers report that bones which are dry at the time of burning will completely calcine in about one hour. Perhaps a fire of such duration would be insufficient to color the soil to the deep red expected, based on observations of cooking hearths.

Finally, fragment size in the Indian Neck cremations is not indicative of extensive post-incineration manipulation. Although there are many small fragments in this series, the amount of whole, intact bone is unusually high and unexpected. It is recognized that fragment size can result from any number and combination of factors. Among these are pre-incineration body condition, temperature of the fire, length of time the bones were exposed to the heat, stirring or disturbance during the burning episode, the manner in which the bones are cooled after burning and a host of variables related to post-incineration treatment. These include possible redeposition, the effects of being in the ground for approximately 1000 years, not to mention the process of excavation and final deposition in the laboratory. Because of the preponderance of large bones, it could be inferred that there was minimal disturbance to the bones during the firing process. Bones raked around while still hot would be expected to break to an extent greater than that observed in this series. An equally plausible reconstruction is that the remains were burned in situ. When the burning event was complete, the remainder of the bones were placed in the pit. It is not possible to test either of these hypotheses and they must remain speculation.

## Summary

The primary goal of this chapter was to describe the morturay activity associated with ossuary burial at Indian Neck. The focus was on inferences about that segment of the population afforded this type of mortuary treatment and whether gender or age were used to exclude some members from burial in the ossuary. In addition, evidence for differential treatment of individuals included in the ossuary was explored.

Analysis of these data would suggest that ossuary burial was afforded all members of the group. Only infants under the age of 6 months were unduly underrepresented. Nearly equal numbers of males and females were identified. The sample of cremations is small, yet individuals of both sexes and adults of various age groups are represented. It is possible that children less than 6 years of age were excluded from cremation since the subadults recovered were both 7-10 years of age. The inclusion of a few bones from a newborn or late-term infant may contradict the age-specific criterion for cremation, although the possibility that this infant was an accidental inclusion cannot be discounted.

Prior to interment in the ossuary, the bodies were defleshed, most likely by natural means such as burial in the ground. Only two adult males exhibited marks around the face indicative of cutting flesh from the bones. Whether these two individuals died just prior to the time the ossuary was used, necessitating removal of the flesh by scraping, or whether removing flesh from the face has some ritual significance is unknown.

Analysis of the cremated remains suggests that these individuals were disarticulated and defleshed prior to incineration. Further, at least 4 of the adults evidenced dry burning while 1 adult and at least 1 of the juveniles show evidence of burning while the bones were fairly fresh. Rather than indicating that the cremations represent recently deceased individuals, the pattern of differential green and dry burning suggests that individuals were variously dessicated prior to incineration. It is suggested that body treatment prior to cremation did not differ in any observable way from the manner in which those unburned individuals were treated. Instead, cremation probably was reserved for some segment of the group that cannot be identified according to age or gender, except that young children might have been excluded.

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☆U.S. GOVERNMENT PRINTING OFFICE : 1986—602-193/30067

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