HARP SEAL (Phoca groenlandica) CANINE DENTINE INCREMENTAL ANNULI AS INDICATORS OF AGE AND/OR SEASON OF DEATH

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HARP SEAL (*Phoca groenlandica*) CANINE DENTINE INCREMENTAL ANNULI AS INDICATORS OF AGE AND/OR SEASON OF DEATH

By

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CHAPTER 1 INTRODUCTION

This research project addresses the use of Northwest Atlantic harp seal canine dentine incremental structures to determine age and/or season of death. Age determination will indicate the age composition of the harvested population. The season of death (harvest time) is employed to derive an estimation of site seasonality.

Determining the season of site occupation is a primary objective for most archaeologists. Season of site occupation or human occupation period is also referred to as site seasonality. Data on site seasonality provides valuable information concerning a culture's subsistence/ settlement pattern. The seasonal and/or yearly subsistence system(s) is interrelated to the entire cultural system and directly influences settlement patterns.

The Dorset Palaeoeskimo and Groswater Palaeoeskimo occupations at Port au Choix, Newfoundland, are sites with uncertain site seasonalities. The recovered faunal remains and excavated house features provide indications of multiple seasons to year round occupation (Renouf 1987, 1993, 1994a, 1994b). The late winter to spring time period is firmly established based on the recovered faunal remains. This material is dominated by harp seals including some fetal, newborn and juvenile (young of the year) bones.

The migratory harp seals are known to whelp on ice off

Port au Choix in late February to early March and remain in the area until at least May. However, harp seals also migrate past Port au Choix in late December to January ahead of the advancing ice. They could be taken in the open water by net or harpooned from a watercraft during this period. Thus, a middle winter occupation period could be assumed if any of the harp seal material is from December or January.

The only potential method available to distinguish between the southward migration (December/January) and northward migration (late February to May) involves dentine incremental annuli. This direct seasonality (Monks 1981) and aging (Bowen *et al.* 1983, Fisher 1954) method will constitute my research project. Dentine and cementum are analyzed by techniques based on the fact that a regular yearly detectable annuli pattern is formed. Interpretation of this pattern can indicate age and/or time of death for the individual specimen. Age is determined by counting the yearly annuli and time of death is suggested by the latest annuli's stage of development.

All age composition data are based on the assumption that the faunal material recovered and analyzed represents the entire original death population or a representative portion of all age groups utilized. However, there are a number of problems with this assumption and with constructing age composition profiles based solely on teeth. Firstly, determining an accurate population size must be based on more than one body element (i.e. teeth). That is, population number/MNI (minimum number of individuals) based on teeth must be compared to the MNI derived from other body elements (i.e. humerus, femur, scapula, etc.) recovered in order to determine how accurately the teeth MNI represents the death population contained in the unit/feature.

Secondly, all teeth sectioned are unlikely to produce readable sections (Spiess 1990:37) thus the complete age composition of the recovered faunal material will be unknown. The proportion of unreadable specimens to total specimens will directly affect the data's accuracy. For example, a few nonaged specimens in a small sample could greatly alter the apparent age composition profile.

Other potential problem areas are a small population size; how to quantify and identify loose teeth to species; whether the deposit represents a single discrete, seasonal, or multi-year deposition; and the assumption that butchery and culling patterns are uniform for a cultural group or single species within a seasonal or yearly deposit.

Likewise, there are caveats to determining site seasonality. For example, the connection between the specimen's time of death and some behavioral activity of the cultural group must be demonstrated (Thomas 1979:261). A direct correlation between site seasonality and a specimen's time of death cannot be assumed where stored (Savelle 1987:72), traded (Davis 1987:75), or transported (Monks

1981:226) resources are utilized.

Estimating site seasonality will depend on how precise (day, week, month, etc.) a seasonal indicator dentine incremental structures are. Monks (1981:178) notes that seasonality or time of year can be considered as an absolute calendrical date, sequential date (estimation of spring, summer, fall or winter season) or Jochim's (1976:45) proposed economic season. The economic season is a period, measured in calender months, when a clearly noticeable and regular group of subsistence activities takes place.

Aging Based on Dentine/Cementum Technique

Scheffer (1950) and Laws (1952) developed techniques for aging marine mammals using incremental growth layers in teeth. Wildlife biologists have continued to utilize these techniques involving dentine/cementum annuli (incremental growth layers) to age terrestrial and marine mammals for decades (Fletemeyer 1978; Goodwin and Ballard 1985; Mitchell 1963; Ransom 1966). The techniques are based on the fact that a regular yearly detectable dentine/cementum layer pattern is formed. This concept is similar to that of dendrochronology (tree ring dating) which is based on the regular yearly concentric growth ring pattern of trees.

Research with known age mammal specimens has shown that the layers are produced annually and that the technique can provide accurate absolute age results (Bowen *et al.* 1983;

Doubleday and Bowen 1980; Erickson and Seliger 1969; Linhart and Knowlton 1967; Low and Cowan 1963; Scheffer 1950). Absolute age according to Morris (1972:71) "is an animal's age expressed in precise measurements of time, usually months or years." Obtaining accurate age estimates is dependent on determining discrete incremental annuli (Gasaway *et al.* 1978:561). However, Goodwin and Ballard (1985:315) noted that accuracy of age determination varied with the reader's experience in interpreting incremental annuli.

Cementum is preferred over dentine for aging mammals because in older mammals the cementum readings are considered more reliable. Dentine is deposited internally until the pulp cavity is filled but the externally deposited cementum is not limited by space being produced until the animal's death. As the pulp cavity is filled with dentine the layers become more compressed and difficult to distinguish. The cementum layers are not compressed and generally easy to distinguish. But, harp seals only produce a thin cementum layer and the cementum growth layer groups are not reliable for age estimating because they are usually indistinct (Bowen *et al.* 1983:1432). Therefore researchers examine the dentine annuli when studying harp seals.

A number of tooth section preparation techniques are available to facilitate and enhance the reading of dentine/cementum annuli (See Chapter 3). The basic techniques for preparing mammalian teeth are: i) decalcifying teeth (usually involves formic acid or a formic acid/formalin solution); ii) razor sectioning; iii) microtome sectioning including both the standard paraffin technique and the freezing technique; iv) staining which most commonly is hematoxylin; v) ground sections viewed with transmitted light; and vi) ground sections viewed with reflected light (Fancy 1980).

These tooth preparation techniques permitted dentine/cementum annuli aging to receive wide acceptance and to be applied to a range of terrestrial mammals. The mammals studied include the badger (Crowe and Strickland 1975), vampire bat (Linhart 1973), black bear (Stoneberg and Jonkel 1966; Willey 1974), grizzly bear (Craighead *et al.* 1970; Mundy and Fuller 1964), bison (Novakowski 1965), bobcat (Crowe 1972), caribou (McEwan 1963; Miller 1974), coyote (Linhart and Knowlton 1967; Nellis *et al.* 1978), deer (Lockard 1972; Low and Cowan 1963), elk (Keiss 1969), red fox (Allen 1974; Harris 1978), moose (Gasaway *et al.* 1978; Sergeant and Pimlott 1959; Wolfe 1969), otter (Stephenson 1977), North American sheep (Turner 1977), and squirrel (Adams and Watkins 1967).

Researchers have applied the incremental growth layer technique to a variety of marine mammals (whales and seals) (Scheffer and Myrick 1980). Klevezal and Kleinenberg (1969) list twenty-one Pinnipedia species known to have annual dentine or cementum layers. Seals aged by this technique include fur (Anas 1970; Scheffer and Peterson 1967), grey

(Hewer 1960), harbour (Mansfield and Fisher 1960), harp (Bowen *et al.* 1983), Hawaiian monk (Kenyon and Fiscus 1963), and ringed (Smith 1973). The Canadian Department of Fisheries and Oceans continues to age bearded, grey, harbour, harp, hooded and ringed seals by the dentine/cementum annuli technique.

Although biologists are concerned with aging the specimens, most reports contain some data on the season (time) of dentine/cementum layer formation. Usually, they describe the last annuli formed and the time (day, month, etc.) of death (Craighead *et al.* 1970:353; Erickson and Seliger 1969:387). Seasonality is then presented in gross terms of between winter and summer or winter/spring and summer/fall (Adams and Watkins 1967:837: Mitchell 1963:351).

Archaeological Application of Dentine/Cementum Technique

The discipline of archaeology has adapted these methods and techniques to estimate age at death and/or season of death of archaeological faunal remains (Cox and Spiess 1980; Gordon 1982, 1988; Gustafson 1968; Kay 1974; Savelle and Beattie 1983; Saxon and Higham 1969; Spiess 1976, 1978, 1979, 1990; Wilson 1978). Bourque *et al.* (1978:530) suggest three advantages for archaeologists in using mammalian teeth as a seasonal indicator. These advantages of mammalian teeth are durability, the fact that they are usually identifiable to genus or species, and that they overcome the need for large statistically significant sample (Bourque *et al.* do not explain why this is the case). But, not all mammalian teeth recovered will produce readable thin sections because of alteration (from fire etc.), poor preservation or destruction during thin section preparation.

Compared to biologists, archaeologists have studied only a limited number of terrestrial and marine mammal species using the dentine/cementum annuli technique. These include black bear (Bourque *et al.* 1978); bison, *Bison antiquus* (Bourque *et al.* 1978; Christensen 1971); caribou (Gordon 1982; Savelle 1987; Spiess 1979); white-tailed deer (Kay 1974: Spiess 1990); muskoxen (Savelle and Beattie 1983); grey seal (Black 1989); harp seal (Spiess 1978); ringed seal (McCullough 1989; Savelle 1987; Spiess 1978: Whitridge 1990); and sheep (Saxon and Higham 1969).

A modern baseline reference sample is required for interpreting the archaeological specimen's age and/or season of death. That is, the technique of determining age and season of death must be established for modern specimens before archaeological specimens can be interpreted. Modern specimens can provide verifiable data not available for archaeological specimens. Using specimens of known age can verify the technique for aging based on incremental annuli. Also, the modern reference sample (of known time of death) provides verifiable data on the season (time of death) when the dentine/cementum annuli are formed.

Following the principle of uniformitarianism, the researchers assume a direct correlation or no significant difference between modern specimens and archaeological specimens in incremental annuli formation. This implies that modern specimens developed under the same conditions and seasonality factors as the archaeological specimens.

Hypotheses and Comments

The research is designed to test the following hypotheses:

Hypothesis 1. Accurate age and/or season of death estimates can be determined from canine dentine incremental growth layers for modern harp seals (*Phoca groenlandica*).

This is a testable hypothesis as age results can be verified for the specimens of known age. Also, season of death estimates can be verified because the time (day and/or month) of death is known for all the studied specimens.

Aging harp seals using dentine annuli is an established and proven technique (Bowen *et al.* 1983; Fisher 1954) but determining season of death has never been adequately addressed. The application to archaeological specimens will be tested once the dentine technique for aging and estimating season of death estimates has been established on modern canines.

Hypothesis 2. Accurate age and/or season of death estimations can be determined from canine dentine incremental growth layers of harp seal (*Phoca groenlandica*) archaeological specimens based on a modern baseline sample.

The hypothesis is untestable as there are no known age or time of death archaeological specimens to verify the results. In theory archaeological specimens whose age and time of death have been established by other means (aging pattern of elements formation, seasonal cycles of modern species) could be used for verification thus making the hypothesis testable.

Also, the hypothesis is based on the assumption that regardless of time difference modern reference data can be applied to archaeological material. This implies that no variation in seasonal rounds or change in migration pattern for harp seals has occurred through time. The assumption is addressed by reviewing changes in modern seasonality movements and the possible factors that influence such changes.

Another assumption is that harp seal season of death indicates the season the Port au Choix sites were occupied and is not a reflection of other factors (storage, curated material, etc.). This assumption is based on the fact that harp seals are presently and were historically hunted off Port au Choix. It is highly improbable that harp seal carcasses and remains were brought to a site where they were readily available. But, harp seal season of death may reflect only a portion of the time the site was occupied.

Aging and/or season of death for archaeological harp seal specimens is not a well documented procedure. Spiess (1978) has analyzed a few canines, from Labrador sites, based on a very small reference sample. A modern baseline sample of known time of death is required to provide precision in the interpretation of archaeological specimens (Spiess 1990:30). I believe this baseline sample must cover the entire period of development being analyzed and include enough samples to account for individual and yearly variations.

If season of death estimates are possible based on modern specimens then interpretations of archaeological site seasonality can be made. Besides separating the two migration periods, it may be possible to divide up the late winter to spring period. A division of this period would highlight any changes in culling patterns or hunting strategies during the harp seal harvest.

Background Information on Port au Choix Sites

Prehistoric artifacts and remains have been recorded for the Port au Choix (Figures 1.0) area since the turn of this century. Howley (1915:328) reports that ivory and bone artifacts along with human remains were recovered in the early 1900s. The first concerted excavations were conducted in

1949, 1950 and 1961-62 by Elmer Harp Jr. (1964) mainly in an area known as Phillip's Garden. The Dorset Palaeoeskimo site consisted of numerous house depressions that possibly represent two types of housing. Harp believes that there are both winter and summer houses on the site. The excavations also produced massive quantities of bone that Harp identified as mainly harp seal.

In 1967 Tuck (1976) excavated a Maritime Archaic Indian burial ground containing grave goods and eighty-nine individuals in fifty-five burials. Parks Canada acquired the area in 1984 and contracted Dr. M.A.P. Renouf, Archaeology Unit, Memorial University, to conduct an archaeology survey. The survey would help in future park development and designate areas for potential research.

Renouf's site excavations have identified both Dorset Palaeoeskimo and Groswater Palaeoeskimo occupations. Numerous artifacts and large quantities of faunal remains have been recovered. The vast amount of the faunal material is seal that is dominated by harp seal. Harp seal canines recovered by Renouf, at Phillip's Garden and Phillip's Garden East, are the archaeological material basis for this research project.

Phillip's Garden Dorset Palaeoeskimo Site

Phillip's Garden is a two hectare site comprised of three raised shorelines. Numerous small rectangular, oval and round house depressions are located on the upper two raised shorelines. This site was occupied for at least 400 years between 1900-1500 years ago but may have been occupied for nearly 1000 years.

The excavated house depressions indicate different house layouts which Renouf (1994a) interprets as representing seasonal differences. These include winter/spring, spring/summer or fall/early winter structures and a summer windbreak. However, all three house types could reflect the changing conditions within the February to June (late winter, spring, early summer) period that seals are available.

The site contains extensive midden deposits with well preserved bone because of the limestone bedrock. Seal bone dominates the faunal remains with a predominance of harp seal. The seal material includes varying amounts of fetal, newborn and juvenile remains in the features. Feature 2 (actually 12 subfeatures) contained small amounts of newborn and juvenile seal, newborn material was identified in Midden Features 49 and 32, and House Feature 1 had some juvenile remains.

This seal material indicates a late winter to spring occupation to coincide with the whelping and moulting periods and the June/July period when only juveniles are available. During the whelping and moulting periods, harp seals would be readily available on the ice along the Port au Choix coast. The other faunal remains recovered support this time period (Hiseler 1990a). However, these species are also available at other times during the year. Renouf (1994a:11) highlights some of these alternative time periods by stating that "caribou are closest to Phillip' Garden in the summer. Late summer is suggested by the presence of the now-extinct great auk."

The great auk is the only species identified for Phillip's Garden that is not available during the late winter to spring period according to Renouf (1994a). Renouf reports that Montevecchi (Renouf 1994a:11) states a late summer (July/August) migration is possible but ice in the Straits of Belle Isle would have prevented a spring migration. However, the harp seals migrate through the Straits of Belle Isle following the retreating ice and reach Port au Choix in late February. It is also known that some Gulf herd seals whelp off Labrador when ice conditions are poor in the Gulf (Bowen 1985). This indicates that the Straits are not always blocked by ice and therefore a spring migration of great auk would be possible.

The harp seal northward migration period (late winter to early summer) can account for faunal remains and house structures located at Phillip' Garden. However, an extended or other seasons of occupation are possible for Phillip's Garden based on the same data. The analysis of harp seal dentine annuli may determine if the occupation period can be extended into middle winter (December/January).

Phillip's Garden East Groswater Palaeoeskimo Site

Phillip's Garden East borders the Dorset Palaeoeskimo Phillip's Garden site covering approximately 1500 square meters. The site has excellent bone preservation and contains at least two house structures with six pit features. Material recovered to date includes over 2700 lithic artifacts and 75,000 faunal remains. The site was at least occupied between 2760+/-90 B.P. to 1930+/-140 B.P. and utilized on a regular seasonal basis (Renouf 1994b).

The site reflects repeated occupations during the late winter to spring harp seal hunt. Harp seal dominates the seal material recovered that is 90% of the site's faunal remains. The late winter period is indicated by the small amount of harp seal fetal material. The high number of juveniles support the late winter/spring period but could also indicate a May-July hunt when they are the only age group available.

Renouf (1994b) reports a high amount of processing tools that indicates a function specific occupation. This function would be the harvesting and processing of the migrating harp seal. Phillip's Garden East would be seasonally re-occupied and these occupations might have been variable based on the two different house structures. The harp seal dentine development in the archaeological specimens may help to define the parameters of the occupation season.

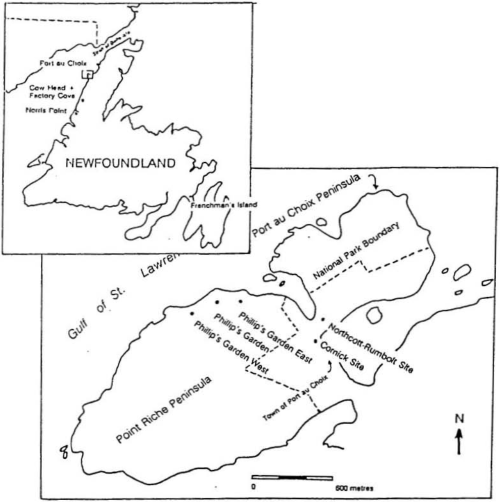

Figure 1.0 Port au Choix Archaeological Sites

(Renouf 1994b:168)

Content of Chapters

Chapter 2 provides background information on the development, composition, and preservation of dentine. Also, the general structure of teeth and the available data on harp seal dentine are reviewed. The methods to prepare and examine modern and archaeological tooth sections are discussed in Chapters 3 and 4, respectively. Included in the discussion are the techniques utilized for this research project and the problems encountered. Data on the harp seal, including migration routes and age group habits, are presented in Chapter 5. The seasonality and aging results on both the modern and archaeological specimens is presented in Chapter 6. Chapter 7 contains a discussion of the potential and problems in developing harp seal age composition profiles based on the canine incremental aging technique. Also, the results of archaeological specimens aged by the technique are presented and analysed. Chapter 8 comprises the conclusions of the research.

CHAPTER 2 TOOTH DENTINE

A brief description of the tooth's basic components (Figure 2.0) provides a framework for understanding dentine's structure and function. The root(s), contained in the jaw, and the crown are the two major sections of a tooth. Enamel covers the crown while the root(s) is coated by cementum. Under the surface layers is dentine, the tooth's main structure, which encapsulates the pulp chamber.

DEFINITIONS

The definitions are based on the internationally accepted meanings for marine mammals (Perrin and Myrick 1980:48-50).

Cementum - always forms layers over the root but in certain species also forms layers over coronal section. The cementum provides for tooth attachment. This mesodermal originated calcified tissue frequently includes osteocytes (cementocytes).

Crown - the distal tooth section which projects from the gingival surface and is covered by enamel in most species.

Dentine - a mesodermal originated tissue that is cellular and calcified. With the exception of ziphiids the crown and root consist primarily of dentine. The crown dentine is coated by enamel while the root dentine is covered by cementum.

Enamel - an ectodermal originated mineralized secretion covering the dentine externally. Cementum may cover areas of the enamel.

Growth layer group (GLG) - countable units of incremental growth layer groupings that form a repeating or semi-repeating pattern. Each unit will contain one or more contrast change (i.e. dark to light, ridge to groove).

Incremental growth layers (IGL) - layers running parallel to the formative surface that are discernibly different from adjacent layers in hard tissue (dentine, cementum, bone).

Neonatal line - an orthodentine growth layer that divides prenatal dentine from postnatal dentine. This division probably results from early post-partum nutritional disturbances.

Pulp cavity - the central tooth chamber containing connective, sensory and nutritive tissues. The dentine defines the boundaries of the pulp cavity.

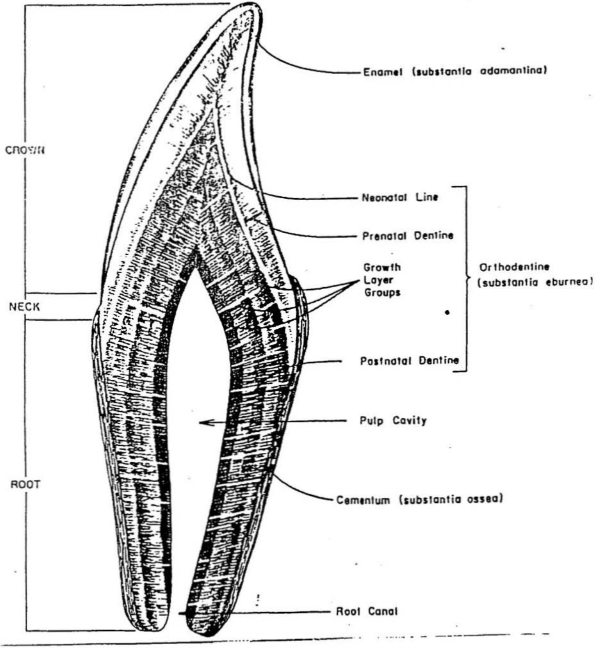

Figure 2.0 Basic Tooth Components

(Perrin and Myrick 1980:49)

DENTINE

Physical Properties and Chemical Composition

COMPONENT	% WEIGHT
collagen	17.5-18.5
resistant protein	0.2
citrate	0.86-0.89
lactate	0.15
lipid	0.044-0.36
chondroitin sulphate	0.2-0.6
water	5

Table 2.0 Organic Components of Dentine by % Weight

COMPONENTS	% WEIGHT
Ca	26-28
P (as PO_4^{3-} and HPO_4^{2-})	12.2-13.2
P (as pyrophosphate)	0.05
CO_2 (as carbonate)	3.0-3.5
Na	0.7
Mg	0.8-1.0
Cl	0.4
K	0.02-0.04
	PARTS PER MILLION
F	50-10,000
Fe	60-150
Zn	200-700
Sr	100-600

Table 2.1 Inorganic Components of Dentine by % Weight or Parts per Millions

Unless otherwise cited all the information concerning dentine is from Avery (1986).

Dentine is softer and elastic compared to enamel but harder than bone. The composition of dentine is 65% inorganic material and 35% organic matter and water. Collagenous fibrils (Collagen of type I) are the main component of the organic material. Other components are glycosaminoglycans, proteoglycans, phosphoproteins, glycosaproteins, and plasma proteins (Torneck 1989). The inorganic material is hydroxyapatite with small quantities of phosphates, carbonates, and sulfates. Decalcified teeth produce valuable histological sections because the dentine shape is preserved and the organic constituents are retained. Mature dentine's weight and volume percentages differ for inorganic material, organic material and water. Respectively the percentages by weight are 70%, 20%, and 10% while for volume they are 45%, 33%, and 22% (Torneck 1989). The primary and secondary dentine are chemically different (Shipman *et al.* 1985). Variations in microscopic dentine structures between mammals has been observed (Hillson 1986).

Structure

A random framework of collagen fibres forms the dentinal matrix. New dentine, called predentine, forms layers circumpulpally. Intertubular dentine comprises the major portion of dentine between zones of peritubular dentine.

Except adjacent to the pulp, peritubular dentine forms tubules walls.

Primary Dentine

Primary dentine is composed of mantle and circumpulpal dentine. Mantle dentine is the outer part of primary dentine first formed in the crown. After the mantle dentine has formed the remaining organic matrix is formed by the odontoblasts. Circumpulpal dentine forms the bulk of the tooth representing the dentine formed prior to root completion. A slightly higher mineral content is one possible difference between circumpulpal and mantle dentine.

Secondary Dentine

Secondary dentine is the dentine formed after root completion and unevenly deposited around the pulp cavity's periphery (Torneck 1989). There is continuous deposition of secondary dentine occurring in the pulp chamber throughout life (Hillson 1986). The earliest dentine forms closest to the outer tooth walls while the latest is next to the pulp cavity (Klevezal and Kleinenberg 1969).

Incremental Lines

The incremental lines are fine striations in dentine which occur at right angles to the dentinal tubules. Dentine incremental lines directly correspond to enamel and bone incremental lines. These lines mirror the recurrent daily rhythmic deposition of dentine matrix and the quiescence period in the daily formative process. Hillson (1986) reports that sharpness and spacing of incremental lines vary within a tooth and between species. But, the sequence of lines in any tooth of an individual can be matched to that individual's other teeth. According to Hillson this "implies that the rhythm is under systemic control." The dentine of deciduous teeth and first permanent molars is composed of prenatal and postnatal dentine. The prenatal and postnatal dentine are separated by the neonatal line that reflects the abrupt environmental change at birth. The neonatal line might represent a zone of hypocalcification.

Some points to consider about incremental lines are:

a) Less distinct lines are best detected with longitudinal ground sections according to Torneck (1989).

b) Not all mammals or teeth and bones of mammals form or preserve incremental lines (Klevezal 1980:89).

c) Increased primary incremental layer width results in additional accessory/secondary incremental lines (Klevezal 1980:89).

d) Generally mammals in climatic zones with no pronounced contrast between warm and cold or dry and humid seasons will form indistinct and variable incremental layers (Klevezal 1980:92).

Interglobular Dentine

Interglobular dentine is known as hypomineralization zones between the globules. These zones are formed when small mineralized dentine globular areas fail to fuse into a homogenous mass. The interglobular dentine forms in the crowns of teeth below the mantle. Deposition of the interglobular dentine follows the incremental pattern.

The Granular Layer

Named for its appearance, this granular appearing root dentine section abuts the cementum. The granular layer's formation probably results from the coalescing and looping of dentinal tubules' terminal sections.

Age and Functional Changes

The process of dentinogenesis and secondary dentine production slows shortly after the teeth erupt. After eruption tooth damage from dental caries, abrasion or attrition is repaired by reparative dentine.

Development

Dentinogenesis is the origin and formation of dentine (Melfi 1988) and is formed by cells called odontoblasts. Apatite crystallites calcify the organic matrix with dentinal tubules of odontoblast cytoplasmic extensions are produced during dentinogenesis. The organic matrix is produced by odontoblasts and mineralizes (globular or calcospheric calcification) to form dentine. Odontoblasts are differentiated "from the ectomesenchymal cells of the dental papilla following an organizing influence emanating from the cells of dental epithelium" (Cate 1989). Dentinogenesis begins at the cusp tips with the forming and then calcification of the collagen matrix. Daily increments of predentine are formed and calcified the following day. Once the crown forms and the teeth erupt the dentine production decreases. A further decrease of dentine production is possible after root development.

Causes for the Annuli Formation

A full range of metabolic and environmental causes are suggested for annuli formation in mammals. These factors may cause the formation of dentine annuli in harp seals. Some of these causes are:

a) Chiasson (1957) suggests dark dentine is formed in Alaskan fur seal during the three month non-feeding land occupation period. A wider dentine band represents the nine month sea period. Variations in annuli are influenced by nutrition, parasitism and disease. Also, males on land utilize their built up fat deposits which lacks calcium salts required to build enamel or dentine.

b) Hewer (1960) suggests that early broad annuli in grey seals are deposited prior to sexual maturity. Semi-starvation during the moult period is responsible for these annuli being visible.

c) The visible interruptions in cementum and dentine deposition in Hawaiian Monk seals results from fasting during the moult period (Kenyon and Fiscus 1963).

d) Low and Cowan (1963) believe nutrition is a prime factor in visible annuli production for mule deer.

e) Differences in seasonal nutrition and sunlight may influence seasonal cementum deposition for barren ground caribou (McEwan 1963).

f) Seasonal metabolic disruptions (i.e. denning, etc.) combine to produce the annuli in black bears (Stoneberg and Jonkel 1966). Rausch (1961:16) studied non-denning captive bears and found no distinct layers of dentine.

g) Possibly environmentally stressful periods produce the similar annulations in North American sheep teeth and horns (Turner 1977).

Any of the above could be possible causes for the annuli formation in harp seals. Research to date has been unable to provide a precise correlation between a metabolic and or environmental event and the annuli formation.

Preservation

Hillson (1986) states that well preserved fossil dentine appears like fresh dentine. But, fossil dentine often displays varying degrees of alteration such as brittleness, or softening from collagen loss. Although collagen is limited in its susceptibility to bacteria and fungi, slow to chemically disintegrate, and is insoluble in water when heated, it rapidly breaks down to form gelatine. The dentine tissue is completely destroyed during the late phase decomposition loss of the apatites (calcium phosphates). Various archaeological contexts, such as heating changes from fire, can produce the altered opacity and dentine structure that is visible in tooth sections. Shipman *et al.* (1984) experimented with the effects of heat on sheep and goat teeth. Increased temperatures were found to progressively alter hydroxyapatite and collagen; microscopic structures; and create shrinkage due to water loss.

Biochemical and radiographic research on archaeological dentine specimens by Beeley and Lunt (1980) showed:

a) Mineral content of the tissue was unchanged.

b) Collagen degeneration created a change in consistency.

c) Only the final destruction stages of bone and tooth showed mineral loss.

d) When over half the original protein content is lost the dentine becomes softened.

e) All calcium salts remain in softened dentine, providing data by means of x-rays.

HARP SEAL DENTINE

Deciduous teeth are resorbed prior (80%) to and after birth in March. Permanent teeth eruption is 38% complete at birth and by weaning (three weeks) is completed (Stewart and Stewart 1987a). A phocid postnatal tooth represents all dentinal growth since prenatal tooth formation (Fisher 1954). The neonatal line in harp seals is formed at birth (Stewart and Stewart 1987a).

Fisher (1954) suggests a common causative factor for harp seal dentine annuli because all of his study sample displayed a similar pattern and structure. Also, Fisher found that harp seal dentine incremental annuli (Figure 2.1) are often crowded and indistinct after about twelve years making interpretation difficult. This crowding results from the decrease in the pulp cavity as dentine is deposited yearly.

Fisher (1954) observed the same regular annual pattern of dentine layer formation for all ages of both sexes. Bowen *et al.* (1983) also saw no difference in the pattern of GLGs for male and female harp seals. They (1983:1434) report:

> at each age the translucent IGL begins to form in June-July and reaches its maximum thickness in February-March, corresponding to the time of harp seal births. The outermost IGL in a typical GLG, the interglobular dentine, is formed in April and

early May, the period when harp seals undergo their annual moult. The middle IGL or opaque band is formed in May and June, during the time when most harp seals are migrating to their summer feeding range.

The regular pattern of GLG formation allows the division of the year into three time periods reflecting each IGL's developmental period. Any modern or archaeological harp seal could be placed in one of these three time periods based on the last IGL. However, the translucent IGL's developmental period spans nine months and includes the southward and northward migrations to the Port au Choix area.

The separation of these two migrations at Port au Choix has implications for defining seasonality of archaeological sites. Therefore, some means to subdivided the translucent layer must be developed in order to separate the two migrations. The translucent dentine may develop at a predictable rate thus permitting an estimation of percentage development at December compared to late February/March. Another possibility is that similar to GLG formation the IGLs are formed by a regular pattern of layers. A number of modern canine sections will be required to attempt this deciphering of the translucent layer. But, first a review of the literature on dentine analysis for mammals must be conducted.

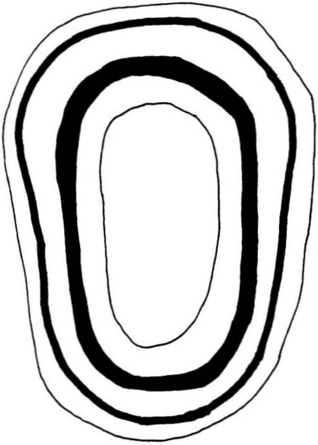

Figure 2.1 Diagrammatic Cross Section of a Harp Seal Canine Section

CHAPTER 3 METHODS: REVIEW AND DISCUSSION: MODERN SPECIMENS

Wildlife biologists age marine and terrestrial mammals using the tooth dentine/cementum annuli method (Klevezal and Kleinenberg 1969; Morris 1972). This chapter discusses tooth selection and the various techniques utilized in sectioning. A wide diversity of tooth section preparation techniques are available to the researcher. Decalcifying, sawing, microtome sectioning, grinding, and staining are some of these techniques. Once the section is prepared a number of viewing techniques are available to analyse the dentine/cementum annuli. Either transmitted or reflected light can be utilized with some form of magnification (i.e. binocular microscope). Photographic techniques (i.e. pictures or slides) to enlarge or enhance the images are also utilized.

Cementum or Dentine

Based on the literature reviewed cementum was preferred over dentine for aging terrestrial mammals whereas cementum and dentine were equally utilized for marine mammals. Only four marine mammals of the twenty-nine mammal species (twenty-one terrestrial and eight marine) were aged solely on the basis of dentine annuli. No terrestrial mammals were aged by dentine although dentine annuli were visible in a number of the teeth examined. McEwan (1963:112) observed annuli in the dentine of barren ground caribou but noted the first three annuli were not very distinct. Marks and Erickson (1966:408) reported that dentine in black bear provide unreliable readings compared to the known age. Only 71% of the sheep teeth sectioned by Turner (1977:213) displayed dentine annuli.

The major problem with interpreting dentine annuli is that the layers become compressed and difficult to distinguish as the pulp cavity fills. Kenyon and Fiscus (1963:281) reported that the Hawaiian monk seal's pulp cavity was completely filled by age four or five. The grey seal's pulp cavity also fills in during the first few years of life (Hewer 1960:960). In other marine mammals such as the steller sea lion the pulp cavity is not filled until fifteen years or older (Fiscus 1961:218). Fisher (1954:30) states that annuli are crowded and indistinct after the twelfth year but up to thirty-four annuli have been distinguished in harp seal canines.

Cementum is preferred over dentine for aging most mammals because in older individuals the readings are considered more reliable. However, harp seals only produce a thin cementum layer and therefore researchers study the dentine. Bowen *et al.* (1983:1432) state that reliable age estimates from cementum growth layer groups (GLGs) are not possible for harp seal. Although visible in tooth sections, the cementum annuli are mostly indistinct. The cementum annuli of ringed seal are also not distinct enough to be reliable for aging (Smith 1973:8). Smith reports aging by cementum annuli when the pulp cavity is full of dentine. Using cementum annuli McLaren (1958:8) aged one male ringed seal at around forty-three years.

Longitudinal Sections Versus Cross-sections

The use of longitudinal or cross-sections to count dentine/cementum annuli varies among researchers. Craighead *et al.* (1970:356) state that longitudinal sections are superior to transverse sections for distinguishing annuli in grizzly bears. Miller (1974:49) believes for barren ground caribou "the occurrence of annuli and the possible splitting, merging, or disappearance of an annuli" are best determined in longitudinal sections. These changes in annuli could be missed in cross-sections according to Miller. In grey wolves the annuli are most distinctive and false annuli most obvious in longitudinal sections (Goodwin and Ballard 1985:315). The longitudinal sections also provided consistent age results for grey wolves. Hemming (1969:553) considered longitudinal sections best for dall sheep because the cementum thickness varies on the tooth root. Harris (1978:95) also found longitudinal sections the easiest to interpret for aging red foxes because the longer section provided a more accurate count.

Cross-sections are preferred by some researchers because more cross-sections than longitudinal sections can be prepared per tooth (Erickson and Seliger 1969:385). Thomas and Bandy (1973:234) while studying black-tailed deer concluded that cross-sections exposed the entire circumference while longitudinal sections only reveal two segments of the circumference. In mule deer teeth Erickson and Seliger (1969:385) noted that while often missing in longitudinal sections the most distinct area of cementum annuli is always found in the cross-section.

Tooth Preference

Teeth producing the most suitable/readable tooth sections varies among mammal species and with researcher preference. Teeth aged by the dentine/cementum annuli technique include canine, incisor, premolar and molar. Wolfe (1969:428) found that moose maxillary teeth annuli show greater separation and regular appearance than the same individuals mandibular teeth annuli. Sergeant and Pimlott (1959:316) used the first incisor for aging moose because it is the largest and first to erupt of the four incisiform teeth. But, Wolfe (1969:428) utilized the first true molar which is the first permanent tooth to erupt in moose. Fogl and Mosby (1978:444) used the third molar of grey squirrels because of that tooth's thick cementum deposit. Canines are preferred for seals because they have the largest pulp cavity.

TOOTH	SPECIES	SOURCE
canine	bobcat	Crowe 1972
canine	coyotes	Linhart and Knowlton 1967
canine	red fox	Allen 1974 Harris 1970
canine	cape fur seal	Fletemeyer 1978
canine	steller sea lion	Fiscus 1961
upper canine	black bear	Marks and Erickson 1966
upper canine	grey wolves	Goodwin and Ballard 1985
upper right canine	badger	Crowe and Strickland 1975
upper right canine	fur seals	Scheffer and Peterson 1967
upper right canine	Alaskan fur seal	Chiasson 1957
upper right canine	harbour seal	Mansfield and Fisher 1960
upper right canine	Hawaiian monk seal	Kenyon and Fiscus 1963
incisor	white-tailed deer	Lockard 1972
incisor	moose	Sergeant and Pimlott 1959
upper incisor	common vampire bat	Linhart 1973
first incisor	mule deer	Erickson and Seliger 1969 Low and McT.Cowan 1963
first incisor	barren ground caribou	McEwan 1963

Table 3.0 Preferred Teeth for Sectioning (continued next page)

TOOTH	**SPECIES**	**SOURCE**
first incisor	elk	Keiss 1969
first incisor	moose	Gasaway *et al.* 1978
first incisor	pronghorns	McCutchen 1969
first incisor	dall sheep	Hemming 1969
premolar	red fox	Harris 1978
first premolar	black bear	Willey 1974
fourth premolar	bison	Novakowski 1965
lower fourth premolar	grizzly bear	Craighead *et al.* 1970
molars	barren ground caribou	Miller 1974
molars	beaver	Van Nostrand and Stephenson 1964
molars	white-tailed deer	Lockard 1972
molars	red fox	Harrris 1978
first molar	white-tailed deer	Ransom 1966
first molar	red deer	Mitchell 1963
first molar	moose	Wolfe 1969
third molar	grey squirrel	Fogl and Mosby 1978
lower third molar	grizzly bear	Mundy and Fuller 1964
lower third molar	ground squirrel	Adams and Watkins 1967

Table 3.0 (continued) **Preferred Teeth for Sectioning**

Techniques for Preparing Tooth Sections

A number of tooth section preparation techniques are available to facilitate and enhance the reading of dentine/cementum annuli. The following presents a sample of this wide range of techniques that have been utilized on modern mammalian teeth.

i) Decalcifying Teeth

Teeth are decalcified to facilitate the successful cutting of tooth sections. Dilute acids are used to dissolve the calcium phosphate minerals contained in enamel, dentine and cementum (Hillson 1986:169). But extended exposure to the decalcifying agent can reduce the staining quality of the remaining tooth tissue (Bhaskar 1986:459). Organic acids such as formic and trichloroacetic have a lesser impact on the staining quality of the tissue (Hillson 1986:169).

Bobcat (Crowe 1972:1330), elk (Keiss 1969:176) and mule deer (Erickson and Seliger 1969:386) teeth were demineralized in formic acid. A mixture of formalin, formic acid and water was used on common vampire bat (Linhart 1973:494), coyotes (Linhart and Knowlton 1967:362) and North American sheep (Turner 1977:212) teeth. The mixture used by Turner was five parts formic acid to one part formalin to 20 parts distilled water. Allen (1974:153) decalcified red fox canine in 77% water, 20% formic acid and 3% formaldehyde. A solution of 10%

formic acid and 5% formalin was used by Thomas (1977:207) to decalcify bear, caribou, cougar, dog, mountain goat, human, muskoxen, North American deer, roe deer and wolf teeth.

California ground squirrel teeth were soaked in Hartman-Ladden decalcifying fluid that contained HCI and chelating agents (Adams and Watkins 1967:836). Goodwin and Ballard (1985:314) decalcified grey wolves teeth in 10% HCL that contained chelating agents. Chelating agents help to preserve the staining properties of the remaining tissue (Hillson 1986:169). RDO, a type of rapid bone decalcifier, was used on American badger teeth by Crowe and Strickland (1975:269). Stephenson (1977:1578) used 5% nitric acid on otter teeth while for black bear Stoneberg and Jonkel (1966:411) utilized 15% nitric acid and 30% formic acid on black bear while Harris (1978:94) used 3% nitric acid in 10% formaldehyde on red fox. Nitric acid according to Turner (1977:213) obliterated the distinct annuli of North American sheep. Morris (1972:87) also notes that prolonged decalcifying in 5% nitric acid will cause teeth to become histologically featureless.

The time required to decalcify the teeth varied from hours to days depending on the solutions used. The RDO rapid bone decalcifier used on badger teeth required four hours or less and had the potential to over-decalcify (Crowe and Strickland 1975:270). Thirty hours are required to decalcify California ground squirrel teeth using Hartman-Ladden decalcifying fluid (Adams and Watkins 1967:836). Caribou teeth required 18 to 72 hours, depending on age and whether incisors or molars, using Miller's (1974:48) nitric acid solution. One of the longest decalcifying periods was the 13 to 15 days required for red fox teeth (Allen 1974:153). Fogl and Mosby (1978:444) preferred formic acid-sodium citrate solution because of a shorter decalcifying time than nitric acid and Hartman-Ladden fluids.

ii) Resin Embedding

Embedding teeth in resin and similar materials strengthens the teeth to withstand the effects of sawing and grinding. Grizzly bear tooth roots were placed in dental rock prior to sectioning by Mundy and Fuller (1964:864). Bow (1966:438) embedded sperm whale teeth in Ciba 'Araldite' casting resin which required a curing time of approximately four hours. Dry mule deer teeth were soaked in uncatalyzed resin and all teeth were embedded in catalyzed resin by Erickson and Seliger (1969:385). The resin was allowed to harden overnight and then heat harden at sixty degrees celsius for three to four hours. Keiss (1969:176) also embedded elk teeth in catalyzed resin while Marks and Erickson (1966:390) used Bioplastic for black bear and for caribou teeth Miller (1974:48) utilized plastic. Miller *et al.* (1988:138) embedded human teeth in polyester casting resin inside butyrate plastic tubing.

iii) Types of Saws

Researchers use a wide variety of saws to cut their tooth sections (see Table 3.1).

Erickson and Seliger, and Miller used the Gillings-Bronwill thin sectioning diamond saw machine. The unit's cutting speed was five rpm while cooled and lubricated by water (Erickson and Seliger 1969:386). A major problem with using saws is the destruction of a section of tooth with every cut. Erickson and Seliger (1969:386) report a 305 micron section was destroyed between each section cut.

iv) Razor Sectioning

Straight edge razor sectioning by hand was used by Allen (1974:153) on red fox teeth and Fogl and Mosby (1978:445) on grey squirrel teeth. Thomas (1977:207) cut some of his sections with a razor blade by hand. A problem with razor sectioning was that a number of sections are slanted making photographs almost impossible (Fogl and Mosby 1978:447).

SAW TYPE	SPECIES	SOURCE
hacksaw	moose	Wolfe 1969:428
diamond blade lapidary	moose	Wolfe 1969:428
fine tooth lapidary	moose	Gasaway *et al.* 1978:559
diamond dental disc/wheel	black bear	Marks and Erickson 1966:390
diamond dental disc/wheel	dall sheep	Hemming 1969:553
diamond rock saw	Alaskan fur seal	Chiasson 1957:311
bandsaw	moose	Sergeant and Pimlott 1959:316
jeweller's circular saw	moose	Sergeant and Pimlott 1959:316
jeweller's saw	seal	Fisher and Mackenzie 1954:535
tooth saw	pronghorn	McCutchen 1969:173
Niclas Bone and Tooth cutting machine	grizzly bear	Mundy and Fuller 1964:864
Dremel electric scroll saw	black bear	Willey 1974:98
thin sectioning saw	mule deer	Erickson and Seliger 1969:384
thin sectioning saw	elk	Keiss 1969:176
thin sectioning saw	caribou	Miller 1974:481
Gillings-Hamco thin sectioning machine	ringed seal	Smith 1973:3
small circular saw	seal	Department of Fisheries

Table 3.1 Saws used to Section Teeth

v) Microtome Sectioning

Microtomes cut thin sections of organic tissue to permit microscopic study of the tissue. Microtome sectioning, including the standard paraffin or parlodion embedding technique or the freezing technique, is a routine histologic procedure. Two embedding techniques used on mammal teeth are cryoform and paraffin wax. The freezing microtome method eliminates the need for tissue dehydration and is more rapid than the standard technique (Fancy 1980:243).

Bobcat (Crowe 1972:1330) and North American sheep (Turner 1977:213) teeth embedded in cryoform were sectioned on an International-Harris Cryostat. Grey wolves (Goodwin and Ballard 1985:314) teeth were sectioned on a Minotome Microtome-Cryostat while Miller used an Ames Tissue-cryostat for caribou. Stoneberg and Jonkel (1966:412) embedded black bear teeth in paraffin wax and sectioned them with a hand-operated sledge microtome. Harris (1978:94) cut red fox teeth sections with a freezing microtome technique.

vi) Grinding Sections

Teeth are ground to produce the actual section or to remove saw cut marks and/or reduce the section's thickness. Fletemeyer (1978:695) produced cape fur seal tooth sections by grinding with 360 grit carbide paper, pumice and whiting. A number of sawed sections were polished and reduced through various grinding methods. Marks and Erickson (1966:390) ground black bear teeth sections on a commercial carborundum stone with water. White-tailed deer teeth (Lockard 1972:48) were smoothed using a fine grit carborundum wheel mounted on a bench grinder and finished by a very fine aluminum oxide wheel hand grinder. Sections were ground by Frost (1958:273) using No. 320, 360 or 400 grit carborundum abrasive paper while Fisher and MacKenzie (1954:536) used a grinding machine with two fine grit carborundum stones. Van Nostrand and Stephenson (1964:431) ground beaver tooth sections with a 4,000 rpm fine texture circular grindstone.

During grinding of the tooth section water or a water spray was used to eliminate a number of potential problems. These problems include dust, odour and burning of the tooth, cracking and overheating of the tooth (Gasaway *et al.* 1978:559; Lockard 1972:48).

vii) Staining

Numerous researchers stain tooth sections to increase the contrast between the opaque and translucent annuli. The increased contrast improves the readability of the dentine/cementum annuli. Although a wide range of stains and staining techniques have been tested, Peragon and Harris' hematoxylin are most commonly utilized.

Goodwin and Ballard (1985:314) tested nineteen stains on grey wolf tooth sections and preferred Harris' modified hematoxylin stain with hot bath. They state that this stain produced consistently detectable and readable cementum annuli. However, Thomas (1977:207-210) found cationic stains superior to the more commonly used hematoxylin stains. Metachromatic cationic stains such as toluidine blue, thionin, and crystal violet were preferred. These stains provide more consistent results and produced contrasting annuli colours. Cementum annuli with the least amount of background colour resulted from using toluidine blue stain. The stains display variability between species, teeth and the staining tests but metachromatic stains had greatly less variability than hematoxylin stains.

STAIN	SPECIES	SOURCE
Peragon	common vampire bat	Linhart 1973:494
Peragon	bobcat	Crowe 1972:1331
Peragon	coyotes	Linhart and Knowlton 1967:363
Peragon	red fox	Allen 1974:153
Peragon	North American sheep	Turner 1977:213
Hematoxylin	mule deer	Erickson and Seliger 1969:386
Hematoxylin	elk	Keiss 1969:176
Hematoxylin	grey squirrels	Fogl and Mosby 1978:445
Hematoxylin	black bears	Stoneberg and Jonkel 1966:412
Hematoxylin	otter	Stephenson 1977:1578
Hematoxylin	red fox	Harris 1978:94
Hematoxylin	grizzly bear	Craighead *et al.* 1970:356
Hematoxylin	grey wolves	Goodwin and Ballard 1985:314

Table 3.2 Tooth Section Stains

Methods of Viewing Teeth Sections

Two methods of viewing teeth sections are:

i) magnification (i.e. binocular microscope) using either transmitted or reflected light

ii) photomicroscope.

Transmitted light was used for black bear (Marks and Erickson 1966:390) and ringed seal (McLaren 1958:5; Smith

1973:3) teeth sections. Chiasson (1957:316) suggests that thick sections could be made clearer for viewing by soaking in cedarwood oil for a minimum of twenty-four hours. Transmitted light was considered better than reflected light by Marks and Erickson (1966:391) for counting black bear cementum annuli. Reflected light was used by Mundy and Fuller (1964:864) on grizzly bear while Lockard (1972:48) and Ransom (1966:198) viewed white-tailed deer teeth. Sergeant and Pimlott (1959:316) also used reflected light for moose tooth sections.

Researchers utilized various types of microscopes and magnifications to enhance tooth section interpretation. A dissecting scope and 40X magnification was used by Allen (1974:153) for red fox and Mundy and Fuller (1964:864) for grizzly bear tooth sections. Sectioned fur seal teeth were only magnified three times by Anas (1970:845). For moose teeth Gasaway *et al.* (1978:559) used a binocular microscope at 10-30X magnification. Sergent and Pimlott (1959:316) viewed alcohol moistened moose teeth sections with 10-40X and measured the annuli width with a eyepiece mounted calibrated micrometer. Wolfe (1969:429) used oil or colourless nail polish to enhance the annuli when viewed at 20X with a binocular microscope. Turner (1977:213) viewed sheep teeth sections at 40-100X magnification with transmitted light using a green filter and a binocular microscope.

Magnification of 160X from a Zeiss Standard GFL fluorescence microscope was utilized by Hemming (1969:554) for aging dall sheep teeth. The microscope was equipped with barrier filters 53/47, exciter filter III and an Osram high-pressure mercury lamp. Linhart (1973:495) used 100X magnification for vampire bats while using a compound microscope and 40X to 100X magnification for coyotes (Linhart and Knowlton 1967:363). Miller (1974:48) read caribou sections at 100X to 400X magnification with a Bausch and Lomb Zoom Microscope.

Bow (1966:438) photographed sperm whale teeth with extra fine grained slow speed (50 A.S.A.) film. Fur seal teeth sections were photographed at 5X magnification by Scheffer and Peterson (1967:36). Erickson and Seliger (1969:386) examined 95 micron thick mule deer teeth sections with a Zeiss photomicroscope. A Zeiss exciter filter BG 12 and a Zeiss barrier filter 53/44 were used with transmitted ultraviolet light. Erickson and Seliger considered the technique promising since the cementum annuli fluoresced to be distinguishable. Photomicrographs were taken of all grizzly bear teeth sections examined by Craighead *et al.* (1970:356). Miller *et al.* (1988:138) made photomicrographs of human tooth sections using Kodak Panatomic X film and 90X magnification under subdued light. The cementum annuli were counted by projecting the photomicrographs onto a screen.

Comments

Selecting the methods to produce and examine tooth sections varies with researcher preferences and animal species. A researcher could follow the methods outlined for a specific species but some experimentation is required to determine what technique produces the desired results for an individual researcher. For example, unaltered annuli are clearly distinguishable to some researchers while others require stains to enhance the contrast between annulus. Selected techniques will also be determined by what resources are available to produce the sections.

Accurate Absolute Age Results

The use of known age specimens is the only way to verify that the dentine/cementum annuli aging technique produces accurate absolute age results. To date, verification of the dentine/cementum technique is generally based on limited known age samples. Terrestrial mammal samples of known age include 42 beavers (Van Nostrand and Stephenson 1964:430), 30 coyotes (Linhart and Knowlton 1967:362), 16 mule deer (Erickson and Seliger 1969:384), 18 elk (Keiss 1969:176), 95 red fox (Allen 1974:152) and 63 grey wolves (Goodwin and Ballard 1985:313). Marine mammals of known age used to test the technique include 40 cape fur seals (Fletemeyer 1978:695) and 390 fur seals comprised of 120 males aged two to five and 270 females aged three to eleven (Anas 1970:845).

One important factor affecting accurate absolute age results is the reader's experience in interpreting the dentine/cementum annuli influences. With red fox teeth, Harris (1978:98) reports that the major source of error is the reader's ability to interpret the annuli. Erickson and Seliger (1969:387) found that the reader requires instruction from an experienced reader, or practice with known age specimens to obtain accurate readings with mule deer teeth. Proper technique and experience were required for accurate aging of black-tailed deer according to Thomas and Bandy (1973:232). Goodwin and Ballard (1985:315) found accurate aging of grey wolves improved with experience of the reader.

Reader experience and the tooth sectioning techniques utilized can cause subjectivity in assigning the age (Van Nostrand and Stephenson 1964:433). Gasaway *et al*. (1978:560) considered determining discrete moose cementum layers to be subjective because the first three annuli have reduced contrast and concentric shape. Also, some teeth produce inconsistent counts because of low quality clarity, contrast, and distinctiveness of the annuli. Nellis *et al*. (1978:682) found it impossible to obtain consistent counts by the same or different readers for some coyote canines. The problem encountered, common to carnivores, was the considerable subjectivity involved with interpreting the cementum layering.

Likewise, a number of sections per grizzly bear tooth were required to locate a readable section (Craighead *et al*. 1970:356). Multiple sections are required because of variation in annuli distinctiveness, width and completeness of formation between individuals. Craighead *et al.* (1970:356) found annuli progressively harder to interpret with age in older grizzly bear teeth. Willey (1974:99) found that no matter the number of sections per tooth some black bear teeth had persistently indistinct annuli. One problem noted was that older bear teeth characteristically produce poorly stained annuli (Willey 1974:99).

Problems with reading annuli correctly can result from lesser annuli and tooth repair. False, split and compound types of irregular annuli were observed by Rice (1980:267). All three types can be defined by their relationship to the root apex. False annuli disappear at the apex, split annuli join at or near the apex, and compound annuli join at the root apex. Erickson and Seliger (1969:387) considered seven of the 226 mule deer teeth sections as unreadable because of indistinct annuli. To help overcome the problems of indistinct annuli etc. more than one tooth per individual can be sectioned. Adams and Watkins (1967:839) and McCutchen (1969:174) found lesser annuli in the cementum of California ground squirrels and pronghorns, respectively. In white-tailed deer teeth Lockard (1972:52) noted many split annuli and two types of false annuli.

Damage to the periodontal membrane can cause resorption or repair of the cementum. Hemming (1969:557) considered one dall sheep specimen had lost one annual increment from resorption. In elk, Keiss (1969:177) reported that the annuli were not readable in all areas because of resorbed and repaired areas of the cementum. Low and Cowan (1963:468) noted the importance of viewing all of the cementum annuli because of potential cementum loss in mule deer teeth.

Harris (1978:95) reports that different annuli counts are possible between teeth of the same red fox. The newest annuli appear at different times in the various teeth and followed no pattern of appearance. Harris found the newest annuli could appear first in the canines, molars or premolars. He recommends that at least two teeth per individual are sectioned for more precise aging.

A number of researchers have shown the dentine/cementum annuli aging techniques produce highly accurate absolute age results. Allan (1974:153) correctly assigned the age to 95 known age red fox specimens by counting cementum annuli. Sixteen known age mule deer specimens were also correctly aged by Erickson and Seliger (1969:386), while Thomas and Bandy (1973:233) aged 37 black-tailed deer accurately. Linhart and Knowlton (1967:365) state that cementum annuli aging for all age groups of coyotes appeared accurate. Cementum annuli of North American sheep provide accurate age estimates according to Turner (1977:215). Marks and Erickson (1966:397) had four zoology students with no previous cementum aging experience age eight known aged black bear canines. They concluded the aging technique was proven highly accurate since only one student wrongly aged a single tooth. Twenty-two of 23 grey squirrel teeth stored in formalin were aged correctly while dry stored teeth were only 75% accurately aged (Fogl and Mosby 1978:446). The age of the animal can affect how accurate the annuli readings are. Fletemeyer (1978:695) reports that the annuli aging method for two year old and under cape fur seals is accurate. The small number of specimens over two years prevents a definite conclusion on the method's accuracy for all ages. But, accurate age estimates on the limited sample were made for seals up to eight years old. Anas (1970:844) reports different results for the fur seals he studied. A 16% error was found for two year olds and only two percent error for three to five year olds but no accurate readings for females seven years and older. According to Bowen *et al.* (1983) the accuracy in age estimations decreases with increasing age of the harp seal. They examined 155 known age canines but lacked sufficient samples to evaluate the reliability past three years of age.

Adams and Watkins (1967:836) found most California ground squirrels can be aged to the nearest year for the first four years. However, after four years of age a deterioration of the cementum annuli reduces distinctiveness. Indistinct layers caused Ransoms (1966:199) problems in assigning an accurate age estimates for white-tailed deer but the assigned ages were never more than plus or minus one year from the known age. Van Nostrand and Stephenson (1964:433) report a very limited percent of older beavers were one to two years over or under the actual age. Overestimation was the main reason for Gasaway *et al.* (1978:559) correctly aging only 56% of moose aged two to 11.

The period between birth and first annuli formation must be accounted for when estimating the specimen's age (Morris 1972:90). Allen (1974:153) adds one year to late winter or half a year to autumn death specimens for an accurate age estimation. McEwan (1963:112) states one year must be added to barren ground caribou annuli counts while Linhart and Knowlton (1967:363) added twenty months to coyote annuli numbers.

Conclusions

The review of methods to produce modern tooth section was to highlight the various techniques available and their associated problems. Despite some problems with clarity and interpretation the method has been shown to provide a precise aging of animals. Also the review demonstrates that a certain amount of technique experimentation is required to obtain the best possible section. Unfortunately this has limited implications for my study of modern harp seal canines. The thin sections were already prepared by the Department of Fisheries and Oceans and were to remain unaltered. Thus, I was unable to experiment with staining to enhance the last annuli in order improve the time of death estimation.

HARP SEAL CANINE SECTIONS

Preparation Method

The modern harp seal canine sections for this study were kindly provided by the Department of Fisheries and Oceans in St. John's Newfoundland. They prepared the harp seal canine cross sections in the following manner. Firstly, the harp seal mandibles are boiled for two to three hours and then the canines are removed with pliers. The canines are soaked in 10% peroxide solution for approximately one hour before cleaning with a brush. If the pulp canal opening is not closed, it is also cleaned to prevent the tooth from yellowing. A one half millimetre section is cut transversely just below the enamel cap, using a small mounted circular saw. The ideal section will be thin enough to just start to curl up. The finished thin sections and remaining canine portions are stored in an equal parts solution of water, 70% ethanol, and glycerine.

Selection Of Sections

The harp seal sections were chosen from the Department of Ocean and Fisheries listing of their harp seal canine collection. The sections were randomly selected from the list while attempting to include all months of the year, all age groups and equal numbers of both sexes. The final group contained 163 sections representing ages from under one year to 30 years old. There were 58 males, 86 females and 19 of unknown sex. All months of the year were represented except for July and September.

Examination Method

i) Binocular microscope

The sections for this study were examined with a binocular microscope using 6-50X magnification and transmitted polarized light. The polarized light permits the annuli to become more distinct and therefore discernable. In the majority of specimens examined (over 95%) the annuli were readily discernable for making age estimations. A problem encountered using this viewing technique was that the most recently formed annuli became progressively more difficult to determine with increasing age of the specimen.

ii) Photomicroscope

Photographs of the sections at 20X magnification were taken using the Wild M400 Photomakroskop. High contrast Kodak technical pan film ESTAR-AH Base at 100 A.S.A. was used. The sections were placed on black plasticine in a small amount of the alcohol, glycerine and water solution. The solution prevented the sections from dehydrating under the full power of two flood lights. Developing the negatives required six minutes in developer and at least ten minutes in each of the following stop, fix and wash baths.

The negatives when mounted were used directly as slides and the annuli measured with a scale similar to the method followed by Buie (1986). All sections from the months of December and April between the ages of three and six were measured. The translucent layers were measured to estimate the decrease in width thickness rate due to the compression of each successive layer. This rate of decrease and the width of the last complete translucent layer were used to calculate the next translucent layer's width. The calculated width was then compared to the actual width of the last translucent layer to determine percentage of development. The measurements and calculated results are presented and discussed in Chapter 6.

iii) Computer Programs

Image enhancement and density profile computer programs were tested on a canine section from a ten year old harp seal. The computer is connected to a video screen that displays the image (via a video camera) viewed through the microscope. The section can be viewed with both binocular and compound microscopes with transmitted or reflected light. The computer program can grab the video image which then permits its manipulation. Image enhancement is one form of manipulation with this system.

The images produced by transmitted light using binocular and compound microscopes were enhanced. A number of problems were encountered with image quality in both cases. The sample was too thick for the compound microscope resulting in poor resolution and no distinct annuli boundaries. The binocular microscope image was not sharp enough for accurate annuli boundary determination. Reflected light was also used with the binocular microscope but the image was fuzzy and difficult to interpret. In all cases the enlargement of the video image failed to improve the interpretation of annuli boundaries.

A profile density slice across the section using the compound microscope was taken. The profile was taken to detect the annuli peaks (light) and troughs (dark) of the compressed dentine. This program takes a density reading for every pixel across a selected section of the screen image. Each pixel receives a numerical reading from 128 - 0. One hundred and twenty-eight represents pure white and the number decreases with increased density (darkness) of the image.

The sample tested was chosen because of the specimen's known age of ten which means a number of compressed annuli. In order to detect the peaks and troughs of the compressed area the image was enlarged with 100X magnification. This resulted in three separate screen widths being required to completely cross the canine section. A problem with maintaining the same line across the three images was encountered and no matching readings between the three printouts were produced. Also, the resulting printout contain one thousand four hundred and eighty readings.

Further testing is required in the following areas:

a) A major problem with the system was the lack of a clear image to correlate the density readings with. This is required to verify what the density readings actually represent but presently the system cannot produce a hard copy of the video image.

b) The section needs to be at a higher magnification, possibly 200X, to create the separation of annuli required to clearly determine the last annuli. But, the resulting printout would be unmanageable and a computer program needs to be developed to handle the generated data.

c) Tests with thinner and stained sections should be conducted to check for clearer and separation of annuli.

Comments

The results of the harp seal thin sections examination by microscope and black and white slides will be discussed in Chapter 6. The next focus of this study is the production of thin sections from archaeological specimens. However, a review and discussion of the available techniques for archaeological specimens must be undertaken before the Port au Choix harp seal canines are sectioned.

CHAPTER 4

ARCHAEOLOGICAL APPLICATION

A historical overview of the dentine/cementum annuli technique is required in order to understand the method's problems and potential for archaeological specimens. Thus, an abbreviated version of the technique's application to archaeological teeth for estimating age and/or season of death is presented. The different techniques and procedures are highlighted to demonstrate how the method has developed to overcome problems related to archaeological specimens. Work on seal teeth is examined in detail with a special focus on the modern reference samples utilized to guide aging and/or season of death estimations.

Historical Summary

The first recorded use, in North America, of tooth incremental annuli for aging archaeological specimens is Gustafsen (1968). Gustafsen wanted to compare fur seal age and sex distribution prior to and after Euro-American contact. A number of prehistoric northern fur seal canines, from the Olympic coast of Washington, were sent to the Bureau of Commercial Fisheries, Division of Marine Mammals. The method of teeth section preparation was not reported. Also, the aging results were not available when Gustafsen wrote this article. Probably the Marine Mammals Division's modern tooth sectioning method was used on the archaeological specimens.

Working in New Zealand, Saxon and Higham (1969) compared cementum annuli of modern New Zealand and South British Iron Age sheep teeth. They were interested in determining prehistoric sheep mortality frequencies to find indications of the animal domestication process. The modern teeth were sectioned by a standard histological technique. A modified petrological technique was utilized to thin section the archaeological specimens. Age at death for both the modern and archaeological teeth was determined within a range of three to six months. Also, the potential for determining season of death based on the cementum annuli was mentioned but not persuaded by Saxon and Higham.

Christensen (1971) referred to Ransom's 1966 work on modern white-tailed deer to devise a technique to examine archaeological bison teeth. Only two of the recovered bison teeth, from Banff National Park, had retained their cementum. The two teeth were embedded in liquid casting resin by Christensen. This appears to be the first recorded occasion when archaeological teeth had been embedded/mounted in any form of resin or plastic. The embedding procedure was already common with fragile petrographic samples and had been used in preparing modern teeth for sectioning (Erickson and Seliger 1969).

Kay (1974) also modified Ransom's 1966 tooth thin sectioning method to examine deer teeth. White-tailed deer teeth, from the Mellor site, a central Missouri, Middle Woodland settlement, were sectioned and analyzed for age and season of death. Kay was interested in determining culling patterns, developing hunting strategies and animal population stability.

A major improvement or modification to the technique was to vacuum impregnate the teeth in epoxide. The teeth were soaked in Buehler thin section epoxide and then placed in a vacuum oven. The advantage of vacuum impregnation is that the teeth are strengthened by filling all the voids with epoxide. Twenty of the 28 teeth sectioned by Kay (1974:226) produced readable sections. Kay noted microscopic cracks in cementum and he recommends care in selecting teeth for sectioning.

Benn (1974) sectioned white-tailed deer molars from the Woodland period Hatfield cave site, Jones County, Iowa. A modified version of the Erickson and Seliger (1969) method was utilized to embed and section twenty-two lower left molars. Ethylene glycol was applied to the molar section to enhance reading the annuli. Annuli were observed in all molar sections but not all the annuli were clear and/or continuous. Benn estimated age and a broad season of death (i.e. spring/summer vs. fall/winter) for each individual.

Frison in collaboration with Michael Wilson and Diane Wilson attempted to age bison by cementum annuli in molar and incisor teeth from the Hawken site, Wyoming (Frison *et al.*

1976). The number of incisor teeth were insufficient to construct age composition profiles and were not sectioned. Physical and chemical alteration caused inconsistent age results with molar teeth. The sectioning technique was not indicated but Michael Wilson (1978) was aware of both Christensen's (1971) and Kay's (1974) work.

At the same time Spiess (1976) was determining season of death based on dentine/cementum annuli formation rates in seal teeth. The technique was applied to historic and protohistoric seal teeth specimens from Okak Bay, Labrador. Spiess does not provide any data on tooth section preparation but Bourque *et al.* (1978) outlines Spiess' procedure. Spiess followed the modern teeth sectioning method of decalcifying, microtome sectioning and staining the seal teeth. In 1978 Spiess in collaboration with Bruce Bourque and Kenneth Morris sectioned mammal teeth from the Turner Farm shell midden, North Haven Island, Maine (Bourque *et al.* 1978). Both the decalcifying and solid sectioning methods caused partial or total destruction of the tooth. Spiess (1979:188) reports that archaeological teeth decalcification is the result of inadequate protein structure preservation and low collagen content. The production of solid sections was largely successful when the fragile teeth were consolidated by encapsulation in a liquid epoxy.

Bourque *et al.* (1978) presented their embedding procedure and decalcifying of teeth as new techniques for sectioning archaeological teeth. Wilson (1978) responded that neither the epoxy embedding nor decalcifying of teeth were new techniques to archaeology. To support his contention Wilson cited the published research of Frison *et al.* (1976), Gustafson (1968) and Kay (1974). Bourque *et al.* (1978b) acknowledge their oversight of Kay (1974) but stated their embedding technique required less equipment, time and cost. Although I will acknowledge their embedding technique requires less equipment to produce the sections Bourque *et al.* success rate with fragile teeth would have been higher had they utilized vacuum impregnation as advocated by Kay. I conducted a comparison of embedded and vacuum impregnated seal canines during my research. Vacuum impregnated teeth retained more structural integrity than embedded teeth, thus increasing the odds of producing readable sections.

Spiess (1978, 1979, 1990; Spiess and Hedden 1983) continues to determine age and/or season of death from archaeological teeth sections. Seal teeth from the Middle Dorset Koliktalik-1 House site in Nain (Spiess 1978); six Rangifer tarandus, one bovine, two red deer and two horse from a Western European site (Spiess 1979); deer, moose, seal and beaver teeth from Kidder Point, Site 41.40 (Spiess and Hedden 1983): and white-tailed deer from the Turner Farm site (Spiess 1990) were sectioned to determine season of death. Spiess (1990) reports that the white-tail teeth data from Turner Farm shows a change in hunting seasons between the Moorehead phase and later occupying groups.

In all cases Spiess does not provide any indication of what preparation method he followed. But, Spiess prepared modern teeth by the similar epoxy embedding method as outlined in Bourque *et al.* (1978). This is possibly the same procedure Spiess utilizes for the archaeological specimens. The teeth samples have produced a limited number of readable sections per site. Only five (two deer, two moose and one seal) of 17 teeth from Kidder Point (six deer, two moose, two seal and seven beaver) produced readable sections for determining season of death (Spiess and Hedden 1983:102). Seven of 40 teeth from Occupation II and nine of 25 teeth from Occupation III at Turner Farm provided readable sections (Spiess 1990). Spiess states the results reflect poor tooth preservation but unless he is vacuum impregnating the teeth it may also reflect his sectioning technique.

Gordon (1982) studied caribou molars collected from across the Beverly range, Northwest Territories and Saskatchewan. The molar sections were used to age and determine season of death for caribou. Changes in culling patterns were demonstrated by the age data with more calves and yearlings being killed over time.

The individual teeth were vacuum-impregnated with clear resin. Gordon advocates refrigerating the impregnated teeth to prevent cracking between the roots and resin. The glass slide mounted tooth sections were cut with a slow diamond saw and then ground to remove all traces of saw marks. Gordon interpreted the annuli using a 100X polarizing microscope aided by both polarized and non-polarized photographs.

Savelle and Beattie (1983) analyzed 44 muskoxen teeth (MNI of at least 36) from five sites on Banks Island Northwest Territories. They tested three techniques for estimating season of death and age at death. The three techniques tested were 1) scanning electron microscopy, 2) decalcification and staining, and 3) standard thin-sectioning. Specimens were destroyed during decalcification and the scanning electron microscope lacked sufficient contrast to permit interpretation. Acceptable specimens were produced only by the thin sectioning technique. The 44 specimens provided 30 season of death estimations to determine site seasonality. The 40 age at death estimates provided comparisons for age estimates from cranial morphology and/or tooth eruption and wear.

Savelle (1987) used caribou and ringed seal teeth to estimate the season of site occupation for Thule sites in the central Arctic. The teeth represented 16 caribou and eight ringed seal from Early Classic Thule and 37 caribou and three ringed seal teeth from Late Classic Thule.

Whitridge (1990) following Savelle's method estimated site seasonality for Thule period sites on Somerset Island. Canines of six ringed seal were microtome sectioned and the dentine were read using reflected light.

Morrison (1983a) sectioned 41 ringed seal teeth from the Thule period Clachen site's western coast, Coronation Gulf, Northwest Territories for age and time of death estimates. The tooth section preparation technique followed is mentioned by Morrison (1983b) and described in detail by Presley (1984). They followed the vacuum impregnation technique with the improvement of using a slow speed diamond saw. Presley (1984) indicates that more tooth tissue can be preserved by using a thin wafering saw blade. The sections are read using transmitted polarized light with a petrographic microscope because this eliminated the problem of trying to stain partly mineralized teeth.

This tooth sectioning method was followed by McCullough (1989) on 63 ringed seal canines from the Ruin Island Thule site. Stenton (1987) used a similar method on 52 ringed seal canines and 19 caribou molars from Peale Point, Frobisher Bay, Baffin Island, Northwest Territories. All three of these researchers (Morrison, McCullough and Stenton) interpret the low number of winter seals to indicate a minor role for winter ringed seal hunting and thus a minor role for the breathing hole hunting method. Since a minor winter seal hunt was not expected a second look at the modern baseline sample, used to determine season of death, is warranted. It is important to remember that the master chart for ringed seal annuli interpretation was devised without samples for the October to February period. A complete discussion of this problem will be conducted in the section on season of death/aging problems.

Primarily the tooth annuli method has been used by archaeologists to estimate site seasonality and/or when the animals were harvested throughout the year. The aging of the specimens has also been utilized to develop age composition profiles to suggest hunting/culling patterns. This study will use harp seal dentine annuli to estimate site seasonality for the Port au Choix palaeoeskimo sites and age composition profiles to infer hunting/culling patterns.

Detailed Techniques for Preparing Tooth Sections

Saxon and Higham (1969:305) adapted a petrological sectioning method to prepare prehistoric sheep teeth thin sections. They state:

> 1. Cut the tooth on a thin-bladed Felker diamond saw.
> 2. Grind flat and smooth the cut surface on a diamond lapidary grinder. For an ultrasmooth surface, the tooth can be ground on plate glass using 700-800 carborundum grit. This was found to be necessary when dealing with a brittle prehistoric specimens.
> 3. Clean and degrease the tooth after grinding, since soluble oil is used in the cooling water of the diamond lapidary grinder. This can be done with xylol or hot water.
> 4. Dry the tooth at approximately 60°C.
> 5. Clean a glass slide with xylol or hot water.
> 6. To ensure adhesion of the tooth to the slide, the slide must be frosted on the mounting side by grinding on 800-1000 carborundum grit on a glass plate.
> 7. Mix an adhesive of AY105 Araldite and 953F hardener in equal parts on a glass slide, and warm, not over 60°C., on a hot plate to facilitate mixing.
> 8. Apply some of the adhesive mixture to the tooth which has already been warmed.
> 9. Mate the glass slide onto the cut surface of the tooth and apply gentle pressure with two prods in

order to expel any air bubbles and to provide a uniform thickness of adhesive.

10. Place the slide with specimen in an oven and allow to cure for half an hour at 80-100°C., and subsequently allow to cool.
11. Remove the remaining bulk of the tooth with a petrological sectioning machine or by grinding on the diamond lapidary grinder. For brittle specimens, grinding with carborundum grit on a glass plate is essential.
12. Once the desired thickness is achieved, clean the specimen with a solvent or degreasing agent.
13. With a sharp razor blade, cut off the excess adhesive from the tooth section.
14. Apply a slip cover by the standard method.

Preparation techniques directed at preservation problems (i.e. fragile or decaying teeth) of archaeological teeth were first devised in North America by Christensen (1971) and Kay (1974). They both modified Ransom's (1966) modern white-tailed deer tooth thin sectioning technique of embedding teeth in resin to consolidate bison and white-tailed deer archaeological teeth.

Christensen (1971) provides scanty details on his preparation technique. Two bison molar teeth were longitudinally sectioned after being mounted in liquid casting resin. Kay on the other hand provides precise details on the four stage process he followed. The stages are:

1) The teeth are vacuum impregnated with Buehler thin section epoxide by immersing the teeth in the epoxide and placing in a vacuum oven at 22mm. of mercury for 10-15 minutes. This causes the epoxide to fill any voids in the tooth. The impregnated tooth is allowed to harden for 24 hours.

2) Longitudinal sections are cut with a diamond cut off wheel and ground using a 12 inch iron lap with 220, 340, and 400 grit silicon carbide abrasives.

3) Sections are mounted on ground glass slides by Hillquist thin section epoxy and set for 24 hours.

4) Sections are ground to uniform thickness of .003 inch.

To strengthen molars for sectioning, Benn (1974) embedded them in bioplastic. The molars were sectioned with a small diamond bladed table saw and ground with 320, 14 and 3 microns carborundum grits. The sections were reground until readable cementum annuli appeared. Benn noted the largest exposure of cementum resulted when longitudinal section removing one third of tooth were cut.

Spiess (1976) followed modern tooth sectioning preparation techniques to prepare historic and prehistoric seal teeth. The teeth were decalcified by a 5% nitric acid solution and sectioned with a freezing microtome. Hematoxylin stain was used to increase the contrast between the translucent and opaque annuli.

Bourque *et al.* (1978) encapsulated teeth in plastic using either Buehler Epo-Kwick or Buehler Plastic kits. The encapsulated tooth was sawed and/or ground to produce a solid longitudinal section for analysis with reflected light under a binocular microscope. Wetting the specimen with ethanol enhanced the contrast of the incremental growth lines.

Gordon (1982) vacuum-impregnated individual teeth in clear resin and then refrigerated them to avoid cracks. A slow diamond saw sectioned the teeth and, once ground, the teeth sections were mounted on glass slides. They were resectioned to a 0.5mm thickness section followed by grinding and polishing.

A modified lithic technique was utilized for tooth sectioning by Morrison (1983) and McCullough (1989) on ringed seal canines. A detailed description of this procedure is presented by Presley (1984). This technique is as follows: the tooth is vacuum-impregnated with resin and sectioned using a thin wafering blade mounted on a slow speed diamond saw. A 600 grit wheel and 1000 grit silicon carbide slurry are used to grind the section to the required thickness. The surface is polished and mounted on a glass slide with balsam. The slide mounted section is reduced to 1/64" by sawing and then ground to about 60 microns using 320 grit silicone carbide slurry. Final reduction to viewing thickness is accomplished by hand with 1000 grit silicon carbide slurry. The section is then polished with tin oxide slurry and covered with a slide cover.

Savelle and Beattie (1983:124) state that they prepared thin sections in the following manner:

> 1) individual tooth roots were removed by cutting slightly above the root/pad interface
> 2) each root was embedded in a synthetic resin, which was allowed to harden
> 3) the embedded specimens were then cut longitudinally, and ground to a thickness of approximately 40 microns.
> 4) the specimens were then dehydrated in alcohol and cleaned in xylene

5) finally, each specimen was mounted on a glass slide and covered with a glass cover slip using Permount.

Two different results were achieved when teeth were decalcified by Savelle and Beattie. Palaeoeskimo site teeth were destroyed while Copper Inuit site teeth produced acceptable sections. Decalcification was also successfully used by Savelle on Thule eskimo site caribou and seal teeth.

Viewing Techniques

Bourque *et al.* (1978) viewed sections with 40-150X magnification, reflected light and a binocular microscope. There is one important difference between the viewing methods of Presley (1984) and Bourque *et al.* (1978) that must be remembered in order to produce comparable results. Presley (1984) used transmitted light when reading the sections while Bourque et al. (1978) utilized reflected light. Whether the incremental growth lines appear opaque (dark) or transparent (clear/light) depends on the kind of light source utilized (transmitted or reflected). What appears dark or light using transmitted light will be the opposite under reflected light (Fisher 1954). Thus, Presley's method produces similar incremental growth line contrast results as the method used to study modern canine thin sections. Following the same method for both modern and archaeological specimens will aid in consistent annuli interpretation.

Modern Reference Samples

Archaeologists have used limited modern reference samples or have depended on biologists to provide the modern baseline data for aging and season of death estimations. Kay (1974:226) followed Lockard's (1972:54) data on white-tailed deer annuli formation.

Spiess (1978) used limited baseline data for interpreting seasonality of ten archaeological seal canines. Only three of ten canines, two ringed and one harp, were positively identified to species. The modern baseline sample for his 1970's research consisted of : 1) fewer than half a dozen seals shot by Inuit during his summer field work in the early 1970's; 2) one grey seal from Massachusetts of known season of death; and 3) the standard published material on grey and harbour seals and Smith's (1973) Eastern Arctic ringed seal studies (Spiess personal communication 1990).

Researchers, such as Spiess (1990), have assumed that cementum in white-tailed deer is formed at a constant rate during the growth season. This assumption was developed on the basis of wildlife biologists research into aging white-tailed deer by cementum annuli. Spiess (1990) acknowledges the need to test this assumption with modern reference specimens whose time of death is known. The modern specimens will improve the precision of determining season of death by developing a rate of cementum formation chart. To develop this chart Spiess obtained 100 incisor teeth thin sections and

35 fresh mandibles from the Maine Department of Inland Fisheries and Wildlife. But only 33 of the 100 thin sections and six of the 35 mandibles sectioned displayed annuli clear enough for reproducible measurements. Spiess states:

> Specimens exhibiting split annuli, possible multiple or subannular layers, layers too thin to be accurately measured with an optical micrometer at 100X magnification, or a thin section of marginal overall quality were eliminated from the sample.

Using these sections Spiess develops a cementum growth rate scheme. The thirty-nine sections measured were spread out over the year as follows:

January	1
February	1
March	3
April	5
May	6
June	2
July	0
August	5
September	0
October	0
November	17
December	0

Presley's (1984) modern baseline sample consisted of 62 ringed seal canines obtained from the Fisheries Research Board of Canada. The canines were collected over a seven month period. The collection date (death of seal date) and number of canines are:

January	0
February	0
March 13	9
April 17	7
May 15-16	11
June 18	11
July 14	5
August 16	6
September 10 29	7 6
October	0
November	0
December	0

Presley devised a master chart for interpreting ringed seal canine based on these 62 canines. This master chart is highly questionable since canines representing five months of the year were not examined. The problems with Presley's chart will be discussed in the next section of this chapter. Estimated ages for the canines ranged from four months to 29 years but over 60% (40 of 62) are approximately two years or under. The first annuli is the widest with the next three being somewhat narrower. All remaining annuli are progressively much narrower. The first three cementum annuli were also irregular.

Presley considers that either dentine or cementum can provide accurate time of death estimates to the month. The best estimates are achieved when the results of dentine and cementum annuli interpretations are combined. A more accurate estimation would be season of death since a standard deviation of plus or minus one month is assumed. Presley reports that the age readings between dentine and cementum differ in some cases. Actually 32 specimens of the 62 provided age readings from either dentine or cementum (not both). Fourteen of the remaining 30 had dentine and cementum age readings that were in disagreement by at least one year. By way of contrast, Presley found similar or identical season of death estimations from the dentine and cementum in most specimens.

Buie (1986) studied the cementum growth rate for Arkansas white-tailed deer in order to estimate season of death for archaeological material. A total of 176 modern teeth were sectioned but only 41 sections displayed annuli for analysis. The limited sample probably did not represent the total formation period. But, Buie proposes a total cementum technique to age and estimate season of death for white-tailed deer. The total thickness is divided by a known rate of growth for the cementum. The precision of this technique is questionable as a vast array of factors influences cementum growth. For example, Buie notes that cementum condition varied between specimens and that affects accurate age or season of death estimates.

Season of Death/Aging Problems

The problems associated with determining age and time of death by incremental structures do not always receive the attention they deserve from the researchers. The review of archaeological incremental annuli interpretation has highlighted a number of these factors/problems. These factors/problems are:

1) Caution must be exercised during the production of tooth sections to prevent any destruction of the last annuli. Any loss of cementum or dentine would make season of death estimations difficult or impossible.

2) Buie (1986) reports variations over space and time in the morphological and morphometric characteristics of white-tailed deer. Thus incremental annuli formation will vary between

locations or within a location over time. The researcher must exercise caution when comparing sections from different sites or different time periods.

3) Spiess (1976) notes that incremental annuli width generally vary between years with a yearly decrease in width. There are variations between teeth and within a single tooth of an animal. Precision in band width estimation is not possible because of these variations. Therefore Spiess advocates a development period involving four spans of three to four months each.

4) Presley (1984) found similar or identical season of death estimations in a canine's dentine and cementum. The readings were taken from modern ringed seal canines. However, the application of Presley's technique on archaeological specimens has not matched the results from modern specimens. McCullough (1989) reports that in a number of specimens the estimates between the cementum and dentine annuli differed by a season.

5) The method for determining ringed seal season of death advocated by Presley (1984) and utilized by McCullough (1989), Morrison (1983b) and Stenton (1987) has major flaws. Presley states that 62 modern ringed seal canines of known time of death were sectioned, and a master chart for annuli development was constructed. However, the teeth studied

covered only a seven month period that excluded the winter season. This excluded period from October to February is important for site seasonality interpretations for Morrison, McCullough and Stenton.

The sample size of 62 teeth is too small, especially given that the majority were age two or under. There is no consideration of possible variation within an individual or between individuals and over time. He also imposes an arbitrary twelve month calender on annuli development. This implies a consistent growth rate or pattern for each month with enough contrast or width to be discernable.

Morrison (1983b) revised the monthly divisions into four seasons with overlapping months:

Spring	March to July
Summer	July to October
Fall	October to December
Winter	December to March

But, remember there are no samples in Presley's data to permit an October or December division of the annuli development between summer and fall or fall and winter.

Morrison, McCullough and Stenton state that only a minimal winter kill is taking place based on Presley's dentine/cementum annuli development data. However, ethnographic studies indicate a winter hunt of mature seals in similar areas. Since Presley had no data for this period of October to February it is highly questionable that they should speculate on alternative hunting/subsistence strategy for Thule Eskimo. Morrison and McCullough also mention season of death to plus or minus one month but never discuss how this would alter their seasonality data. This actually creates a three month season of death period which means that a number of the seals could be placed in more than one seasonal category. It is possible there are more fall and winter kills than they have indicated. Thus, another baseline sample study of ringed seal canines is required to either confirm Presley's work or clarify the fall and winter developmental period.

6) Morrison's (1983a) ringed seal canine data from the Clachen site highlights the problems with interpretation. Forty-one canines were sectioned and are considered to represent 41 individuals. Morrison does acknowledge that there would be some duplication of canines from the same individual. But, there are four canines per individual and based on his assigned ages the MNI could be as low as 14. Also the 41 canines came from his laboratory faunal sample and it is highly questionable how representative these canines are of the total site. They were recovered only from house walls and the upper midden; the 1980 faunal material was excluded from

the study; and the randomly collected laboratory faunal material was only ten percent of the recovered material.

PORT AU CHOIX SPECIMENS

Port au Choix Sites

The harp seal canine material was recovered from the Phillip's Garden Dorset Palaeoeskimo and the Phillip's Garden East Groswater Palaeoeskimo sites at Port au Choix. These sites were described in Chapter 1.

Archaeological Problem

A major objective of this study, as previously stated, was to determine if the southward and northward migrations time periods at Port au Choix could be identified in the canine dentine developmental sequence. Isolating the southward migration period in the dentine, which occurs in December and January, would provide a method to test for a winter season of occupation at the Port au Choix sites. A late winter-spring (late February to May/June) period of occupation is well established based on fetal and juvenile (young of the year) harp seal remains. Renouf(1994) suggests at Phillip's Garden a possible occupation into the summer and in the fall- winter based on the faunal availability while Murray (1992) proposes a fall-winter or spring-summer occupation based on house structure and faunal remains of House Feature 1. However, all the faunal remains at Phillip's Garden are available in the late winter-spring period. A middle winter period of occupation during the December and January southward harp seal migration would appear logical because of the Dorset Palaeoeskimo specialization on marine mammals. Unfortunately there are no osteological indicators on the bone to separate December/January harp seals from any other period of the year. The method involving the interpretation of the dentine annuli developmental pattern provides a potential means to isolate this middle winter period.

Archaeological Sample

Seventy-three canines were selected for thin sectioning with 15 from Phillip's Garden East (Groswater Palaeoeskimo) and 58 from Phillip's Garden (Dorset Palaeoeskimo) sites. The canines were randomly selected except that all mandibles/skulls (19) identified as harp seal were included and only teeth that appeared structurally sound were selected. All of the loose seal canines are considered to be harp seal because of the abundance of harp seal compared to other seal species that are barely represented in the faunal remains (Renouf 1993). A complete listing of the canines' provenance on the Port au Choix site is provided in Chapter 6.

Preparation Method

A test sample of six harp seal canines were embedded in a mixture of Buehler epoxide resin (No. 20-8130) and hardener (No. 20-8132). Thin sections were prepared following the standard petrological method. The resulting thin sections showed breakage of the dentine next to the pulp cavity because the resin had not penetrated through the dentine. These canines and all other harp seal canines were vacuum impregnated with the resin in a vacuum jar at the archaeological laboratory, Memorial University.

The thin sections were cut and mounted on glass slides by Foster Thornhill at the Department of Earth Sciences' lapidary shop. He prepared the sections in the normal manner for petrological specimens with a standard lapidary saw and ground to viewing thickness with powder grit. Once prepared the slides were examined with a binocular microscope at 20-100X magnification and using transmitted polarized light.

The sections were aged by dentine annuli following the method used on modern seal canines. An estimation of last annuli formed and its relative width were also made. Width estimations were a percent of annuli development based on the results obtained from the study of modern canine dentine annuli. The results of aging and determining last annuli development are presented and discussed in Chapters 6 and 7. The discussion includes the implications of these methods and results for Port au Choix and other archaeological sites.

CHAPTER 5 HARP SEALS (*Phoca groenlandica*)

General Information

The Port au Choix area is one location where whelping and sealing occurs. Chafe's Sealing Book (Mosdell 1923) reports that harps are found west of Point Ferrole on the Newfoundland side of the Straits. Wells (1988) suggests that the Point Riche peninsula would be an ideal location to exploit harp seals. Harp seal remains have been identified from Port au Choix archaeological sites (Harp 1964; Renouf 1985).

Bowen (1985) provides a comprehensive summary of information on Northwest Atlantic harp seal herds. Harp seal populations (Figure 5.0) are located in the White Sea, Jan Mayen Island area and off Newfoundland. The Northwest Atlantic (Newfoundland) harp seal population consists of two sub-populations called the "Gulf" and the "Front" herds. The Front herd breeds off Southern Labrador on the southward drifting Arctic pack ice, while the Gulf herd breeds in the Gulf of St. Lawrence off the Magdalen Islands. In times of little Gulf ice a portion of the Gulf herd whelps on Labrador ice floes. Based on marking individuals and blood protein studies it is believed the two sub-populations interbreed. The only major difference between the sub-populations is the five day difference in the date of whelping. This probably relates to ice stability variations since the ice along the

Figure 5.0 Population Locations (from Bowen 1985)

Front is stable until March or early April while the Gulf ice is stable until mid-March. Therefore, Gulf pups must be born earlier to improve their survival rate.

Migrating (Figure 5.1) south from Baffin Island during late September the herd passes northern Labrador, by mid-to-late October. Around mid-December the herd reaches and separates at the Strait of Belle Isle. Approximately one third heads into the Gulf of St. Lawrence while the others move along Newfoundland's east coast. The seals disperse during January and February mainly feeding on pelagic fish (capelin, herring, etc.) and crustacea. Before the northward migration pregnant females give birth on pack ice during late February or early March.

The pups are approximately eleven kilograms in weight and eighty-five cm. in length at birth. The medial age and age categories for harp seals pups (Stewart and Stewart 1987a) are: a) Zero days - Newborn; b) One day - Yellowcoats; c) Two days - Thin whitecoats; d) Six days - Fat whitecoats; e) Ten days - Greycoats; f) Sixteen days - Ragged-jackets; and g) Twenty days - Beaters. Pups begin to moult and wean during the greycoat stage and then start a five-six week postweaning fast. Males mature around age 7 or 8 while females mature earlier between 4 and 6. Mature males are 169 cm in length compared to 162 cm for females. Weight varies with seasons ranging between 85 to 180 kg. Both sexes moult in April with adult females starting two or three weeks after adult males

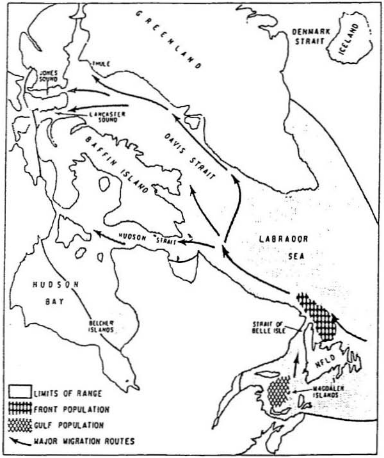

Figure 5.1 Migration Routes (from Bowen 1985)

and immatures (bedlamers). The seals basically fast during the moulting period with body weight loses up to 20% consisting mostly of fat. Once moulted the bedlamers and adult males continue the Arctic bound migration.

The Labrador Inuit Association project (Freeman 1977) reports the following characteristics/habits of harp seals:

a) The old larger harp seals arrive first during the spring northward migration.

b) There are regional variations in seal availability and migration patterns.

c) Harp seals were seen to travel in herds at all times.

d) When in the water, harp seals are fast swimmers, sensitive to disturbances and appearing to be clever in their responses.

e) Harp seals are least cautious when dozing on loose ice pans as they only scan the surrounding area every half hour or so.

f) Harp seals appear to be sensitive to noise, smell, and sight.

Aging Methods for Harp Seals

Two early methods of age estimation (Bowen *et al.* 1983) were Plekhanov's 1933 use of the claw's transverse growth ridges and Chapskii's 1952 study on the periosteal zone layers of the lower jaw. Beloborodov (cited in Stewart and Stewart 1987a) proposed using pelage changes and pattern of permanent tooth eruption to age harp seal pups. According to Beloborodov permanent teeth erupt in the following sequence:

molars, canines, premolars and finally incisors. The PC3 (lower) erupts before the PC4 (lower) in harp seals according to Loughlin (1982). But the study by Stewart and Stewart (1987a) concluded that: 1) permanent tooth eruption sequence was not statistically significant; 2) reliable prediction of eruption sequence were not possible; and 3) the eruption sequence cannot be utilized for aging pups.

Fisher (1954) conducted the first comprehensive study of harp seals including a section on aging by canine dentine annuli. Approximately three thousand thin sections were examined. Both the January southward migration and the March-April whelping and moulting period were equally represented. Although, annuli up to thirty-four were distinguished, the annuli were generally crowded and indistinct after the twelfth annuli (Fisher 1954). The method utilized by Fisher has been refined by researchers like Bowen *et al.* (1983).

Enamel, cementum and dentine are three potential incremental annuli sources available to researchers studying harp seals. All three sources have potential limitations to the annuli information available for interpretation. The growth of enamel ends shortly after tooth eruption (Scott and Symons 1974) while the thin cementum layer contains indistinct GLG's (Bowen *et al.* 1983). Dentine is deposited in the finite space of the pulp cavity which usually is filled by age twenty-five. The first GLG is the widest with a linear decrease in successive GLG widths and individual variation in growth rate (Bowen *et al.* 1983).

Neonatal Line

Canines in pups under six days of age displayed clear homogeneous dentine. A dark band of dentine near the open pulp cavity was seen in older pups. The neonatal line which has formed at birth was separated from the pulp cavity by translucent dentine prior the pup's first summer (Stewart and Stewart 1987a).

Annual Nature of Growth Layer Group

Fisher (1954) observed the same regular annual pattern of dentine layer formation for all ages of both sexes. Fisher (1954:33-34) states:

> The dentine of harp seals taken at La Tabatiere, P. Q., during the southern migration early in January shows, in all teeth examined, a recently completed dark band, and in the case of teeth with only a few annuli and a comparatively large pulp cavity, a small amount of the clear inter-annular dentine. The teeth of seals taken during the pupping and moulting season all show a greater amount of clear dentine on the pulp side of the innermost annulus than do those taken in January. Many of those teeth collected well on in the moulting season (late April) show a beginning of the formation of interglobular spaces. This picture is the same for all age classes, regardless of sex. It is apparent that the clear areas of dentine between the annuli are laid down in the period of active feeding and fattening from the southward migration until the moulting (whelping), that the interglobular layer is started during the moult, and that the dark or opaque layer is laid down at some time between the moulting and the beginning of the southward migration, probably during the summer sojourn in the Arctic.

Bowen *et al.* (1983:1430) reports:

> The first growth-layer group (GLG), representing 1st year growth, consists of two IGL's: an outer layer of opaque dentine, bounded by the neonatal line, and an inner layer of translucent dentine. Subsequent GLGs, each representing 1 year of growth, generally consist of three IGLs: an outer layer of interglobular dentine deposited during the annual moult in April, a middle layer of opaque dentine formed during the northwest spring migration (May-June), and an inner layer of translucent dentine formed from July to March.

However in the same article, Bowen *et al.* (1983:1434) extends the developmental period for the translucent and interglobular layers. The translucent begins June-July and finishes February-March while the interglobular is formed in April and early May.

Bowen *et al.*	Fisher
Translucent dentine June/July to Feb./March	Translucent dentine southward migration to moulting
Interglobular dentine April to May - moult	Interglobular dentine started during moult
Opaque dentine May to June	Opaque dentine between moulting and southward migration

Both Bowen *et al.* and Fisher divide yearly annuli growth into the three divisions of translucent, interglobular and opaque. There is only a slight inconsistency with their assigned times for the annuli layer formation. The problems are with the beginning of the translucent layer and the end of the opaque layer. Fisher's time frames are more general because he only examined canines from January to April. He stated that a recently finished opaque band was found in January samples but went on to report the presence of some translucent dentine after the opaque band. Since Fisher had no canines for the period prior to January it is not possible for him to know when the opaque band finished forming. It is also not possible to know when the translucent dentine started to form or at what rate it developed. Fisher was providing his best estimate based on the information available to him. This study will follow the annuli developmental sequence proposed by Bowen *et al.* (1983).

As outlined in Chapter 1, a major objective of this study is to determine if a distinction can be made between Port au Choix harp seals killed in the southward and the northward migrations based on dentine annuli formation. There is approximately a two month period between the two migrations arriving in the Port au Choix area. The time that the two migrations arrive at Port au Choix is represented in the translucent IGL. If there are no obvious subannuli or layers to indicate these time periods than the only method available would be to determine percentage of translucent IGL development. Is it possible to create a developmental profile for the translucent IGL? This question will be addressed in Chapter 6 in the discussion of the results of this study.

Factors in Formation of Incremental Growth Layers in Harp Seal Dentine

Knowledge concerning the factor(s) responsible for when dentine layers form would assist in estimating season of death. But, the cause(s) of the dentine incremental growth layers are unknown (Stewart and Stewart 1987a:1425). Fisher (1954) suggests a common causative factor since all individuals of both sexes displayed a similar pattern and structure. Fisher (1954:31) states that ridges and annuli of dentine in harp seals are "a reflection of the marked and regular seasonal fluctuations in metabolism arising from the habits associated with a migratory existence."

Suggested causes for the variation in type and deposition rate of dentine are:

i) nutritional factors (Mellanby 1928 cited in Fisher 1954)

ii) seasonal variation in hormone balance (Carrick and Ingham 1962 cited in Bowen *et al.* 1983);

iii) vitamin D levels (Fisher 1954, McLaren 1958)

iv) nutritional state or feeding intensity (Mansfield 1958; Scheffer 1950)

v) endogenous factors (Grue and Jensen 1979).

Aging Based on Canines

Besides dentine annuli there are a number of other methods that can indicate age. The pulp canal can provide an age estimation of between over and under three years of age. A rapid decrease in the canal diameter occurs in the first year. Around three years of age only a small opening for nerves and blood vessels is not closed by cementum (Bowen *et al.* 1983; Fisher 1954). Tooth eruption can also provide an indication of age. The lower canine appears within one week of the seal's birth (Bowen *et al.* 1983:1432) and all permanent teeth are present by three weeks of age (Stewart and Stewart 1987a).

Accuracy of Age Estimation

Canines are preferred for accurate age estimation because harp seal canines appear free of dental anomalies. Stewart and Stewart (1987b) reported only one anomaly in 2267 canines examined. Transverse sections of canines provide more accurate estimations than sagittal (longitudinal) sections. The sagittal section has incremental growth lines which are difficult to define and interpret according to Bowen *et al.* (1983).

Bowen *et al.* (1983) studied 155 known age teeth from age three months to ten years. March 1 is assumed to be date of birth because 92% born between late February to early March. They considered the aging method was reliable for seals aged three years and under. However, the study lacked sufficient samples to determine accuracy of the method for seals over the age of three years but they noted that accuracy decreases with age. Bowen *et al.* (1983:1430) states:

> Based on a single examination of a transverse section, the probabilities of correctly estimating age are 0.983, 0.889, 0.817, and 0.553 at ages 1, 2, 3, and 4+ year, respectively, when clearly inaccurate tag-tooth associations are omitted. The respective probabilities are only slightly higher when age is based on the average of five blind readings, being 1.0, 0.889, 0.833, and 0.625."

Hunting Methods for Harp Seals

It is important to have an understanding of hunting methods for harp seals when developing age composition profiles (Chapter 7). The method utilized to harvest seals will have a direct impact on what age range of seals are captured. Nets indiscriminately capture any seal while a hunter can be selective when clubbing seals on the ice pack.

An understanding of harp seal habits and how they react to various hunting methods is also required. Harp seal habits and availability will impact on how successful any hunting method will be. Various reported hunting techniques and how harp seals are approached are:

a) Hook and Line - Sergeant (1965) reports past harvesting of harp seals by hook and line off the Magdalen Islands.

b) Net Hunting - Labrador Inuit Association project reports that harp seal were hunted with nets (Freeman 1977). Moravian missionaries reported the Inuit were using nets to capture seals in 1830's (Brice-Bennett 1981). The type and size of net were not reported in either case.

c) Ice Hunting - The traditional European method was to club seals on the ice floes (e.g., while basking).

d) Driving in coves or ashore - McGovern (1980) suggests communal driving of seals by boats onto shore or into nets.

e) Hunting from watercraft using harpoons - The Textbook of Hunting and Fishing in South and North Greenland (Laerebog i fangst for Sydog Nordgronland) originally published in Greenlandic (1922-23) contains a wealth of information on harp seal hunting (Freeman 1977). Seals surface seaward from their previous feeding locations. A sign of surfacing seals is Kittiwakes climbing higher and stopping to hover. Seals are less cautious the longer they feed in the same location. But hunters should allow all seals to surface before moving as underwater seals are highly sensitive to movement. Once on the surface the seals station guard seals which requires vigilance from the hunter. Any noise will be heard when their nose is below the water surface. The hunter should approach from the sea except when the hunter's wind blown scent will be detected. A dark background or the sun should be behind the hunter as he approaches the seals.

The direction of harpooning is another important consideration for the hunter. Harpooned seals flee forward and should be harpooned from the back or side. Also harpooned seals that continue to stare at the hunter are known to attack and/or bite.

Comments

The aging of harp seals by canine dentine annuli is well established by the researchers reviewed in this chapter. This will permit the aging of the Port au Choix archaeological specimens. The migration habits provide information on availability of various age groups that will aid in proposing culling or hunting strategies.

Bowen *et al.* have clarified the formation time period for the three IGLs (translucent, interglobular and opaque). However, the dentine formation time period for the three IGLs does not isolate the arrival periods of the northward and southward migrations at Port au Choix which are represented in the translucent dentine. A major aspect of this thesis is to determine if those time periods can be identified in the growth pattern of the translucent dentine. The results from this study of the modern and archaeological specimens are presented and discussed in Chapters 6 and 7.

CHAPTER 6 RESULTS

Modern Teeth Age Estimates

The modern canine sections studied were from the collection at Department of Fisheries and Oceans (referred to as Fisheries in this chapter), Northwest Atlantic Fisheries Centre, St. John's, Newfoundland. These sections have known time of death as the kill date is noted by Fisheries or the sealer. The sex of the seal is also recorded for most specimens. The sections have all been aged by Fisheries and some have a known age because they were tagged as pups. This information provides a check for my ability to age the canine sections and to determine the accuracy of any time of death estimations.

Training in aging by dentine annuli was kindly provided by Wayne Penny who prepares and reads the sections for Fisheries. A number of known and assigned aged teeth of various ages were studied to develop my skills in the aging technique. Once I was familiar with the aging technique, 163 modern harp seal thin sections were selected from the collection.

The selected sections were viewed under transmitted polarized light with a binocular microscope. All the sections were photographed and viewed as 35 mm black and white slides. The quality of resolution and density, which created a dark image, prevented the interpretation of all slides.

About ninety-eight percent of age estimates for the sections agreed with the assigned or known ages when aged using the microscope. The older aged specimens with crowed annuli required three or more readings before a satisfactory age estimate was obtained. The three sections (2%) that caused problems with aging required numerous readings (10+) before a consistent age was obtained.

Only about fifty percent of the canine black and white 35 mm slides produced ages that matched the assigned ages. The last few annuli in older specimens, age six and over, were difficult or impossible to discern because the resolution of the more crowded annuli was inferior. This resolution problem could possibly be a reflection of my ability in the technical aspect of slide taking or the lack of adequate contrast between annuli as the tooth cavity becomes increasingly crowed.

Tables 6.0 to 6.11 list the 163 canine sections studied in the age groups that I assigned them to.

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
M831311	20/03/83	Male
F900240	23/06/90	Female
F900239	23/06/90	Female
F900238	23/06/90	Female
F900237	23/06/90	Female
F900236	23/06/90	Female
F900235	23/06/90	Female
M900151	23/06/90	Male
M900150	23/06/90	Male
M900149	23/06/90	Male

Table 6.0 Canine Sections Age 0 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
U821983	18/02/82	Unknown
F841933	--/04/--	Female
F841796	--/04/--	Female
F821996	17/04/82	Female
M810617	16/05/81	Male
M810590	14-22/05/81	Male
801521	16/08/80	Unknown

Table 6.1 Canine Sections Age 1 Year Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
U821984	18/02/82	Unknown
U821982	18/02/82	Unknown
U821986	23/02/82	Unknown
U821993	13/03/82	Unknown
U821995	23/03/82	Unknown
U811315	12/08/81	Unknown
U811316	21/08/81	Unknown

Table 6.2 Canine Sections Age 2 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
M900027	15/01/90	Male
U821992	20/03/82	Unknown
U821991	20/03/82	Male
M831475	--/04/--	Male
M8339011	--/04/--	Male
M900042	30/10/89	Male
M900043	30/10/89	Male
M900044	30/10/89	Male
M900040	30/10/89	Male
F900103	23/11/89	Female
M893450	28/11/88	Male
M893451	28/11/88	Male
M900050	30/11/89	Male
F893432	03/12/88	Female
M893438	03/12/88	Male
M893441	03/12/88	Male
F900015	07/12/89	Female
M900021	07/12/89	Male
M900018	07/12/89	Male
F900016	07/12/89	Female
M900016	07/12/89	Male
M900108	13/12/89	Male
M900106	13/12/89	Male

Table 6.3 Canine Sections Age 3 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
F900066	09/03/90	Female
799620	10/03/79	Unknown
M893472	11/05/89	Male
M893475	11/05/89	Male
M893470	11/05/89	Male
F900231	17/06/90	Female
M900045	30/10/89	Male
F893464	28/11/88	Female
F893474	28/11/88	Female
M900047	30/11/89	Male
F900031	30/11/89	Female
F900030	30/11/89	Female
F893441	03/12/88	Female
F893436	03/12/88	Female
F893440	03/12/88	Female
F900009	07/12/89	Female
M900025	07/12/89	Male
F900005	07/12/89	Female
M900019	07/12/89	Male
F900013	07/12/89	Female
M900008	07/12/89	Male
M900023	07/12/89	Male
M900022	07/12/89	Male
M900104	13/12/89	Male
M900028	15/12/89	Male
F900022	16/12/89	Female

Table 6.4 Canine Sections Age 4 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
U811318	--/01/81	Unknown
F900118	06/01/90	Female
F900065	09/03/90	Female
F900067	09/03/90	Female
F900076	11/03/90	Female
U821994	23/03/82	Unknown
F841819	--/04/--	Female
M831621	--/04/--	Male
F831474	--/04/--	Female
M8331773	--/04/--	Male
F831199	--/04/--	Female
U821987	24/04/82	Unknown
M893471	11/05/89	Male
F900233	23/06/90	Female
801530	27/08/80	Unknown
F900106	23/11/89	Female
F893460	28/11/88	Female
F893473	28/11/88	Female
F893463	28/11/88	Female
F893462	28/11/88	Female
811322	--/12/80	Unknown
F893438	03/12/88	Female
M893437	03/12/88	Male
M900015	07/12/89	Male
M900013	07/12/89	Male
F900014	07/12/89	Female
M900012	07/12/89	Male
F900010	07/12/89	Female
F900110	13/12/89	Female

Table 6.5 Canine Sections Age 5 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
U811320	--/01/81	Unknown
U821985	18/02/82	Unknown
F900060	09/03/90	Female
F900058	09/03/90	Female
F900070	09/03/90	Female
F900061	09/03/90	Female
M810456	20/04/81	Male
M810471	20/04/81	Male
M893473	11/05/89	Male
M893469	11/05/89	Male
F900105	23/11/89	Female
F893461	28/11/88	Female
F893457	28/11/88	Female
M893449	28/11/88	Male
F900032	30/11/89	Female
F900035	30/11/89	Female
M900017	07/12/89	Male
M900004	07/12/89	Male
M900014	07/12/89	Male
F900108	13/12/89	Female

Table 6.6 Canine Sections Age 6 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
F900075	09/03/90	Female
F900090	11/03/90	Female
F900134	17/03/90	Female
F900131	17/03/90	Female
F900134	17/03/90	Female
F900131	17/03/90	Female
M810369	18/04/81	Male
M900101	23/11/89	Male
F893458	28/11/88	Female
F893451	28/11/88	Female
M900105	13/12/89	Male

Table 6.7 Canine Sections Age 7 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
M821990	--/03/82	Male
F900129	16/03/90	Female
F900007	07/12/89	Female

Table 6.8 Canine Sections Age 8 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
F900045	08/03/90	Female
F900083	11/03/90	Female
F900092	16/03/90	Female
F900092	16/03/90	Female
M893447	28/11/88	Male
F893447	28/11/88	Female
M900052	30/11/89	Male

Table 6.9 Canine Sections Age 9 Years Old

IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
F900128	16/03/90	Female
F900135	17/03/90	Female
U821989	25/04/82	Unknown
M900049	30/11/89	Male
F893434	03/12/88	Female

Table 6.10 Canine Sections Age 10 Years Old

AGE	IDENTIFICATION NO.	DATE OF DEATH	SEX OF SPECIMEN
11	F900086	11/03/90	Female
11	F900097	16/03/90	Female
11	F900133	17/03/90	Female
11	F900011	07/12/89	Female
14	F900074	09/03/90	Female
14	F900082	11/03/90	Female
14	F893453	28/11/88	Female
16	F900140	17/03/90	Female
21	F900085	11/03/90	Female
21	F900095	16/03/90	Female
21	F900139	17/03/90	Female
23	F900081	11/03/90	Female
28	F900099	16/03/90	Female
28	F900126	16/03/90	Female
30	F900036	30/11/89	Female

Table 6.11 Canine Sections Age 11+ Years Old

Modern Season of Death Estimates

As discussed in Chapter 1, this study is concerned with determining what stage of annuli formation occurs at the December/January period and the March/April period. Harp seals migrate southward in December/January and northward in March/April past Port au Choix. There are seasonal indicators for late February to May (late winter to spring) Palaeoeskimo occupations at Port au Choix but not for December/January (middle winter) occupations. It is proposed that some of the abundant harp seal remains at the Port au Choix sites could represent middle winter kills. The annuli formation pattern in dentine is the only potential method presently available to provide this information on harp seals.

It has been determined (Bowen *et al.* 1983) that the translucent IGL begins in June-July and is complete during February-March. The layer should be around 60% complete in December and 100% in April provided a constant growth rate can be assumed. However, precise measurements of annuli is pointless because of vast variations in annuli development between individuals. But percentage development of an IGL may be a possible to determine within an individual. The development of the last translucent layer is compared to the previous translucent layers and a percentage development is estimated. The fact that each layer is progressively narrower (compressed) must be factored into the estimate. That is, does the layer's width yearly decrease occur in a predictable pattern or rate?

All sections from the months of December (37) and April (10) between the ages of three and six were examined. This age group was selected because the last annuli was not too compressed and enough annuli are present to detect any pattern of annuli width. It appeared that all April sections displayed a complete translucent IGL but the December percent width was not as easily discernible. That is the width of the December layer, in a number of specimens, appeared larger or smaller than expected based on the previous annuli. The

December width percent varied between individuals and it would be pointless to assign a standard percent of growth. For example, the width ranged from 100% to 33% of that expected for an April specimen.

The width range is clearly shown in the following examples:

a) F893436, four year old December kill

The measurements for the last four translucent layers are: 30; 20; 16 and 12. The last layer is already at 100% of what would be estimated for April development. Other examples of approximately 100% development for December kills are:

F900013	21	14	10	7
F900009		29	17	17
M900019		40	23	20
F831199			18	18
M900104		21	22	21
F900118	20	13	10	9
F893438			14	14

b) M900104, four year old December kill

The measurement are 37; 20; 18; 5. The last layer is about 33% of what would be expected for the fully developed layer. This is also seen in M900022 (39; 20; 16; 5) and

M900021 (24; 8).

c) Other December kills have translucent layer development around the 50% range. Examples of this are: F893432 (22; 12); M873408 (14; 7) and M900108 (16; 8).

The individual variation of layer development is highlighted by three readings taken across different sections of F893436. These readings are:

1) 30; 20; 16; 12

2) 31; 26; 22; 17

3) 27; 20; 17; 12

The variation in the width of each layer can vary by approximately 25% and can greatly alter the estimated width reduction of each successive layer.

The problem is that you cannot be certain what the final width of the last annuli would be and at what rate it is being formed. It is impossible to state with any precision whether the layer is 30% completed or 100% because of individual variation. You might, for example, identify a 60% developed archaeological specimen as December that in fact may be a 100% March/April kill. However, the probability that a December kill is represented would increase with increasing numbers of specimens displaying 33% or less development. In this case you could use the percentage method very cautiously to suggest a December kill and thus a possible winter seasonality indicator.

Caution is recommended because of the sample size and problems associated in determining percentage of development. The sample size was relatively small with 37 December canines between the ages of three and six years. It is possible that the low end of percentage development for December could be less than 33%.

Fisher's (1954) research on January killed harp seals supports the notion that the low end could be well below 33%. All the seals showed an opaque layer and those with only a few annuli showed small amounts of translucent dentine. Seals taken during the April moult showed greater amounts of translucent dentine. This implies that the translucent layer was barely discernible on the approximately 1500 January killed seals Fisher studied. The percentage development must have been well below the 33% development displayed on the specimens I examined. The translucent dentine was probably not detected on the older seals because of the compressed nature of the annuli. Difficulties in determining the percentage development increase with increasing age of the specimen because of this dentine annuli compression.

Also, the interpretation of annuli involves a certain amount of subjectivity as there are detectable variations between specimens. There is a considerable range in annuli contrast, clarity and boundary edge besides variation in width. All of these factors impact on the researcher's ability to determine the percentage development. Another factor is a significant reduction in empty pulp cavity space between the ages of four and five. The available space to fill at age five is approximately 25% of that at age four, in the sections I studied. Therefore, after age five the annuli are significantly compressed and make percentage development determinations more difficult. The percentage development method is best suited for immature animals aged five years or under.

One possible method, beyond the scope of this project, that might clarify the validity of percentage development would be to precisely determine the percentage development of a statistically significant sample with a known December/January death. This sample would have to span a number of years to account for yearly variation and should include some of Fisher's (1954) sample (if possible). Then the probability that a certain width percentage indicates the December/January time period must be determined. If the probability was shown to be high then the method could be applied to archaeological specimens.

Another possible method to determine period and rate of development is to use computer programs. Secondary or lesser annuli are clearly visible within the translucent IGL. These are visible throughout the entire layer and continually form over its several months of development. The pattern of these secondary layers needs to be identified to subdivide the IGL and provide a December indicator. The image density computer program as discussed in Chapter 3 may provide the means to achieve these results when the process is refined. This method holds the most promise to precisely define the December stage of development.

Implications for Archaeological Specimens

The modern sections failed to provide a precise method to determine December/January (middle winter) season of death for Port au Choix seals. What is possible is to infer a middle winter death if a number of specimens display less than 33% development of the last translucent annuli based on the specimens I studied. But, Fisher's (1954) study suggest that the 33% development figure is too high thus making the results more speculation than fact.

However, the dentine annuli method would be more precise for separating the two migrations past Labrador coastal sites. The interglobular dentine is formed prior to the northward migration during the moult and the opaque dentine is being formed during the northward migration.

PORT AU CHOIX ARCHAEOLOGICAL HARP SEAL CANINES

Seventy-three seal canines (Table 6.12) consisting of 19 from mandibles/skulls identified as harp seal and 54 loose teeth believed to be harp seal were selected from the Port au Choix faunal material. The Dorset palaeoeskimo Phillip's Garden site was represented by 58 teeth and there were 15 teeth from the Groswater palaeoeskimo Phillip's Garden East site. All the teeth were sectioned producing both thin sections and solid sections for estimating age and season of death.

The thin sections produced few readable annuli even though annuli were clearly visible in the solid section. Only 17 age estimates (Table 6.13) were possible with the thin sections. The dentine in the remaining 56 showed little annuli and were granular in texture. It is obvious that the dentine structure decomposed through time (1,500 years+-/). All the canines showed signs of dentine breakdown possibly caused by:

1) environmental factors such as soil chemical composition and weathering;

2) treatment after excavation as the canines were allowed to dry out;

3) the utilized thin section technique's saw speed or grinder may have fractured the brittle dentine; and

4) pressure may have been required to ensure fragile dentine consolidation by total penetration of the epoxy during the vacuum impregnating process.

The annuli were more visible in the solid section despite the dentine decomposition. This probably occurs because of the annuli's greater thickness in solid sections. A thicker section provides more dentine particles to make the annuli more distinguishable. The dentine particles would be too separated in the shallow thickness of a thin section, thus making the annuli boundaries difficult to discern.

The solid section produced more readable annuli with 60 age estimates and only 13 unreadable sections (Table 6.14). The age estimates are the countable annuli and a plus sign is added to specimens that also contained some unreadable dentine width. It was decided to use four factors to estimate age since neither the thin sections or the solid sections provided a complete age estimate for all of the sections (Table 6.15). This best educated guess estimate was based on the following:

1) thin section;
2) solid section;
3) pulp cavity size; and
4) total thickness of dentine.

The thin sections and solid sections provide a minimum age based on distinguishable annuli. Then the pulp cavity size and the total dentine thickness are determined. The pulp cavity reduces in size through time as dentine is deposited while total dentine thickness increases with age. These help to interpret the potential annuli in the unreadable sections. Overall dentine thickness can be compared to that in modern and archaeological aged specimens to assist in the estimation. Combined these methods probably provide at worst an age within 2-3 years of the actual age despite their limitations. The results of the aging are analyzed and discussed for Phillip' Garden and Phillip's Garden East in

Chapter 7 on age composition.

NUMBER OF CANINES	SITE LOCATION	CANINE LOCATION	THIN SECTION NUMBER
1	PG 7A 250 A 0018 E050 S21 2	loose	1
1	PGE 7A 394 A 0283 E241 S12 2L	mandible	2
1	PGE 7A 394 A 561 E242 S12 3	mandible	3
2	PG 7A 250 A 8 E050 S21 2	loose	4, 5
1	PGE 7A 385 B 472 E251 S11 3	loose	6
1	PGE 7A 385 B 518 E239 S13 3	mandible	7
1	PGE 7A 394 A 641 E242 S14 3R1	mandible	8
1	PG 7A 250 A 119 E050 S21 2A	loose	9
2	PG 7A 217 D E14 N21 2	loose	10, 11
2	PG 7A 250 Midden	skull	12, 13
1	PG 7A 295 D 0661 E090 N13 3	loose	14
1	PGE 7A 394 A 0965 E241 S11 3R1	mandible	15
1	PG 7A 293 B 116	loose	16
2	PG 7A 285 C 0115 E089 N14 2A	loose	17, 18
2	PG 7A 323 A 166	loose	19, 20
3	PG 7A 250 A 143 E50 S21 3	loose	21, 22, 23
2	PG 7A 323 A 385	loose	24, 25
1	PGE 7A 394 A 0220 E241 S12 2	mandible	26
1	PGE 7A 394 A 641 E242 S14 3R1	mandible	27
2	PG 7A 323 A 712	loose	28, 29
1	PG 7A 250 A 119 E50 S21 2A	mandible	30
1	PGE 7A 383 D 854	loose	31

1	PG 7A 250 A 050 E050 S21 2A	mandible	32
1	PG 7A 302 D 814	loose	33
1	PG 7A 323 A 33 E123 N09	loose	34
3	PG 7A 250 A 0070 E50 S21 2A	loose	35, 36, 37
1	PG 7A 250 A 119 E50 S21 2A	mandible	38
1	PG 7A 323 A 734	loose	39
1	PG 7A 250 A 0050 E050 S21 2A	loose	40
1	PG 7A 250 A 0018 E050 S21 2	mandible	41
1	PG 7A 250 A 119 E50 S21 2A	mandible	42
1	PG 7A 323 A 734	loose	43
1	PG 7A 250 A 119 E50 S21 2A	mandible	44
1	PG 7A 250 A 130 E050 S021 2A	mandible	45
1	PGE 7A 383 D 1115 E234 N04 2	loose	46
1	PG 7A 283 B 034 E086 3 3	loose	47
1	PG 7A 250 A 0008 E50 S21 2	mandible	48
1	PG 7A 250 A 119 E50 S21 2A	loose	49
1	PG 7A 250 A 143 E050 S21 3	mandible	50
2	PG 7A 250 A 8 E050 S21 2	loose	51, 52
1	PG 7A 250 A 119 E50 S21 2A	mandible	53
3	PG 7A 250 A 0018 E050 S21 2	loose	54, 55, 56
1	PGE 7A 385 B 591 E239 515 3R1	loose	1
1	PGE 7A 385 B 472 E239 S11 3	loose	2
1	PG 7A 293 B 301 E98 S01 3	loose	3
1	PG 7A 294 C 351 E98 N04 2	loose	4
1	PGE 7A 394 A 863 E241 S11 3R1	loose	5
1	PG 7A 295 C 0145 E099 N010 2A	loose	

1	PG 7A 295 D 436 E091 N14 2A	loose	
4	PG 7A 323 A 291	loose	
2	PG 7A 295 D 0561 E090 N13 U4	loose	
1	PG 7A 293 B 150 E95 S03 2A	loose	
1	PG 7A 295 D 0477 E090 N13	loose	
2	PGE 7A 385 B 518 E239 S13 3	loose	

Table 6.12 Canines from Phillip's Garden (PG) and Phillip's Garden East (PGE) sites, Port au Choix

SECTION NO.	AGE	CONDITION	LAST ANNULI
1	-	unreadable	-
2	-	unreadable	-
3	-	unreadable	-
4	-	unreadable	-
5	4	fair	-
6	-	unreadable	-
7	-	unreadable	-
8	-	unreadable	-
9	1	good	opaque
10	13	fair	-
11	-	unreadable	-
12	-	unreadable	-
13	-	unreadable	-
14	-	unreadable	-
15	-	unreadable	-
16	-	unreadable	-
17	-	unreadable	-
18	-	unreadable	-
19	7-8	fair to poor	-

20	-	unreadable	-
21	7	fair	-
22	14+	fair	-
23	-	unreadable	-
24	-	unreadable	-
25	-	unreadable	-
26	-	unreadable	-
27	-	unreadable	-
28	-	unreadable	-
29	9	good	-
30	-	unreadable	-
31	18+	fair	-
32	-	unreadable	-
33	-	unreadable	-
34	13+	fair	-
35	-	unreadable	-
36	-	unreadable	-
37	-	unreadable	-
38	1	fair	start opaque
39	-	unreadable	-
40	1	poor	-
41	15+	fair	-
42	12	fair	-
43	-	unreadable	-
44	-	unreadable	-
45	-	unreadable	-
46	-	unreadable	-
47	-	unreadable	-
48	-	unreadable	-
49	12+	fair	-

50	-	unreadable	-
51	10+	fair	-
52	-	unreadable	-
53	-	unreadable	-
54	-	unreadable	-
55	-	unreadable	-
56	4+	poor	-
1A	-	unreadable	-
2A	-	unreadable	-
3A	-	unreadable	-
4A	-	unreadable	-
5A	-	unreadable	-
295C0145	-	unreadable	-
295D436	-	unreadable	-
323A291	-	unreadable	-
323A291 i	-	unreadable	-
323A291 ii	-	unreadable	-
323A291 iii	10	fair	-
295D0561	-	unreadable	-
295D0561 i	-	unreadable	-
293B150	-	unreadable	-
295D0477	-	unreadable	-
385B518	-	unreadable	-
385B518 i	-	unreadable	-

Table 6.13 Thin section Age Estimates

SECTION NO.	AGE	CONDITION	LAST ANNULI
1	1	good	full translu-cence
2	8+	fair-poor	-
3	7+	good-poor	-
4	10+	good	-
5	4	fair	-
6	-	unreadable	-
7	6+	fair	-
8	5+	fair	-
9	1	good	opaque
10	6+	good-poor	-
11	7+	good-poor	-
12	6+	good-poor	-
13	6+	good-poor	-
14	5+	poor	-
15	6+	fair-poor	-
16	5+	fair-poor	-
17	-	unreadable	-
18	-	unreadable	-
19	3+	fair-poor	-
20	8+	poor	-
21	5+	good	-
22	11+	good-fair	-
23	5+	fair-poor	-
24	6-6+	poor	-
25	5+	fair-poor	-
26	3+	fair-poor	-

27	6+	fair-poor	-
28	4-4+	poor	-
29	13+	good	-
30	8+	fair-poor	-
31	11+	good	-
32	6+	good-poor	-
33	-	unreadable	-
34	14+	good	-
35	4+	fair-poor	-
36	4	fair-poor	-
37	-	unreadable	-
38	1	good	opaque
39	6+	fair-poor	-
40	1	poor	-
41	6+	good	-
42	6-6+	good-poor	-
43	4-4+	fair-poor	-
44	5+	poor	-
45	-	unreadable	-
46	-	unreadable	-
47	5+	fair-poor	-
48	7+	fair-poor	-
49	8+	good-poor	-
50	7+	fair-poor	-
51	8	fair-poor	-
52	-	unreadable	-
53	6+	poor	-
54	-	unreadable	-
55	-	unreadable	-
56	7	good-poor	-

1A	-	unreadable	-
2A	5+	poor	-
3A	5-5+	poor	-
4A	2	good-poor	full translu-cence
5A	3	fair-poor	-
295C0145	4	poor	-
295D436	-	unreadable	-
323A291	7	fair	-
323A291 i	3	fair-poor	full translu-cence
323A291 ii	-	unreadable	-
323A291 iii	7-7+	good-fair	-
295D0561	5+	poor	-
295D0561 i	6+	poor	-
293B150	5+	fair-poor	-
295D0477	14+	poor	-
385B518	6+	poor	-
385B518	8	fair-poor	-

Table 6.14 Solid Section Age Estimates

SECTION NO.	AGE
1	1
2	10
3	8
4	20
5	4
6	3
7	7
8	10
9	1
10	13
11	13
12	12
13	12
14	8
15	10
16	6
17	3
18	20
19	4
20	14
21	6
22	15
23	20
24	6
25	6
26	4

27	20
28	6
29	20
30	20
31	20
32	8
33	5
34	20
35	8
36	4
37	16
38	1
39	8
40	1
41	20
42	12
43	8
44	10
45	6
46	6
47	7
48	10
49	14
50	10
51	10
52	6
53	8
54	5
55	10
56	7

1A	14
2A	8
3A	8
4A	2
5A	3
295C0145	4
295D436	3
323A291	7
323A291 i	3
323A291 ii	6
323A291 iii	10
295D0561	15
295D0561 i	15
293B150	8
295D0477	20
385B518	8
385B518 i	8

Table 6.15 Actual Age Estimates From All Data

Season or Time of Death

Only four specimens had clearly defined last annuli in the thin section and/or solid section that could be used to suggest time of death. The lack of clear annuli resulted from poor dentine preservation and the large number of mature specimens with compressed dentine annuli. The four specimens all came from the Dorset palaeoeskimo Phillip's Garden site.

SECTION NO.	AGE	LAST ANNULI
9	1	start opaque
38	1	opaque
4A	2	full translucent
323A291 ii	3	full translucent

Table 6.16 Last Annuli

All the annuli suggest the same spring time period of death as the translucent is finished in March and the opaque starts in May. The translucent layer percentage development method was applied to sections 4A and 323A291ii to determine time of death. Despite the methods limitations, the width of the translucent layer in both sections indicates a February-March period rather than a December-January period.

This study has highlighted a number of problems with the Port au Choix material and the potential to identify the winter kill period. These problems are:

1) The major problem is poor preservation of the dentine. Port au Choix has differential dentine preservation thus providing only a limited number of specimens for seasonality estimation. This low number of specimens makes it increasingly difficult to isolate the southward migration period.

2) Another problem is what canines should be selected for sectioning? In other words, how can you isolate potential December/January (winter) kills from the other seasons? This problem is compounded when the faunal remains are not collected by shallow layers. The rejection of canines associated with spring seasonal indicators would be possible by having tight provenance on harp seal canine material. It would be pointless to section canines associated with spring if your objective is to identify a winter hunt. The sorting of canine material would reduce the sample size and increase the odds of sectioning winter material (assuming there is some). This is important considering the abundance of harp seal material at Port au Choix. The majority of this material should represent the spring hunt when seals could be taken on the ice.

3) The pulp cavity edge of the last annuli must be evaluated once a section has been produced. This evaluation must determine if the dentine present truly represents the dentine deposited. The edge would be examined for signs of cracks or flaking for indications of dentine deterioration. The loss of any dentine could significantly alter the percentage development estimation.

Fortunately, specimens can be aged whether or not the last annuli is totally readable and even with dentine deterioration. The age data can be used to construct age profiles and infer culling patterns and hunting strategies.

CHAPTER 7 AGE COMPOSITION

Age composition data from the Port au Choix harp seal faunal sample provides information to construct a mortality profile. The mortality profile could potentially supply information on hunting or culling strategies. But, numerous natural and human factors must be addressed when developing and interpreting mortality profiles. These factors include portion of death population recovered, required MNI, discrete deposition, taphonomy, hunting and culling methods, treatment of carcasses/bones by humans, and cultural practices. Starna and Relethford (1985) state that age-sex exploitation rates along with nonhuman predation effects and climatological impacts are important factors not usually addressed by researchers. It is important to remember that animal populations are not static and unchanging as often portrayed but continue to fluctuate and change in response to various factors. Likewise hunting strategies and technology, treatment of carcasses/bones and cultural practices change through time because human cultures are also not static.

One crucial aspect in developing useful mortality profiles is the aging techniques utilized to estimate age at death. Techniques based on tooth eruption, tooth wear, and epiphyseal fusion actually produce limited or relative age groupings that can be overlapping. Age groupings that overlap create problems in assigning individuals to constructive categories. This results from the considerable individual variation concerning these continuous ontogenetic variables used for aging (Lyman 1987).

The dentine/cementum annuli technique, unlike the other aging techniques, can provide absolute ages to at least the year. This permits discrete yearly age classes for mortality profiles instead of age groups. The age data must be obtained from a faunal sample that has had the inherent biases quantified. Biases in the archaeofaunal sample result from human and nonhuman culling, carcass/bone treatment techniques, and environmental influences (Davis 1987:27-28).

Another consideration is the problem created by aging from a single type of element (i.e. teeth) when comparing site subsamples. The same animal species could be exploited for different purposes and thus be represented by different kinds of bones in the subsamples (Hesse and Wapnish 1985:106) and not reflected in the single element age profiles. Also, primary butchery may take place elsewhere on some occasions limiting the elements discarded at the site.

The two basic age profiles produced from the quantified data are the catastrophic (life assemblage) age profile and the attritional age profile (Klein 1982: Klein and Cruz-Uribe 1984:56-57; Levine 1983). Various ages are found in the same proportion as the live population in the catastrophic age profile. Catastrophic profiles are created by natural floods, droughts, volcanic activity or human hunting or slaughtering. Driving a herd off a cliff resulting in mass or entire population kills would create a catastrophic profile.

The attritional age profile contains higher numbers of young and/or old individuals. Natural factors creating this type of profile are disease, malnutrition, predation and accidents. Human hunting and slaughtering (pastoral populations) techniques also can create attritional age profiles. These techniques include scavenging the natural (normal) death population or hunting based on the weakest prey individuals.

Levine (1983:29-31) included five additional mortality profiles in her discussion of prehistoric horse population structure. These profiles are:

1) **Carnivorous Husbandry Model** - Involves the slaughter of surplus mature males combined with the normal attritional pastoral pattern.

2) **Social Group Models** (variants of the life assemblage model) - Animals form select social groupings such as family or bachelor groups. A resemblance to the life assemblage model is possible if these different groups are deposited together.

3) **Family Group Model** - This group contains a low proportion of adolescents and the absence of bachelor males.

4) **Bachelor Group Model** - The absence of individuals under the age of two years identifies this grouping.

5) Stalking Model - Reflects the hunting of prime adults but the sample is likely too small and indistinguishable from the bachelor group.

Types of group models similar to Levine's could be developed for harp seals. The composition of the harp seal herds varies throughout the year from migration patterns. Mature seals depart and arrive first on the southward migration. Mature males and immature seals depart first after the moulting period to be followed shortly by mature females. Juveniles (young of the year) remain longer in the Port au Choix area with some stragglers there until June or July. Three possible mortality profiles for harp seal are:

1) Mature Individuals - Involves the slaughter of the first to arrive mature individuals only. This could include fetal and new born material associated with whelping mature females.

2) All Age Groups - The death population would contain representatives from all groups including young of the year.

3) Juvenile Individuals - This group would represent the later departing juvenile seals including the June to July stragglers.

Problems with obtaining an accurate harp seal age profile based on dentine annuli limits the value of age composition and mortality profiles for the Port au Choix sites. As Fagen (1988:357) states the two basic problems to be solved during faunal analysis are:

> 1) A statistical problem - estimating the characteristics of a fossil assemblage from a

sample.

2) A taphonomic problem - inferring the nature of the deposited assemblage from the fossil one.

Presently, neither of these problems can be satisfactorily controlled for the harp seal canine material at Port au Choix to develop age composition profiles. The only practical application is to compare the dentine derived age to age data based on other faunal aging techniques for each feature/unit excavated.

The problems in developing harp seal canine based age composition profiles for Port au Choix harp seals are:

a) Death Population

For the faunal population to be valid for determining the age composition one major assumption must be true. The assumption is that the excavated remains are the total death population or a representative proportion of the death population. This appears to be a difficult if not an impossible assumption to verify for most archaeological sites. Not only must the researcher account for all preservation and processing biases but also be able to reconstruct the past lifeway including cultural and ritual practices. Researchers such as Binford (1978, 1981) and Grayson (1981) state that you cannot assume that the faunal remains accurately represent all the death population of a species. Depending on the death assemblage numbers for each species any individuals not accounted for could make the profiles developed nothing more than speculation. Thus, a statistically significant sample must be utilized when constructing age profiles.

Secondly, the aging of all remains recovered may not be possible. Poor preservation, alterations by environmental or human factors, and bias against the preservation of immature animals can inhibit aging a specimen. Not all canine teeth recovered will be sectionable or produce readable thin sections.

b) MNI Required

Since a number of factors influence age profiles Klein and Cruz-Uribe (1984) suggest at least twenty-five individuals are required to develop interpretable age profiles. The exact number required depends on the factors shaping the age profile but the larger the number of individuals the better. Lyman (1987) reports that the MNI required for mortality profiles depends on the life expectancy of the taxon. Taxons with an average life expectancy of approximately three years require an MNI of thirty individuals to construct morality profiles (Lyman 1987:125). Present seal faunal remains from Phillip's Garden (Hiseler 1990b) produce MNI counts of less than the required thirty per subfeature. MNI's based on harp seal canines in mandibles (to allow positive identification to species) are extremely low being under ten per excavated feature/unit.

3) Discrete Deposition

One major problem with the Port au Choix material is determining discrete deposition of faunal material. While certain features and subfeatures have been identified by Renouf (1987) it has yet to be determined/shown what these features actually represent in terms of the depositional sequence of daily, weekly, seasonal, yearly or multi-year deposits. It is important in determining age profiles and culling patterns to know what time period the deposit represents.

Phillip's Garden midden, Feature 2, is an example of the problems encountered at Port au Choix. It was excavated as seventeen subfeatures but subsequent analysis reduced the number to twelve. Some of the reported depositional sequence is:

1) Subfeature 2U - A small hearth was dumped

2) Subfeature 2G - This small midden deposit partially covered subfeature 2U

3) Subfeature 2T - In the house centre a sizable garbage dump covered subfeature 2U and abutted subfeature 2G.

4) Subfeature 2F - This deposit was dumped over the northern end of subfeature 2T.

5) Subfeature 2A - This deposit covered subfeature 2T's southern end.

6) Level 2 - A sod and peat layer formed over the deposits.

Renouf (1987:18) states: "clearly the midden had been formed by a series of separate dumps deposited over a period of weeks, seasons, or years." The features represent discrete deposits/dumps according to Renouf (personal communications 1991) because each dump has a different soil texture than the surrounding matrix and/or the adjacent dump.

Component dimensions (Renouf 1987) are:

1) Component's (i.e. subfeatures 2D, 2F, 2Q) maximum dimensions are 1.65 metres east-west and 1.20 metres north-south with a 13 cm. maximum depth.

2) Subfeature 2H - Dimensions of 40 cm. north-south and 1.03 metres east-west and a shallow 2 cm. deep.

3) Subfeature 2J - This deposit was approximately one metre square and a maximum 21 cm. deep.

4) Subfeature 2K - A 13 cm. deep small pit 50 cm. north-south and 40cm east-west.

5) Subfeature 2T - This large pit feature was 1.55 metres north-south and over one metre east-west at the base. The southern end was the deepest area at 21 cm..

Two cautionary points to consider about these discrete deposits are 1) they are probably seasonal, yearly or multi-year deposits that have decomposed and compressed over time rather that a single dump episode, and 2) as reported by Renouf (1987) the separate layers were discerned by soil textural change which can be a subjective determination. If the same faunal material is present in the all the subfeatures what factor has caused the different soil textures?

It is possible that smaller dumps were not discernable in the subfeatures because of the blending of the daily, weekly or monthly deposits. The discernable layers may represent the yearly or multi-year deposits that have permitted a minor soil interface to build up to highlight the deposit's boundaries. Radiocarbon dates for subfeature 2T and the underlaying subfeature 2U support this notion. There is at least 200 years between the deposition of 2T (1520+/-90) and 2U (1900+/-110). Also, the subfeatures were only detected in the profiles during the previous year's excavation (7A323A).

If they do represent seasonal, yearly or multi-year deposition then any variations in mortality/culling patterns within or between seasons and years will be masked as the entire faunal remains for each subfeature are considered together. Any variation in culling patterns and deposition of bones between the seasons or within a season will only be detected if the features are excavated in a highly controlled manner. That is each midden deposit (feature, subfeature) must be excavated and recorded in shallow arbitrary layers to provide any indication of body part clustering or age groupings.

Examples of this would be:

1) if the forequarters and hindquarters of the seals were saved for consumption and the remaining portions were discarded into the midden. The forequarter and hindquarter remains would be deposited in the midden once the meat had

been consumed.

or 2) what if seals were harvested and deposited in a manner that reflects the migration pattern (i.e., first mature seals, followed by all age groups and finally juveniles).

These separate clustering of faunal remains should be evident in a controlled arbitrary levels excavation. But, if the midden was excavated as a single layer the faunal remains will have no provenance within the midden and the clustering would not be evident. This would mask important information on culling patterns and consumption habits.

4) MNI Comparisons

The MNI obtained from canines must be compared to the MNI's from other body parts to see how accurately the teeth represent the total death population. Also, age groupings based on canines and other body parts must be compared to see how closely they match. Any difference might represent environmental differential preservation or human butchery and carcass treatment practices. Faunal material aged by means other than canines is presently not available for the tested units/features.

Examples of different MNI's derived for the same subfeature are evident from Feature 2, at the Phillip's Garden site, Port au Choix (Hiseler 1990b). The head portion in most subfeatures produced MNI's half of those based on the forequarters. This should not be a reflection of differential preservation because certain identifiable cranial elements are as preservable as any other skeletal element. Therefore, the age composition profile derived from canine annuli would potentially represent only half of the actual death population for that subfeature.

5) Taphonomy

Cultural (human behaviour) and non-cultural (natural environment) are the two basic types of formation process (Schiffer 1987). Schiffer (1987:11) states these formation processes:

> 1) Transform items formally, spatially, quantitatively, and relationally,
> 2) can create artifact patterns unrelated to the past behaviours of interest,
> 3) exhibit regularities that can be expressed as (usually statistical) laws.

Deposition of an item is considered primary if discarded at the location of use or secondary if discarded anywhere else. Items in primary and secondary deposits can be affected by a number of cultural or non-cultural activities/processes. Cultural influences include the method and reason for discard and treatment after deposition. After deposition disturbances are trampling, burning or reclaiming the site or item for reuse. Noncultural processes include chemical weathering, mechanical (freeze-thaw), recycling processes, curatorial factors (changed environment, packing, etc.).

The cultural and noncultural impact on a deposit are considered under the area of taphonomy. Taphonomy examines the factors that have altered the fossil assemblage from the deposited assemblage (Davis 1987). Modern and past noncultural factors are considered to effect remains in a similar fashion following the uniformitarian principle (Klein and Cruz-Uribe 1984). Behrensmeyer (1978) notes that the inherent taphonomic biases concerning a bone assemblage's attrition must be considered. Binford (1981) advocates the use of middle-range theory to learn about bone taphonomy including actual studies of animal carcass decomposition. The absence of seal taphonomy studies places severe limitations on the interpretation of archaeological seal remains. The inherent taphonomy biases cannot be accounted for since how seal bone is altered or decomposed by human, chemical, mechanical or recycling processes has not been demonstrated.

Davis (1987) notes that immature animal bones and teeth are destroyed more easily because of incomplete ossification. Caution is recommended in developing profiles with juvenile dental age groups. Also, collagen is decomposed by microorganisms when water and oxygen are present but can occur inside bone independent of soil solution's ions and pH (White and Hannus 1983).

Questions concerning taphonomy of the Port au Choix site are:

a) Is the textural difference between levels 2A and 2 at Phillip's Garden caused by differential decomposition from the mechanical action of the freeze and thaw cycle?

b) How did the palaeoeskimo process the seal carcass and what storage techniques where utilized (dried, boiled, cooked, stored in oil)? In what ways were the bones affected by the various treatments?

c) Did the heads receive special treatment that would effect the teeth preservation and recoverability? Were the heads treated the same way throughout the season, every season and every year?

6) Culling of Animals

(A reflection of the death or life assemblage)

Culling implies a conscious selection process and that various (if not all) age grouping are available to exploit. But, culling practices probably changed through the season(s) or between years depending on the availability of seals. As noted previously animal populations are dynamic entities undergoing continuous changes. There are two important changes that affect the interplay between hunter-gatherers and prey. Firstly, resource selection varies with changing prey densities and secondly the impact of exploitation on population densities (Winterhalder *et al.* 1988). All age groups are not available equally throughout the entire culling/hunting period.

Harp seal availability and population composition changes throughout the year because of herd migration patterns and environmental factors such as ice conditions. The older seals are the first to arrive on the southward migration and to leave on the northward migration. Females and young of the year spend more time on the ice than do males. Juvenile seals remain longer in the area with some stragglers there until June-July.

The ability to cull the harp seal population would depend on the time of year, the availability of age groups and the hunting techniques utilized and the desired results. The actual seal hunting techniques of the Groswater and Dorset Palaeoeskimoes are unknown.

As discussed in Chapter 5 various methods that have been utilized by other cultures to harvest harp seals. Some of the methods utilized are hook and line, nets, clubbing on the ice and driving seals ashore. The hunting method has a significant impact on the number and age groups killed. A net would capture a swimming seal of any age while a hunter could select his desired prey on the ice. Also driving a herd of seals ashore to be slaughtered could provide more carcasses than the hunters could utilize. The overabundance of carcasses could alter butchery practices with only select portions being removed. This selective process would be similar to that found at bison kill sites (Speth 1983).

7) Treatment of Carcasses/Bones

(butchery, cooking, trampling)

It is probable that the carcasses/bones were not treated or utilized in the same pattern within a single season, between seasons, between years and between individuals. Greater utilization of the entire carcass at the beginning and end of the hunting season and in years of low seal population numbers is probable. This could result in different butchery practices including the complete carcass brought to the site instead of preliminary butchering on the ice.

The size of the seal may influence whether the seal is brought back whole or in sections from the ice. Removing the head and gutting (causes the loss of blood) the seal would greatly reduce the weight and facilitate the dragging of a carcass across the ice. A reduction in the potential 180 kg. weight is particularly likely in the case of a single hunter dragging the carcass any distance.

Any Port au Choix seals whose heads were left on the ice cannot be accounted for by the canine method. This reenforces the need for a comparison of MNI's based on canines and other seal faunal remains. Similar MNI's would indicate that the canines reflect the actual number of seals for that location/feature.

8) Cultural Practices

We lack an understanding of the cultural systems that produced the Port au Choix archaeological site. It is possible that the residents followed ritual practices concerning the first seals of the season. These seals may have been differently butchered and utilized than the subsequent seals harvested.

The Maritime Archaic burials (Tuck 1976) at Port au Choix contained animal body parts that were manufactured into tools or curated as charms and amulets. These objects included mammal teeth, bird bones and seal claws.

The Cree of Quebec provide an example of where religious ideology influences the disposal of animal remains. An ethnoarchaeology study of a modern camp showed that the site is left clean (Gordon 1980:92). The bone is disposed in a number of ways including being suspended in trees. This treatment shows respect and repayment to the captured animals by not allowing dogs and predators to gnaw the remains.

Tanner's (1979) study of the Mistassini Cree reported the use of animal parts for divinatory dreams, to please hunting spirits and to show respect to and gain power from the animal killed. Also, he notes that the Naskapi use a fat called *wiin*, from the lower leg of caribou or moose, during ritual feasts.

Besides nutritional or ritual value, seals are used for health maintenance and healing agents (Borre 1994). The Inuit of North Baffin Island believe that the "seal maintains the physical, mental and spiritual health of the individual, the social well-being of the community ...." (Borre 1994:1). They utilize the meat, oil, liver and blood of seals to cure problems such as ear infections, gastrointestinal distress, headaches and nausea.

PORT AU CHOIX HARP SEAL

AGE COMPOSITION

The seventy-three canines produced a maximum MNI of 68 for the entire sample. The sample is divided into a MNI of 54 for the Dorset Palaeoeskimo site of Phillip's Garden and a MNI of 14 for the Groswater Palaeoeskimo site of Phillip's Garden East. The ages utilized in this analysis are the best estimation of actual age based on the thin sections, solid sections, pulp cavity size and total dentine thickness. These MNI's per yearly age category are:

AGE	1	2	3	4	5	6	7	8	9	10
NO.	4	1	3	4	2	7	3	8	0	6
AGE	11	12	13	14	15	16	17	18	19	20
NO.	0	2	1	2	2	1	0	0	0	8

Table 7.0 Age MNI for Phillip's Garden Sample

AGE	1	2	3	4	5	6	7	8	9	10
NO.	0	0	2	1	0	1	1	3	0	3
AGE	11	12	13	14	15	16	17	18	19	20
NO.	0	0	0	1	0	0	0	0	0	2

Table 7.1 Age MNI for Phillip's Garden East Sample

The MNI numbers per level, subfeature etc. of an operation are too small to construct meaningful age composition profiles based on the literature reviewed. What can be interpreted is the composition of the total sample for each site. The samples can be divided into four grouping based on maturity. These groups are immature (under 4 years), immature/mature (ages 4-7 to reflect the age period females and males mature), mature (over age seven) and very mature (over age 15).

	Phillip's Garden	Phillip's Garden East
immature	8	2
immature/mature	16	3
mature	21	7
very mature	9	2

Table 7.2 Number of MNI's per Maturity Groups

The Phillip's Garden sample comprises largely mature seals with only 15% under the age of three and about 56% over the age of seven. Phillip's Garden East shows a similar pattern with 14% under the age of three and 65% over the age of seven. Also, both sites contained about 15% very mature seals over the age of 15. This suggests larger mature seals were preferred over the smaller immature seals or that mature females whelping on the ice were the preferred or the easiest seals obtained.

No juvenile (young of the year) were identified in either of the samples. However, four canine sections were aged at one year old for Phillip's Garden. Sections number 9 and 38 display the formation of the opaque layer which means they are at least 13 months old. The translucent layer is the last IGL in sections number 1 and 40 indicating that they could be either be a summer (July) or winter/spring kill. Based on the amount of translucent material deposited, it is assumed they represent a winter/spring rather than a summer kill. A summer seal's translucent layer would just be starting to be deposited and should not have the width displayed in both sections. Therefore, the seals are aged at one year because they are considered to be 10 to 13 months old.

This means that there were no juveniles in the test sample selected for this thesis. The lack of juveniles could reflect the inherent bias against their preservation or that no juveniles were deposited in the units examined. Also, juvenile teeth, if present, may not have been selected for the test sample because they displayed poor preservation.

The high number (15%) of very mature seals, fifteen years old and over, may suggest they are slower etc. and easier to hunt. These seals may have been close to a natural death from old age or disease since eight of the nine Phillip's Garden's specimens were twenty years old. Another possible interpretation is that the older seals represent the scavenging of carcasses on the ice or washed ashore.

Scavenging of carcasses may have taken place during periods of limited seal availability caused by natural events such as ice conditions, changes in migration routes and arrival time. I believe it is a valid assumption that all potential resources will be utilized during periods of diminished resource availability. The palaeoeskimo groups at Port au Choix would probably exploit the first large fresh meat source available in winter/spring whether a natural carcass or a killed one.

The limited age profiles for Phillip's Garden and Phillip's Garden East indicate an overwhelming preference for mature seals. If half of the immature/mature category are considered to be immature that would increase the number of immature seals to approximately 25% of all seals taken. A predominance of mature seals would be expected during a spring hunt on the ice. The mature females would be readily available during whelping while mature male and females would be vulnerable during the moult.

CHAPTER 8 CONCLUSIONS

The objectives, of Hypotheses 1 and 2, to test the aging and season of death techniques utilizing harp seal dentine annuli were achieved. However, the results were limited and did not met the original expectations of the research project. The vast variation in the formation rate of translucent dentine and the lack of adequate technology to decipher the translucent formation pattern prevents positive separation of the two migration periods. The poor preservation of dentine and the numerous mature age specimens prevented accurate aging and last annuli interpretation of the Port au Choix archaeological specimens.

Modern Harp Seal Canine Sections

Hypothesis 1. Accurate age and/or season of death estimations can be determined from canine dentine incremental growth layers for modern harp seals (*Phoca groenlandica*).

1) Aging

The harp seal does meet the conditions stated by Buie (1986) that are required for a species to be aged by incremental structures. The time of birth, tooth eruption sequence, and period of incremental line formation are known for harp seals. Annuli counting starts from the neonatal line that is formed at birth.

Numerous studies have established canine dentine incremental growth layers as an accurate and valid technique for aging harp seals. This research project's results with known age specimens supports the technique's validity. But as noted in other studies and this research project the reliability decreases with increasing age of the specimens. The increasing compression of each additional dentine layer makes it difficult to discern all the annuli and requires multiple readings.

However, there are a number of methods available to enhance the annuli's readability. These methods include:

a) training and experience of the reader;

b) staining of the annuli;

c) using polarized transmitted light;

d) wetting the section with alcohol (Sergeant and Pimlott 1959), oil or colourless nail polish (Wolfe 1969); and

e) using filters with the microscope such as a green filter (Turner 1977) or barrier and exciter filters (Hemming 1969).

2) Season of Death Estimations

Presently it is not possible to obtain a complete seasonal, monthly, weekly or daily dentine developmental sequence. The available sequence is based on when the three IGLs are formed. These IGLs are:

1) interglobular layer formed in April to early May;

2) an opaque layer formed May-June; and

3) a translucent layer formed June/July-February/March.

One problem with analyzing the dentine development is trying to impose human seasons, that are eventually defined by an arbitrary twelve month calender, on a natural event. The translucent dentine's developmental period spans nine months that includes the seasons of summer, fall, winter and spring. The difficulty is how to isolate the particular developmental segment associated with a human activity such as a middle winter hunt that has no bearing on the dentine's development. There is no reason to expect the dentine to display a marking flag to reflect this hunt.

The translucent dentine developmental sequence from December and April is required to provide constructive data for the Port au Choix archaeological sites. If this sequence can be deciphered then, for archaeological specimens, the two migration periods can be separated and the time of death within the two periods can be estimated. This time of death information can be used to derive culling patterns and highlight any changes between or within the migration periods. Identifying harp seals killed in December/January would extend the period of occupation at Port au Choix into the middle winter period from the known late winter to spring period.

However, the modern specimens studied for this period displayed too wide a variation in rate of layer development to create a percentage of development chart. The December and January rate was between 30-100% of that expected based on the previous years translucent layers. Also, Fisher's (1954) study of 1500 January killed seals indicated that the translucent layer was barely visible. This vast variation makes it pointless to construct a monthly or season dividing developmental chart. Therefore without this chart the translucent layer can not be separated into the late winter and middle winter periods.

This division of a season into late, middle and early highlights another problem that was encountered with this project. That is what defines a season? Renouf (1993, 1994a, 1994b) does not clearly define what time period is represented by her seasons. Two examples are that late summer is considered to be July/August when the Great Auk is available and seal fetal material indicates spring. Seals are born in late February to early March and would indicate a late winter time period rather than spring. Also, what would be early and middle summer if July/August are late summer? Therefore, clearly defined seasons must be included in any discussion of seasonality to permit the reader a comprehensive understanding of the author's interpretation or problem.

The one method that might separate the translucent layer into season divisions or smaller developmental periods is pattern of development. Determining a pattern of development is required rather than a rate of development that varies between years and individuals. The three IGLs have been shown to develop within a regular time frame regardless of their developmental rates. It is highly probable that the secondary annuli visible within the IGLs also follow a predictable pattern of development.

A possible solution to deciphering the developmental sequence is computer programs. The density image of a profile slice across the canine section holds promise for understanding the sequence. Using sufficient magnification on a thin, stained section will highlight the density peaks and troughs that can be recorded. The printout would then be compared to an image of the section to interpret the developmental sequence.

One approach to reduce the amount of data to analyze would be to concentrate on the translucent dentine layer in an attempt to isolate the southward migration period. Canines from December/January killed seals would have density slices taken for their translucent layers. Each translucent layer's density printout would be compared to the other ones for a single individual to determine any signs of patterning.

The test density slice printout conducted for this thesis displayed density variation within the separate IGLs thus indicating secondary annuli layering within an IGL. A regular and predictable pattern of these secondary annuli should be evident in all the translucent annuli. This pattern should be distinguishable even in the highly compressed annuli of older seals. Once the pattern is identified then it would be possible to recognize the period of development associated with the downward migration. The identification of winter killed seals from archaeological collections would become possible from density slices of the last deposited translucent layer. Unfortunately, this technique was not sufficiently developed to be utilized in this research project.

Archaeological Harp Seal Canine Sections

Hypothesis 2. Accurate age and/or season of death estimations can be determined from canine dentine incremental growth layers of harp seal (*Phoca groenlandica*) archaeological specimens based on a modern baseline sample.

1) Aging

Archaeological specimens displayed annuli in various degrees of clarity. The well preserved dentine was identical in appearance to modern dentine and the annuli could be counted. Unfortunately all specimens displayed some degree of dentine decomposition. This decomposition made the vast majority of the thin sections unreadable or partially readable. The solid section of the canine showed more annuli and most of these sections permitted age estimations.

The problems associated with constructing age composition profiles from the Port au Choix archaeological material are:

a) Death Population

It is uncertain whether the canine based seal faunal population represents the death population or a representative proportion of the death population. However, based on material from Feature 2, Phillip's Garden site, it is probable that the canine material does not represent the death population. The seal head material in the subfeatures of Feature 2 represented about half the number of individuals indicated by other body elements.

b) MNI Required

The requirement to have an MNI of 25 or more to construct a meaningful age composition profile is not met. However, if the canine material represents all the faunal material in a discrete deposit then the age composition profile is meaningful and valid regardless the MNI. A small family group may not require 25 or more seals to maintain themselves during their seasonal occupation of the site. It must be remembered that a mature seal weighs between 80 and 180 kilograms.

c) Discrete Deposition

It is presently unknown whether the discrete deposits at Port au Choix represent daily, weekly, seasonal, yearly or multi-year deposits. If they do represent seasonal, yearly or multi-year deposition then any variation in mortality/culling patterns within or between seasons and years will be masked because the entire faunal remains are considered as a single deposit.

d) MNI Comparisons

Presently, none of the faunal collections for Port au Choix units/features have been analyzed to compared body part MNIs and age groupings. Any differences between body parts and age groupings might reflect environmental differential preservation or human butchery and carcass treatment practices.

e) Taphonomy

The effects of natural and human factors on seal remains have yet to be studied. Some of these factors are:

1) the effects of mechanical action of the freeze thaw cycle on all seal remains but particularly juvenile material;

2) did palaeoeskimos process seal carcasses by drying, boiling, cooking or storing in oil and what impact do these processes have on the associated bone; and

3) did certain body parts such as heads receive special treatment that would effect the preservation and recoverability of teeth?

f) Culling of Animals

The harp seal herd's composition is known to change throughout the winter to spring period. Mature seals arrive first on the southward and northward migrations. Whelping females and juveniles spend more time on the ice than males or immature seals. Males and immature seals depart first on the remainder of the northward migration with mature females departing a few weeks later. Juveniles remain the longest with some stragglers there until June-July. This variation in harp seal availability should be reflected in the death population unless a selective culling pattern was followed. However, the ability to cull certain seals is depended on the time of year, the availability of age groups and the hunting techniques utilized and the desired results. The actual seal hunting techniques of the Groswater and Dorset Palaeoeskimos are unknown.

g) Treatment of Carcasses/Bone

It is probable that the carasses/bones were not treated or utilized in the same pattern within a single season, between seasons, between years and between individuals. Greater utilization of the entire carcass at the begining and end of the hunting season and in years of low seal population numbers is probable. This could result in different butchery practices including the complete carcass brought to the site instead of prelimanary butchering on the ice.

The size of the seal may influence whether the seal is brought back whole or in sections from the ice. Removing the head and gutting (at least the loss of blood) the seal would greatly reduce the weight and facilitate the dragging of a carcass across the ice. A reduction in the potential 180 kg. weightis particularly likely in the case of a single hunter dragging the carcass any distance.

Any Port au Choix seals whose heads were left on the ice cannot be accounted for by the canine method. This reenforces the need for a comparision of MNIs based on canines and other seal faunal remains. Similar MNIs would indicate that the canines reflect the actual number of seals for that location/feature.

h) Cultural Practices

We lack an understanding of the cultural systems that produced the Port au Choix archaeological sites. It is possible that the residents followed ritual practices concerning the first seals of the season. These seals may have been differently butchered and utilized than the subsequent seals harvested.

Port au Choix Harp Seal Age Composition

The seventy-three canines produced a maximum MNI of 68 for the entire sample. This was divided into a MNI of 54 for the Dorset Palaeoeskimo site of Phillip's Garden and a MNI of 14 for the Groswater Palaeoeskimo site of Phillip's Garden East. The composition of the total sample for each site was interpreted because the MNIs per level etc. were too small to construct meaningful age composition profiles.

The only method that could provide an age estimate for all canine samples included thin section, solid section, pulp cavity size and total dentine thickness. This approach provides an estimation of actual age which can separate the sample into juvenile (young of the year), immature,

immature/mature, mature and very mature age categories.

The Phillip's Garden and Phillip's Garden East samples produced similar age profiles. Neither sample contained any juveniles and the majority of the seals were mature and very mature. The Phillip' Garden sample comprises largely mature seals with only 15% under the age of three and about 56% over the age of seven. Phillip's Garden East shows a similar pattern with 14% under the age of three and 65% over the age of seven. Also, both sites contained about 15% very mature seals over the age of 15.

Reasons for no juvenile and few immature seals being represented in the sample are:

1) Mature females whelping on the ice and mature males and females moulting on the ice were more accessible than immature seals.

2) A preference for mature animals because of more meat etc. return for energy expended in the hunt.

3) Poor preservation of immature faunal material but the immature faunal material was reasonably well preserved. The good condition of immature seal teeth would indicate that they could survive equally well as mature specimens.

4) Older very mature seals were easier to hunt because of age, slower speed or illness.

5) Immature seals were harvested by harpoon or net later in the season when the mature seals had returned to the water. This is supported by the last annuli in four immature seals

which implies later season kills. Also, immature seals would likely be easier to hunt or net in open water than larger mature seals. During the late season other food sources (fish, birds) and stored seal meat would be available thus reducing the dependence on fresh killed seals.

6) The high number of very mature seals could represent the scavenging of carcasses from the shoreline or ice. That is the inhabitants could be taking advantage of the natural attrition of the herd. They would be getting the maximum return for the least energy expended. Also scavenging may be required when seal numbers were low due to ice conditions. It is known that during periods of limited ice a portion of the herd will whelp off Labrador.

2) Season of Death Estimations

Four specimens had last annuli that permitted a time of death estimation. However, season of death estimations between southward and northward migrations was not possible without a modern sequence. The three IGL sequence can help to identify late season (May-June) kills by the development of the opaque IGL. Two immature specimens provided readable last annuli that indicate this time period. Two other specimens displayed apparently full translucent layers that imply late winter to spring.

Season of death estimates would not have been possible for any of the other sixty-eight specimens even if a sequence

chart existed for the translucent dentine. The last annuli were difficult to distinguish for two reasons:
1) The last annuli area along with the first deposited dentine suffered from decomposition in most specimens.
2) The majority of specimens were from mature and very mature individuals. The compressed nature of the last annuli made it difficult to clearly distinguish it and impossible to determine the size.

Based on modern harp seals, it is highly probable that harp seal migration periods, herd locations etc. have varied over time. Harp seals are not a static entity but respond to changing factors such as in ice conditions and food supply. The present herd migrates earlier and spreads further as the herd size increases and food supply decreases. But the developmental sequence probably stays within the overlapping range outlined by Bowen *et al.* (1983). The periods for IGL development overlap which likely covers any variation in the prehistoric developmental sequence.

Season of Death/Aging Problems

The problems encountered in determining age and season of death are:
1) The dentine was in a fragile state and caution must be exercised during the production of a section to prevent any destruction of the last annuli.
2) There is variation in morphological and morphometric

characteristics over space and time. Thus creating variations between locations and/or within a location over time.

3) There is variation in IGL's width between individuals and within an individual.

4) Presley's (1984) work with ringed seal canines highlighted the need to have a complete modern baseline sample before devising a developmental chart.

5) A large modern baseline sample is required to account for all the possible individualand/or yearly variations in dentine development.

Future Research

The following are suggestions for further investigations of this technique on harp seal canines:

1) The image density program should be investigated further.

2) Thin sections should be avoided for archaeological specimens. The tooth should be sectioned first and examined to determine the quality of the dentine before a thin section is attempted.

3) When making thin or solid sections the least damaging equipment must be used.

4) Archaeological specimens should maintain the moisture content they contained when excavated until sectioning.

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RESEARCHING THE EARLY HOLOCENE OF THE MARITIME PROVINCES

By

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ABSTRACT

This thesis features a review of the early Holocene period in Maritime Provinces prehistory. A reexamination of regional collections, paleoenvironmental evidence, and comparative archaeological information from the State of Maine has lead to the development of a new model for early Holocene occupation of this region. The new model replaces the former "Great hiatus" model which proposes a 5000-year gap in the cultural sequence (10,000-5000 B.P.). Implications of the model for interpreting regional cultural development, and for future research strategies are also addressed.

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CHAPTER 1

INTRODUCTION

The primary objective of this study is to develop a model of early Holocene occupation of the Maritime Provinces. The cultures of the Archaic Period in Northeastern North America are believed to represent hunting, fishing, and gathering adaptations to the early post-glacial environment ca. 10,000-3500 B.P. Although the Archaic Period in the Northeast is usually divided into Early, Middle and Late manifestations (Funk 1978), researchers working in the Maine/Maritimes region have grouped the Early and Middle Archaic periods together to represent the time period between 10,000-5000 B.P. (Sanger 1979; Tuck 1984). In the prehistoric culture sequence of the Maritime Provinces there are no professionally excavated sites dating to the Early and Middle Archaic Period. This is problematic when we consider the significant evidence of earlier Palaeoindian and later Archaic and Ceramic Period cultures. Until the last couple of decades, this apparent hiatus in the archaeological record was a shared characteristic of all the Northeast and led to a variety of explanations and hypotheses by numerous researchers (Fitting 1968; Ritchie 1965; Sanger 1979; Tuck 1984).

Early and Middle Archaic complexes have been known from both Southern New England (Dincauze 1976; Ritchie 1985) and Labrador (McGhee and Tuck 1975; Renouf 1977; Tuck 1975) for the last twenty years. In the State of Maine it has only been in the last ten years that archaeologists have discovered and excavated sites of this antiquity (Petersen 1991; Petersen et al. 1986; Petersen and Putnam 1992; Sanger et al. 1992). The recent research in Maine has demonstrated that the hiatus has persisted because of several factors, including noncompatible survey techniques and unrecognized diagnostic artifact forms in existing collections. The excavation of well dated sites and recognition of diagnostic artifacts from this period (Petersen 1991; Petersen and Putnam 1992; Robinson 1992, 1996; Sanger 1996; Sanger et al. 1992) has led to the formulation of the Gulf of Maine Archaic tradition and the elongation of the Moorehead burial tradition by Robinson (1987, 1992, 1996). In the Maritimes, except for one paper (Deal and Rutherford 1991), there has not been any serious investigation of the Early and Middle Archaic period, even with all the apparent evidence from neighbouring areas.

In a preliminary survey of Archaic artifact forms in Nova Scotia, Deal and Rutherford (1991) have shown that a substantial number of diagnostic Archaic artifacts indeed occur. They also point out that the Gaspereau Lake collection, excavated in the 1960s by John Erskine (1967) and now housed at the Canadian Museum of Civilization, contains a significant Middle Archaic component. In New Brunswick, although a few isolated Middle Archaic style projectile points have been reported (Deal 1984; Tuck 1991), the existing collections have not been examined. It is also likely that previously published reports contain reference to artifacts that have been misinterpreted as belonging to more recent cultural manifestations.

Research Objectives

The main focus of the present research is to examine existing collections in New Brunswick and Nova Scotia, and to reexamine the Archaic component of the Gaspereau Lake site in order to develop a model of early Holocene occupation for the Maritime Provinces. This model will then be used to address the existing hypotheses that have focused on explaining the lack of archaeological evidence from this period. This is the first attempt to review existing evidence for this period and will provide a working base upon which to build future research.

The specific goals of this thesis are:

1. To devise a working model of the Early and Middle Archaic cultural manifestations in the Maritimes. Evidence will be based on information on the early Holocene environment, the Gaspereau Lake site assemblage, and collections from New Brunswick and Nova Scotia.

2. To compare this model of cultural manifestations to earlier hypotheses for a low population threshold during the Early and Middle Archaic Period and to the proposed Gulf of Maine Archaic tradition; to assess its implications for interpreting early Holocene developments in the Maritime Provinces.

CHAPTER 2

HISTORY OF RESEARCH

In the literature concerning the archaeology of the Maritime Provinces the Early and Middle Archaic Period is only briefly mentioned, described as an occupational hiatus inferred from the lack of archaeological remains (Sanger 1979; Tuck 1984, 1991). However, in neighbouring Maine, recent research and excavations have shown that a similar occupational hiatus model is no longer valid. This has stimulated much research including the proposal of both a technological tradition and burial complexes for the occupants of Maine and adjacent areas during the early Holocene. This chapter will explore the history of research in the Maritimes, Maine, and introduce the currently proposed models.

Research in the Maritimes

In the prehistoric chronological sequence for the Maritime Provinces the Early and Middle Archaic Period is known as the "Great Hiatus" (Tuck 1984). This is reflected in the amount of literature dedicated to this period. Although few sources exists, those that do include: previous excavations that have been recently revised, artifacts from private collections that are similar to early Holocene forms from other regions, and hypotheses to explain what has been perceived as a hiatus in occupation during this period. It is the latter that has been given the most attention.

Recently, two previously excavated sites in the Maritimes have been re-interpreted as having assemblages that date to the Early and Middle Archaic Period. Sanger (1996) has reported artifacts that he uncovered in 1967 near the town of Meductic, along the St. John River in New Brunswick, could be of Middle Archaic age. This is based on morphological similarities to artifact forms from Maine of that antiquity, since the single radiocarbon sample in association with the artifacts returned a modern age. These artifacts were buried within fluvial deposits below the plowzone in an area that is still accessible today (Sanger 1996:23).

In Nova Scotia the Gaspereau Lake site (BfDd-5) has also been reinterpreted as containing evidence of Early and Middle Archaic Period manifestations. Originally excavated by avocational archaeologist John Erskine in 1965 (Erskine 1967), several researchers have since pointed out the similarities between some of the projectile points found in the assemblage to Middle Archaic forms from Southern New England (Deal and Rutherford 1991; Keenlyside 1984b, slide 7). The reexamination of this collection is part of the present study and will be discussed in further detail in Chapter Four.

Certain projectile points forms found in private collections from the Spednic Lake area of southwestern New Brunswick are also indicative of an Early and Middle Archaic occupation. Both Deal (1984) and Tuck (1991) have pointed out the similarity between two contracting stemmed projectile points in these collections to 'Stark' style points that have been dated between 7600 to 7000 B.P. at the Neville site in New Hampshire (Dincauze 1976). This has led Tuck to speculate that "the Maritimes, therefore *appear* to be at the northern end of the distribution of small human groups who occupied the Northeast following the disappearance of Paleoindians" (1991:39, emphasis in original).

Most of the attention given to the Early and Middle Archaic Period has focused on possible hypotheses to explain the lack of archaeological evidence from this period. One of the most popular hypotheses is informally known as the "Ritchie-Fitting Hypothesis" (Petersen and Putnam 1992:15), named for its two leading proponents (Ritchie 1965; Fitting 1968). The Ritchie-Fitting hypothesis, or variants thereof, explains the gap in the archaeological record as being the result of the low biotic productivity of a Boreal type environment, analogous to that found today in the subarctic. This "unproductive" environment resulted in a low population density, that is inferred from the scarcity of remains from the Early and Middle Archaic Period. Fitting states that "People were probably present in the boreal forest, but with such a low population density that contemporary archaeologists find only the faintest traces of their presence" (1968:441). Although this was originally proposed to explain the lack of sites in Southern New England, and elsewhere westward to Michigan, researchers have applied it to the Maine/Maritimes region as well (Sanger 1979; Snow 1980; Tuck 1984, 1991). Sanger initially supported this theory pointing to pollen diagrams from central Maine that indicated a distinct shift from a conifer-hardwood forest to one with more hardwood trees ca. 5000 B.P.; this type of forest is thought to have increased the browse habitat suited to deer (1979:30), therefore increasing the population of people that relied on that resource.

Over the last couple of decades research has continued to question this hypothesis. In the mid 1970s, the Neville site in New Hampshire provided an Early and Middle Archaic sequence for Southern New England (Dincauze 1976). Research in Maine during the last decade (Petersen 1991; Robinson et al. 1992; Sanger 1996) also indicates that this hypothesis is no longer valid in Northern New England. Stemming from their research, Petersen and Putnam believe that there is no overwhelming evidence that suggests unfavourable environmental conditions for human habitation during the early Holocene, and that it may have been more favourable than later periods (1992:20). Sanger has changed his earlier stance as well, stating that claims for the presence or absence of Early Archaic populations based on the forest communities need to be revised (Sanger et al. 1992:158).

David Sanger has also proposed two hypotheses suggesting that the marine environment could not support a significant population. This first hypothesis proposes that the Bay of Fundy/Gulf of Maine was to shallow too allow for the circulation of sea water, which led to a suppression in marine resources (Sanger 1975). Although the history of the tidal amplification and relative sea level rise in the Bay of Fundy has been addressed (see Turnbull 1988 for overview), their effect on the availability of marine resources has not. It has also been pointed out that this hypothesis does not take into account sites along the Atlantic coast of the Maritime provinces (Tuck 1984:15).

Based on the high correlation between large prehistoric sites and productive fishing locations, Sanger has also proposed the "River Gradient Hypothesis" (Sanger

1979). This hypothesis suggests that with lower sea levels during early Holocene times, the gradient of certain rivers may have been too steep for certain "weak fish species" to ascend. As sea levels rose, these features were drowned out, therefore encouraging the migration of fish populations and the people who relied on this resource (Sanger 1979:30-32).

What might be termed the "Drowned Site Hypothesis" has been proposed by Tuck (1975, 1984, 1991) to explain the scarcity of Early and Middle Archaic sites in the Maritimes. This hypothesis is based on the belief that the coast supported populations throughout the Archaic Period, but that evidence for these occupations has been erased by rising sea levels. This theory stems from his research in Labrador where the land is actually rising, causing sites that were located on the coast during the early Holocene to be well away from the shoreline today, and safe from coastal erosion. The land in the Maritimes is slowly sinking about 30 centimeters per century, relative to sea level rise (Grant 1975; Shaw et al. 1993; see Chapter 3 for more in-depth discussion). This would result in sites located along the coast during the early Holocene to be inundated by the rising sea levels.

Using the Drowned Site Hypothesis to explain the lack of evidence of an Early and Middle Archaic occupation in the Maritimes, Tuck has proposed the "North Eastern Maritime Continuum" (1975). This continuum suggests that there was a biological, cultural, and linguistic continuity in the Maritimes from Palaeoindian times until the present day. He contends that once populated, the Eastern North American coastal plain was never abandoned (Tuck 1975:140). Further validity of this hypothesis is supported by comparing Labrador and the Maritimes (Tuck 1991). Evidence from southern Labrador and adjacent Quebec suggests that the late Paleoindians and Maritime Archaic people lived and 'flourished' on the resources of the sea coast with their backs to a forest (Tuck 1991:41). Although Tuck warns that the amount of systematic surveys done in the interior of both Labrador and the Maritimes is not great, with what has been done, little has been found. If the coast of Labrador had been submerging rather than rising since early Holocene times, no archaeological evidence would exist for any but the most recent sites (Tuck 1991:41).

The Drowned Site Hypothesis has been criticized both on the basis that sites cannot "be *shown* to be eroded away, a virtually impossible thing to demonstrate" (Sanger 1979:27), and by the recently excavated early Holocene sites in Northern New England. In the State of Maine there are 22 sites that have been recently reported to date between 10,000 and 5000 B.P. Seventeen of these are situated along inland rivers.

Lastly, the "Data Too Incomplete" hypothesis has been proposed by Sanger (1979). This hypothesis suggests that a lack of systematic surveys of the interior portions of Maine and the Maritimes is responsible for the absence of evidence for Early and Middle Archaic occupations. This hypothesis holds that interior sites exist but the evidence has been washed away, or that pre 5000-year old artifacts are unlike contemporary forms from Southern new England. Sanger, however, cautions that collections containing 1000's of artifacts have been inspected, from both coastal and inland sites, and do not contain artifacts similar to contemporary early specimens. Part of the current research will be to show that this is not the case. This thesis will attempt to demonstrate that certain classes of ground stone artifacts that have recently been characterized as diagnostic for the newly proposed occupational models for Northern New England do exist in the regional collections in the Maritimes.

It should be noted that the previous occupational hiatus hypotheses were not primarily intended to stand on their own and that several explanations, or combinations of explanations, are possible (Sanger 1979:32; Tuck 1991:40). This thesis will present new evidence of Early and Middle Archaic occupation in the Maritimes, and reconsider the applicability of the previous hypotheses. This new evidence is based on the recent research in Northern New England, and especially in Maine.

Research in Maine

In the last decade there have been 57 radiocarbon essays reported from 22 sites dating ca. 10,000-5000 B.P. in the State of Maine. Seventeen of these sites (77%) are situated inland on relatively deep riverine alluvium (Petersen and Putnam 1992). The results of this research have been published, including their implications generally (Petersen and Putnam 1992), site reports (i.e. Bunker 1992; Maymon and Bolian 1992; Petersen 1991; Sanger 1996; Sanger et al. 1992), subsistence studies (Spiess 1992), and mortuary and technological patterning (Robinson 1987, 1992, 1996).

The assemblages of two of these sites, Brigham and Sharrow, have been the most comprehensively published (Petersen 1986, 1991; Petersen and Putnam 1987, 1992; Petersen et al. 1986, 1988). These sites represent the longest chronology and best separated deposits attributable to the early Holocene in Northern New England and are the basis for most of the current interpretation and research. Both sites are located near the confluence of the Piscataquis and Sebec rivers in Milo, Piscataquis County, Maine (Figure 1). Testing has revealed that cultural deposits extending two meters below the modern ground surface, in deep alluvium, preserved a cultural sequence of approximately 10,300 and 9500 years in duration for the Brigham and Sharrow sites respectively (Petersen and Putnam 1992:27). Cultural remains from the sites include both lithic assemblages, as well as small faunal assemblages containing bone and antler tools.

The lithic assemblages of the Brigham and Sharrow sites are made from locally or regionally available stone, reflecting a limited degree of long-distance acquisition of material. Flaked stone tools are characterized by a core and uniface technology. Bifaces of any kind are rare in the early pre-5000 B.P. deposits, suggesting that early populations did not employ lithic biface technology to the same degree as in later times. The paucity of bifaces is also a feature of the other early Holocene radiocarbon dated sites in Maine and various other suspected early, but undated, sites (Petersen and Putnam 1992:37). Ground stone tools are relatively diverse and are considered the earliest known in the broader Northeast. They include choppers, celts, full-channeled gouges, ground stone rod

Figure 1. Location of sites mentioned in the text: 1) Neville/Table Land; 2) Morrill Point; 3) Wadleigh Falls; 4) Weirs Beach; 5) Turner Farm; 6) Brigham/Sharrow; 7) Blackman Stream; 8) Spednik Lake/Mud Lake Stream; 9) Gaspereau Lake.

fragments, ground slate points, and plummets. Of these tools, it is only the choppers that are known from other early Holocene sites in the Northeast. Gouges, small chisel celts, stone rods, and plummets may be unique to the Gulf of Maine Region by 8000-6000 B.P., relative to other portions of the Northeast (Petersen and Putnam 1992:49).

Evidence of a bone and antler tool technology from the Brigham and Sharrow sites is one of the earliest from the far Northeast. Calcined manufacture scraps of grooved and split longbone fragments, as well as one questionable tool fragment, have been identified from Feature 10, Stratum IV, and dated to ca. 8500 B.P. at the Brigham site (Petersen and Putnam 1992:43). At the Sharrow site over 60 individual fragments of calcined bone tools have been recorded from Features 16 and 17, dated ca. 6000-5800 B.P. These include a barbed antler point, an awl or point tip, a tool blank, the end of a notched antler artifact, a ground beveled shaft fragment, a perforated bone needle, and scraped shaft fragments (Petersen and Putnam 1992:42-43: also see Figure 16). It is due to the calcined nature of the faunal assemblages from the Brigham and Sharrow sites that any remains are preserved.

Using the information from the excavated sites, as well as reanalyzing existing collections, Robinson has proposed a model of technological and mortuary patterning for the early Holocene Period in Northern New England (1987, 1992, 1996). This model, the Gulf of Maine Archaic tradition, is defined as a broad technological pattern, while the Morrill Point and Table Land complexes, of the recently revised Moorehead burial tradition, represent the mortuary patterning during this period.

The Gulf of Maine Archaic

Both technological and burial traditions have been proposed by Robinson (1987, 1992, 1996) for the occupants of Maine and adjacent areas during the early Holocene. The Morrill Point burial complex and Gulf of Maine Archaic tradition have been proposed "as preliminary units for structuring the growing body of evidence for Early and Middle Archaic Period occupation in Northern New England" (Robinson 1992:63). The Morrill Point burial complex, and the recently added Table Lands complex (Robinson 1996), are dated ca. 8500-7000 B.P. (Robinson 1992:64). The Gulf of Maine Archaic tradition, a regional technological tradition, has been tentatively dated ca. 9500-6000 B.P. (Robinson 1992:64).

The Gulf of Maine Archaic tradition is defined only as a broad technological pattern that shows continuity through time, not as a whole culture unit (Robinson 1996:104). This tradition spans the Early and Middle Archaic Periods (ca. 9500-6000 B.P.) over the geographic area that includes the watershed of the Gulf of Maine between New Brunswick and the northern shore of Cape Cod in Massachusetts (Robinson 1992:96). Assemblages are characterized by three broad patterns: a flaked stone industry dominated by core, uniface, and flake technology; a relatively minor role for bifaces and flaked stone projectile points; and the early development of a diverse assemblage of ground stone tools, including ground stone rods, full-channeled gouges, celts and adzes, among other forms (Robinson 1992:96).

While some regional variation in materials occurs, it is local high quality quartz and quartz crystal that are selected for the uniface/core flake technology. This technology is characterized by steep-edged quartz unifaces, irregular cores, flake tools, blocky fragments, and flakes (Robinson 1992:96). The selection of quartz for this technology is considered one of the most characteristic attributes of the early assemblages. The high quality of material combined with the small size of some of the cores has led Robinson to speculate that it could represent a microflake technology, perhaps for the production of insets for organic hafts (Robinson 1992:97).

Bifaces are scarce in the tool assemblages of the Gulf of Maine Archaic and when they do occur they are often large, thick and partly unifacial (Robinson 1992:98). The lack of evidence for associated reduction sequences and the low number of bifaces in tool assemblages, has led Robinson to propose that they were not systematically employed as projectile points (Robinson 1992:98). Most of the projectile points associated with this period have been found in mortuary contexts and do not fall into clear cut typologies. The early development of woodworking tools in the Gulf of Maine Archaic tradition (see below), coupled with the low number of chipped stone projectile points, suggests that the Gulf of Maine Archaic tradition probably included a well developed technology in wood and bone (Robinson 1992:99-100). Projectile points made from wood and bone are suggested to be more advantageous for riverine and maritime hunting because the toughness of bone and wood barbs may be superior to the brittleness of sharp stone tangs when piercing and holding of prey is required (Robinson 1992:99).

The Gulf of Maine Archaic tradition includes a poorly defined, yet diverse, ground stone technology. It is comprised of miniature and full sized celts, adzes, full-channeled gouges, ground stone rods, whetstones, and possible ground slate tools (Robinson 1992:100). To date, artifact samples attributed to this period have been either small or imprecisely dated. Ground stone rods and full-channeled gouges are thought to be the most diagnostic artifact types. The earliest tool forms yet identified are the ground stone rods that have been dated ca. 9000 B.P. at the Weirs Beach site (Bolian 1980; Maymon and Bolian 1992; see Figure 1 for location). Full-channeled gouges have been dated ca. 8000-6000 B.P. (Robinson 1992:100). The diversity of forms and number of ground stone tools associated with the Gulf of Maine Archaic tradition suggests a heavy woodworking industry.

The Morrill Point and Table Land complexes of the recently revised Moorehead burial tradition correspond in time, and geographic region, to the Gulf of Maine Archaic tradition. The Moorehead burial tradition, until recently believed to be a Late Archaic phenomenon (5000-3700 B.P.), has been revised by Robinson (1996) to include the Early and Middle Archaic, extending it back to 8500 B.P. This was the result of reanalyzing most of the known mortuary assemblages (increasing the number of published assemblages from 25 to 37), more dating, and an increased attention to ground stone tools (Robinson 1996).

The continuity of the Moorehead burial tradition is based on the selection of artifact types, and the elaboration that is present on specialized mortuary artifacts. The copious use of red ochre, and the association of whetstones and newly sharpened woodworking tools being the most consistent characteristic throughout the Moorehead burial tradition (Robinson 1996:127). These similarities are said to extend the Moorehead burial tradition back in time without necessarily implying that a single culture is represented (Robinson 1996:98).

The Table Land burial complex, ca. 8500 B.P., is represented by a single site in Manchester, New Hampshire, and a small number of red ochre-stained artifacts from other locations. The Table Land site, located on a gravel ridge 100 feet (30 meters) above Amoskeag Falls (Figure 1), was salvaged by an avocational archaeologist in 1937 and later briefly mentioned in an *American Antiquity* article (Marshall 1942). The described site consists of a large red ochre-stained feature containing up to nine bone deposits at different levels, most of which included ground stone rods. Among other artifacts recovered were five complete ground stone rods and seven fragments representing at least four more, including two with expanding heads (Robinson 1992:99-100). Although there were no datable remains in the Table Land assemblage, a ground stone rod with an expanding head was found in a feature at the Weirs Beach site that dated to 8985 +/- 210 B.P. (Bolian 1980:125).

Recently, another red ocher deposit that had been excavated in the immediate vicinity of the Table Land site, by another avocational archaeologist in 1940, has been 'discovered' and documented (Robinson 1996:100-102). Although this 'deposit' did not contain any ground stone rods or diagnostic tools, it did contain charcoal and calcined bone. A piece of red ochre stained charcoal has recently returned an AMS radiocarbon date of 8490 +/- 60 B.P. (Robinson 1996:101), and the analysis of the calcined bone has resulted in the identification of both human and animal remains. Skeletal remains represent a middle aged female "... that had been cremated while still green and heavily stained with red ochre" (Sorg 1994:6, as quoted in Robinson 1996:102). The 35 fragments of animal bones are believed to represent a cremated bone tool kit that included, among other artifacts, a cut, gouge-shaped, bone shaft (see Robinson 1996:101-102 for a more complete description and photograph). This has led Robinson to speculate that the earlier ground stone rods may have been used to sharpen bone gouges, with the later ground stone full-channeled gouges being copies of the bone prototypes (Robinson 1996:102).

The Morrill Point burial complex, ca. 8000-7000 B.P., is represented by four multi-grave cemeteries, as well as isolated caches of artifacts that could possibly represent isolated burials (Robinson 1992, 1996). The two largest sites were excavated by experienced avocational archaeologists, and the other two were examined after being disturbed by gravel operations (see Robinson 1992 and 1996 for a more in depth description).

The Morrill Point burial complex is characterized by red ochre deposits containing full-channeled gouges, ground stone rods, and a variety of other ground stone tool forms. Bifaces are present in some cases but are not attributable to well defined regional types.

Cremations and non-cremation deposits occur with cemeteries being found on sand and gravel knolls and ridges, separate from occupation sites (Robinson 1992:94).

The most characteristic artifact types of the Morrill Point burial complex are the full-channeled gouges and ground stone rods. The gouges occur in two distinct forms: long parallel-sided gouges with deep rounded channels, and wide flared-bit gouges with full channels that are flat in cross-section (Robinson 1996:104-105). Variability in the form of the ground stone rods, usually in their end treatment, suggest multiple functions, but they apparently were meant to facilitate the sharpening of full-channeled gouges (Robinson 1992:91, 1996:105-106).

The Table Land and Morrill Point complexes of the Moorehead burial tradition correspond in time and geographic region to the Gulf of Maine Archaic tradition. It is the presence of ground stone rods with expanding heads, and the absence of both rods that are perforated and ground stone woodworking tools, that distinguish the Table Land complex from the later Morrill Point complex. Regionally, based on similarities in artifact forms and red ochre mortuary practices, the Table Land and Morrill Point burial complexes are believed to be broadly related to the early Maritime Archaic mortuary pattern of Labrador and Quebec (Robinson 1992:95).

It is both the Gulf of Maine Archaic tradition and the Table Land and Morrill Point complexes that currently represent populations in Maine during the early Holocene. These models have provided the structure of which the current research is built on. The first step of which is to review the environmental factors.

CHAPTER 3

ENVIRONMENTAL SETTING

The majority of the hypotheses proposed to explain the apparent occupational hiatus during the Early and Middle Archaic are based on environmental considerations, such as the environment not having the carrying capacity to support a significant population, or that rising sea levels have erased all evidence of a maritime-adapted culture who lived along the coast during this period. This chapter will look at the available evidence pertaining to the environmental setting of the Maritime Provinces during the early Holocene. First, the focus will be on reconstructing the terrestrial paleoenvironment using evidence from palynological studies, and comparing the results from within the Maritimes and regionally. Second, the focus will shift to the changes in the relative sea level and related effects on the geography of the Maritimes during the Holocene epoch. Lastly, implications for the present study will be discussed.

Paleoenvironmental Reconstruction

The paucity of Early and Middle Archaic archaeological remains from the Northeast, interpreted as an occupational hiatus, has led archaeologists to look for unfavourable environmental conditions during the early Holocene. Although this correlation has since been challenged elsewhere (e.g. Petersen and Putnam 1992), it has not yet been addressed for the Maritimes.

Paleoenvironmental reconstructions for the Northeast are, for the most part, based on palynological studies (e.g. Bradstreet and Davis 1975; Livingstone and Livingstone 1958; Livingstone 1968; Mott 1975a and 1975b; Sanger et al. 1977). In reconstructing paleoenvironments, palynologists attempt to correlate fossil pollen taken from ponds, lakes, and bogs to forest species at a particular time. There are, however, problems with this methodology, including the correlation of fossil pollen assemblages to climate (Terasmae 1973:203), the lack of radiocarbon-dated profiles for the Maritimes (Mott 1975b: 286-287; Sanger et al. 1977:462), and the correlation of fossil pollen studies with those of modern pollen rains (Livingstone 1968:87). Methodologies can also be biased by formation processes which create the pollen record (Butzer 1982:177-181). For a more general discussion of using paleoenvironmental reconstructions in archaeology see Dincauze (1987).

The limited amount of research, and problems inherent in the method, have made paleoenvironmental reconstructions of the early Holocene problematic. The available palynological evidence will be reviewed for both New Brunswick and Nova Scotia, as well as how they relate regionally. Only data available from the period representing the Early and Middle Archaic will be discussed (see Davis and Jacobson 1985, and Stea and Mott 1989 for discussion of the earlier environment and landscape).

The best paleoenvironmental evidence from New Brunswick is from two well dated pollen cores of lake sediments reflecting vegetational and climactic change since glaciation (Mott 1975b). Cores were taken from the Basswood Road Lake and Little Lake in southwestern New Brunswick (Figure 2) which possess pollen sequences that have been divided into nine zones reflecting changes in species diversity over time (Figure 3).

For the purpose of the present discussion only Zones 4 and 5 will be discussed. These zones represent the period ca. 9500-5100 B.P. (Figure 3), with Zone 5, dating ca. 9500-6500 B.P., and Zone 4 dating ca. 6580-5120 B.P. Zone 5 begins with a large two, to threefold increase in absolute pollen frequencies and pollen influx rates. This increase is caused by an invasion of pine (*Pinus*) along with a concomitant increase in birch (*Betula*) and other hardwoods, including a sparse occurrence of spruce (*Picea*). This is indicative of a change from an open to a closed forest type that lasted throughout Zone 5 (Mott 1975b:285). This mixed forest of pine with an abundance of birch, oak (*Quercus*) and a minor proportion of other hardwoods, including blue beech/ironwood (*Carpinus/Ostrya*), ash (*Fraxinus*) and maple (*Acer*), remained until about 6600 B.P. (Mott 1975b:284).

Zone 4 is defined on the basis of an abrupt increase to a maximum occurrence of hemlock (*Tsuga canandensis)* and subsequent sharp drop thereafter. During this time pine pollen gradually declined, as did oak, while some hardwood genera (beech, maple and ash) increased (Mott 1975b:284-285). This created a mixed forest of hardwoods with an abundance of hemlock, and some pine and maple. Hemlock played a prominent role until 5100 B.P., when it abruptly declined in abundance, while beech (*Fagus*) began to increase until it dominated the forest, along with birch, maple, ash, and various other hardwoods (Mott 1975b:284-285).

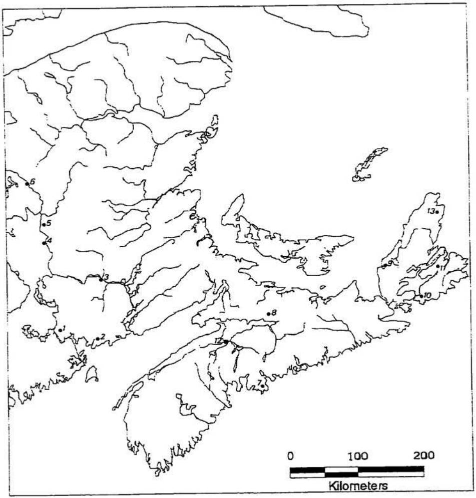

Figure 2. Location of sites used in paleoenvironmental reconstructions: 1) Basswood Road Lake; 2) Little Lake; 3) Fredericton Bog; 4) Hartland Bog; 5) Upper Kent; 6) Grand Falls Bog; 7) Bluff and Silver Lakes;8) Folly Bog; 9) Hillsborough Interstadial Deposit; 10) Gillis and Salmon River Lakes; 11) McDougal and Upper Gillis Lakes; 12) Shaws Bog; 13) Wreck Cove Lake.

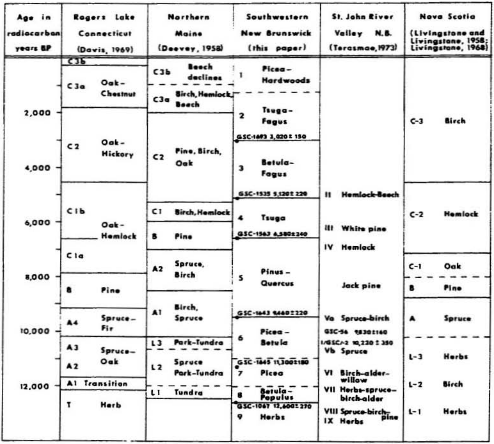

Figure 3. Palynostratigraphic correlations of selected profiles from Northeastern North America (After Mott 1975b).

Other data from New Brunswick include a sequence from the Saint John River Valley (Terasmae 1973), and undated sequences from the western part of the province (Mott 1975a). In Figure 3 zones II, III, and IV, given by Terasmae (1973) for the Saint John River Valley, are thought to be equivalent to Mott's zones 2, 3, and 4 (Mott 1975b:387). Four undated pollen sequences from sites located in the western part of the province (bogs in Fredericton, Hartland, Upper Kent, and Grand Falls; see Figure 2) are also similar to both the Basswood Road Lake, Little Lake, and the St. John River sequences. This indicates a general pattern in New Brunswick, with only slight variations within the sequences of specific localities.

The interpreted pattern for New Brunswick is that the increase in pollen deposited at the beginning of Mott's Zone 5, ca. 9500 B.P., indicates the beginning of a closed forest type with a warming climate. This warming continues until zones 4 and 3, when thermopholous hardwood genera are represented by greater amounts of pollen than any other time before or since (Mott 1975b:287). This abundance of hardwood is indicative of a climate warmer than present day, and is further indicated by the peak of hemlock ca. 5800 B.P. In comparison with other sequences from Northeast, Mott believes (1975b:284) the New Brunswick profile is similar to the sequence for Roger's Lake, Connecticut (Davis 1969), and that his Zone 5 is similar to the pine zone designated Zone B in all of New England (Mott 1975b:284). In an earlier study by Sanger (Sanger et al. 1977), Mott's data are considered equivalent to sequences from Maine. In a more recent study, Sanger has continued to point out the similarities between the paleoenvironments of Maine and New Brunswick (Sanger et al. 1992).

The most comprehensive paleoenvironmental study for Nova Scotia is the analysis of six pollen sections by Livingstone (1968), based partially on previous research (Livingstone and Estes 1967; Livingstone and Livingstone 1958). Pollen diagrams were constructed using samples from the Bluff and Silver Lakes, Folly Bog, the Hillsborough interstadial deposit, Gillis and Salmon Lakes, McDougal and Upper Gillis Lakes, and Wreck Cove Lake (see Figure 2). These samples were then divided into four zones (Figure 3), which were arranged temporally, based on a few radiocarbon dates and similarities between assemblages.

In the pollen profile for Nova Scotia, Zones A, B, and C represent the Early and Middle Archaic Period (see Figure 3). Zones A and B are characterized by high percentages of coniferous pollen, with spruce and fir being relatively more important in Zone A, while pine is more important in Zone B. Zone A is thought to be similar to diagrams from modern day Riviere de Loop in Quebec, which is three or four degrees of latitude north of Nova Scotia, suggesting that the climate was not as warm as present day (Livingstone 1968:123). Taken generally, Zone A is also thought to be similar to the A Zone for New England, but might not have ended at the same time (Livingstone and Livingstone 1958:353).

Zone B is defined on the basis of an increase in pine pollen, indicating a forest in which pine trees became dominant. This forest is thought to be analogous to that reported by Deevey (1951) from modern day Caribou Lake in Aroostook County, Maine (Livingstone 1968:123). In a comparison with other pollen diagrams, the Nova Scotia sequence is said to be stratigraphically, but not necessarily temporally, equivalent to the B Zone for Connecticut (Flint and Deevey 1951), and may not be vegetationally equivalent to the B Zone for Maine. These differences are based on how the B and C zones are defined in Nova Scotia, Connecticut, and Maine.

Zone C represents a mixed temperate hardwood forest comprised of oak, ash, maple, beech, and elm (*Ulmus*), along with hemlock. Zone C has been divided into three subsections at all localities (Livingstone 1968:123). These subzones reflect similar pollen changes, principally the development of a marked hemlock peak in C-2, at all Nova Scotia localities. This hemlock peak suggests a change in conditions that were somewhat moister than those which prevailed in C-1, and warmer than present day. Zone C-3 represents a decline in hemlock and other coniferous species, with birch becoming the dominant species. Comparing the Nova Scotian C zones to other pollen profiles, Livingstone states that they are stratigraphically equivalent to those of southern New England, but only as a group, not zone for zone. Compared to Maine, Livingstone and Livingstone (1958:355) state that although the C zones cannot be stratigraphically or temporally equated with those of Nova Scotia; however, the return of terminocratic species, particularly spruce and fir, in the upper part of C-3 suggest very strongly a stratigraphic correspondence between part of this zone and Deevey's C-3 (Deevey 1951).

Other paleoenvironmental evidence from Nova Scotia includes the analysis of plant macrofossils from Gillis Lake (Shofield and Robinson 1960), and the pollen stratigraphy of a peat bog in Hants County (Hadden 1975). The plant macrofossils from Gillis Lake were from the same deposits that Livingstone and Livingstone (1958) used to construct their pollen diagrams. The results of Shofield and Robinson's study was that the macrofossil record largely supports the conclusions made from the pollen analysis (1960:521). The results of Hadden's analysis of the pollen stratigraphy of Shaws Bog (see Figure 2 for location), however, resulted in some differences.

Although Hadden's Zone A is similar to other studies, Zone B from Shaw Bog is different. In her Zone B, pine does not increase significantly as it does in other profiles. Instead, this zone is delimited at the base by an abrupt drop in spruce and at the top by a sharp rise in hemlock (Hadden 1975:44). This trend is thought to be correlated with some sites in Nova Scotia and Maine, but not with the overall trend. Zone C, having two peaks of hemlock, is thought to indicate a greater correlation to Maine and Massachusetts than most Nova Scotia sites, but the first hemlock peak is contemporaneous with the peak elsewhere in the Northeast (Hadden 1975:45).

Palynological evidence from New Brunswick and Nova Scotia shows broad similarities, albeit with some incongruities. Differences may be accounted for by the lack of radiocarbon dates and how these zones are defined. For the Early and Middle Archaic Period Mott's sequence is based on four radiocarbon dates from two sites, while Livingstone's sequence is based on three radiocarbon dates from two sites. Looking at how the zones are defined, there is little vegetational difference between Mott's Zone 6 and Livingstone's Zone A, or Zone 5 and Zone B and C-1, and Zone 4 and C-2. Broad similarities include the change from open to closed forest type, as indicated by an increase in pine at the beginning of the Holocene, and a peak in hemlock ca. 5700 B.P. These characteristics are also shared with Northern New England. The latter is demonstrated by all of the available radiocarbon dates on the hemlock peak falling within a narrow range in Nova Scotia, New Brunswick, and New England (Mott 1975a:79). In all locations the peak in hemlock has been interpreted as representing a warmer period than today.

This trend also fits in with a warming trend throughout the Northeast. Bradstreet and Davis (1975) state that the available palynological data from New England indicate a possible xerothermic period occurring ca. 8500-6000 B.P., coinciding with the early portion of the Hypothermal. The Hypothermal is a period of postglacial warming extending from 8500-7500 to 4000-3300 B.P. A thermal maximum has been proposed for approximately 5000 B.P. There are several other paleoenvironmental indicators that denote a climactic optimum, or Hypothermal, generally occurring ca. 8000-4000 B.P One example is the analysis of foraminiferans in cores of sediments from the Atlantic Ocean, indicating a generally warm interval for the past 11,000 years, with a thermal maximum occurring ca. 7000-6000 B.P., after which temperatures declined irregularly to the present day (Bradstreet and Davis 1975).

While the evidence for a warming trend does not tell us that the Maritimes were occupied by humans during the early Holocene, it does indicate that environmental conditions were more favourable than previously believed. Similarities between paleoenvironmental reconstructions of locations in the Maritimes and New England, where there is indisputable evidence of an early Holocene occupation, is cause to re-evaluate previous environmentally deterministic hiatus hypotheses. The terrestrial biotic productivity of the early Holocene environment should no longer be considered a factor in limiting human subsistence. Another environmental factor which may have affected the archaeological visibility of Early and Middle Archaic populations are changes in the relative sea level.

Relative Sea Level

Change in the relative sea level and its effects on the geography of the Maritimes also affects our interpretation of the prehistoric archaeological record. During the early Holocene, the landscape was vastly different than today. In fact, it would hardly be recognizable. With much lower relative sea levels, ca. 9000 B.P., the Atlantic coast of Nova Scotia was up to 10 km seaward of its present position (Shaw et al. 1993), the Gulf of Maine was an inland sea (Kellogg 1988), and Prince Edward Island was connected to New Brunswick and Nova Scotia, only becoming a separate island ca. 6000 B.P. (Keenlyside 1983, 1984a, 1985a, 1985b, 1991).

Changes in the relative sea level are caused by many factors. Eighteen thousand years ago the earth's crust was compressed and deformed by the sheer weight of the Laurentide ice sheet. This pressure caused the mantle below the crust to flow outward around the edge of the ice, which in turn caused the earth to bulge around the circumference of the ice sheet. As ablation occurred and glacial meltwater flowed back into the oceans, global sea levels rose. Simultaneously, the crust that had previously supported the great weight of the ice sheet sprang back, with the viscous mantle creeping back under land previously depressed by ice, collapsing the bulge.

Changes in the relative sea level are produced by eustacy and isostacy simultaneously (Quinlan and Beaumont 1981:1154). Eustatic change is caused by the removal of water from or addition of water to the ocean's basins. The warming of the global climate in modern times is believed to be causing global sea levels to rise eustatically at a rate of approximately six centimetres per century (Grant 1975:83). When the weight of the water in the oceans, or the ice on land, deforms the crust and underlying mantle, it causes the crust to sink or rise isostatically relative to sea level. In the Maritimes excessive isostatic change, when compared to world-wide rates, is believed to be caused by subsidence of the earth's crust as a former glacier-marginal bulge collapses (Clark et. al. 1978; Grant 1970, 1975, Quinlan and Beaumont 1981). The bulge around the ice sheet parameter, caused by a displacement of sublithopheric mantle, is called a forebulge (Quinlan and Beaumont 1981:1148). The Maritime Provinces sit on such a forebulge and are effected by its collapse, as it slowly retreats towards the center of the former ice mass.

Change in relative sea level can be illustrated as a curve that is created from field observations. Such curves can be constructed by observing and dating markers that exhibit a known relationship to a past sea level. Marine markers may include such things as marine shells, driftwood, beached whale bones, peat beds, raised or submerged marine deltas, freshwater lake sediments containing marine deposits, or marine sediments containing freshwater deposits (Quinlan and Beaumont 1981:1160). There are, however, specific problems associated with indicators of past sea levels that have to be taken into consideration when constructing sea level curves (see Kellogg 1988 for a comprehensive review of the problems in the use of sea level data in constructing sea level curves).

Using 47 age and depth determinations, which include submerged tree stumps and other freshwater vegetation overridden by transgressing barrier beaches and buried beneath tidal marshes, supplementary evidence of drowned Indian campsites, colonial artifacts buried in tidal mud, and the rise of high tide at the historic site of Louisbourg, Grant (1975) constructed a relative sea level curve for the Maritime Provinces (Figure 4). Grant found that the resulting relative movement of the shoreline began with the sea being 75 m higher in the Bay of Fundy and Gulf of St. Lawrence when glaciers began to recede ca. 12,000-14,000 years ago. Since then, as the land rebounded from the weight of the glaciers, the coast emerged and sea levels appeared to fall for several thousand years. During the last 8000-6000 years the trend has been reversed with the sea rising, causing a renewed drowning throughout the Maritimes. Based on geological data from the past 4500 years, Grant has concluded that the Maritimes are being inundated at a rate of 30 cm per century (1975:97). This is perceived not as a single linear event, but a series of fluctuations with different localities submerging at different rates. The average world-wide rate of sea level rise is six centimetres per century. The excessive submergence in the Maritimes, being five times the world rate, is due to subsidence of the earth's crust as the former glacier-marginal bulge collapses.

The relative sea level curve for the Bay of Fundy, and Gulf of Maine, is quite different from that of the Maritimes. Figure 5 demonstrates the relative sea level curve for the Gulf of Maine, where 9000 years ago the sea level was approximately 65 m lower than modern levels, as compared to the maximum of 20-30 m for the Maritimes (Grant 1975). The additional water levels in the Gulf of Maine and Bay of Fundy are due to the amplification of the tidal range. This amplification has been caused by the rise in sea level which has widened and deepened their entrances, and optimized basin geometry. Studies on the development of the Gulf of Maine and Bay of Fundy tides have conflicting interpretations regarding the inception of tidal conditions and rates of amplitude change (Turnbull 1988:95; e.g., Grant 1970; Amos 1978; Scott and Greenberg 1983). Generally, relative sea level changed rapidly as the water level became deeper over George's Bank with comparatively quick and rapid development of tides (see Turnbull 1988 for a more in-depth discussion).

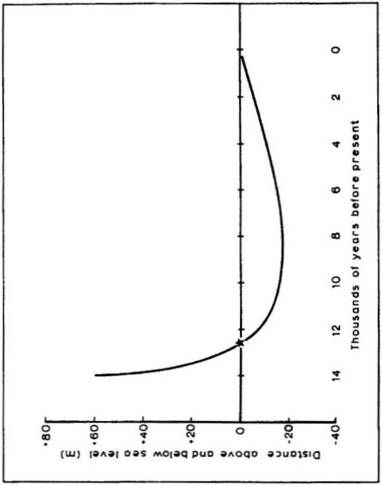

Figure 4. A relative sea level curve for the Maritimes Provinces generalized for the Bay of Fundy and Gulf of St. Lawrence (after Grant 1975).

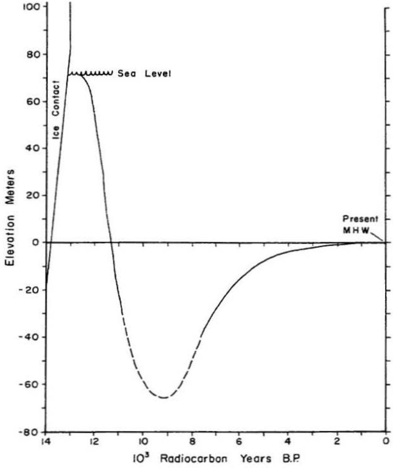

Figure 5. A relative sea level curve for the coast of Maine (after Sanger 1988).

Due to the location of the Maritimes on the periphery of the Laurentide ice sheet and its resulting forebulge, as well as other factors such as the development of the famous Bay of Fundy Tidal system, the geography of the Maritimes has changed drastically in the last 10,000 years. The combination of eustatic and isostatic factors, causing the relative sea level to be abnormally high for the Maritimes, would have inundated any evidence of early Holocene sites along the coast. As a result, Early and Middle Archaic settlement patterns are forever skewed, leaving only data from interior sites and artifact distributions.

Implications and Discussion

With most of the hypotheses proposed to explain the apparent occupational hiatus during the Early and Middle Archaic based on reduced carrying capacity or coastal site inundation, this chapter has served to review the related literature. It becomes apparent that when looking at paleoenvironmental reconstructions and changes in the relative sea level, general statements can be deceptive. This is because of many area and site-specific factors. However, in this regional study only the more general patterns will be discussed.

Evidence from palynological studies indicates that the paleoenvironment of the Maritimes was more favourable to habitation than previously interpreted by archaeologists. The pattern that emerges between 10,000-5000 B.P. is that earlier conditions were less boreal while later periods were warmer than previously believed.

While this alone does not serve as evidence that the Maritimes were populated by humans during this period, it does tend to favour the possibility of such occupation. It is the similarities between the paleoenvironments of the Maritimes and New England that will be emphasized in the present study. It should follow that: if the environment of the Maritimes were similar to that of New England, where there is no overwhelming evidence to suggest that the early Holocene environmental conditions were unfavourable for human habitation (Petersen and Putnam 1992), then the situation in the Maritimes should be the same. These similarities suggest that population occupational hiatus models based on environmental conditions, such as the Ritchie-Fitting Hypothesis, need to be revised.

The changes in the relative sea level drastically changed the geography of the Maritime Provinces during the Holocene epoch. Although some research indicates that a few specific modern areas are actually emerging (Vanick 1976:664-665; Bird 1980:119), generally it is suggested that the Maritimes are sinking at a rate of 30 cm per century (Grant 1975), as noted above. This submergence has resulted in the 'drowning' of Early and Middle Archaic sites which may have been located along the coast. Evidence for the existence of such sites exists in the form of discrete artifacts found by scallop draggers and divers, and it will be discussed in Chapters 6 and 7.

The previous review of the available literature concerning the paleoenvironment of the Maritimes has served to both strengthen the Drowned Site Hypothesis, and weaken the Ritchie-Fitting hypothesis. These are the two more popular hypotheses proposed to explain the lack of Early and Middle Archaic sites. Within this reconstructed environmental pattern an early Holocene occupation model will be advanced, which is based on available archaeological material.

CHAPTER 4

THE GASPEREAU LAKE SITE

The Gaspereau Lake site (BfDb-5) was excavated in the mid 1960s by an avocational archaeologist. Included in the site assemblage are artifact types that are similar to Early and Middle Archaic forms found in Northern New England. Using excavation notes, which include provenience data on most of the artifacts, the Archaic component of the Gaspereau Lake site has been reexamined and reinterpreted as representing use of the site for the entire Archaic Period.

The Gaspereau Lake Site

The Gaspereau Lake site (BfDb-5) is located on the north shore of Gaspereau Lake in Kings County, Nova Scotia (see Figure 1). The lake drains into the Gaspereau River, so named for the run of gaspereau, an anadromous herring, which swims upstream during May and June to spawn (Erskine 1967, 1998). Since 1929, Gaspereau Lake has been dammed for the production of hydro electric power, with all outlets diked except one. This remaining outlet has been deepened and reduced to a sluice feeding water into a fish ladder, near the Gaspereau Lake site.

The lake area had been test pitted by John Erskine initially in 1957, producing only blackened soil and a few flakes of quartzite. Erskine was an avocational archaeologist who worked under auspices of both the Nova Scotia Museum and later the

National Museum of Man between 1957 and 1967, and whose work represents almost all of the archaeological research conducted in Nova Scotia during that time. In 1964, James Legge, a local collector, reported to Erskine that he had picked up numerous projectile points and some Archaic material around the lake. In 1965, George MacDonald, National Museum of Man, reported to Erskine that he had also found some Archaic artifacts while testing around the lake. This prompted Erskine to return to the lake in September of 1965 to excavate what is now known as the Gaspereau Lake site (or the Erskine site).

The site is 70 m southeast of the sluice gate at the head of the fish ladder in an indentation of the shoreline. The location consists of a flat area 8 m wide and 15 m long sloping evenly about 1 m from north to south, with tumbled boulders at the sides. At the landward end, the ground rises rapidly to a forest of second growth hardwoods and white pine. The soil of the site was reported to be a yellow clay similar to that of the Melanson site downstream (Erskine 1967).

For excavation, the site was divided into five foot (1.5 m) squares. All artifacts were collected and levels recorded from the natural surface (Figure 6). Features were numerous and included a line of occupation floors, interpreted as wigwam-like structures, with shallow hearths dug in their centers. Numerous hearths, often overlapping, suggested that the position of occupation floors had shifted from occupation to occupation. Hearths on the west side were dug to a depth of about 15 inches (38 cm), surrounded with boulders and lined with stone or with clay baked almost to the consistency of brick, and therefore interpreted as having been smoking hearths (Erskine 1967).

West of the smoking hearths the site ran out into superficial cooking hearths among boulders, and eastward from the occupation floors it ran out similarly. At the north end of the site, Late Ceramic style projectile points were found in an eroding shallow occupation layer. At the south end of the site, digging deeper, Erskine found more Archaic material and less ceramic material until the site ran out at the edge of the slope. The artifact distribution, with the earliest artifacts being buried deeper in the southern portion of the site and more recent material culture shallower at the north end, gave the site a discernable horizontal stratigraphy. This suggests a slow northward shift of occupation floors as the forest encroached upon the drying beach. The horizontal stratigraphy/distribution is illustrated as a schematic in Figure 7.

During the initial excavation Erskine uncovered numerous Archaic artifacts, including some that he attributed to his "Blue-whin phase". Blue-whin being a name for the material culture that he attributed to an indigenous fishing people inhabiting the south shore of Nova Scotia during the thaw of the local glaciers (Erskine 1964, 1969). The Blue-whin occupation of the Gaspereau Lake site was based on the recovery of two 'very primitive' stemmed projectile points (Erskine 1967).

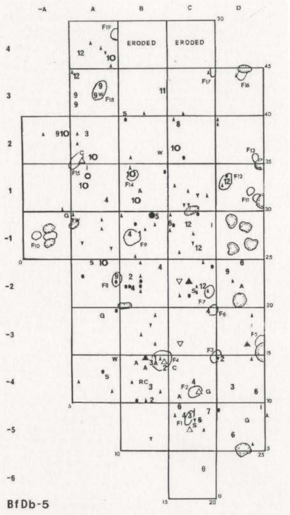

Figure 6. Excavation grid map for the Gaspereau Lake site (BfDb 5). Rocks are shaded and features are not. Features are preceded by an "F." Projectile points are indicated by their Group numbers. The following symbols and letters are used to designate other artifacts: small solid triangle = slate knife: large white triangle = plummet; large inverted triangle = ulu; large solid inverted triangle = axe; small ellipse = gouge (in A1); small solid circle = scraper; vertical ellipse with center bar = atlatl weight (C-6); A = adze; B = borer; C = chopper; G = ground stone fragment; I = chisel; S = whetstone; W = wedge. (after Deal and Rutherford 1991).

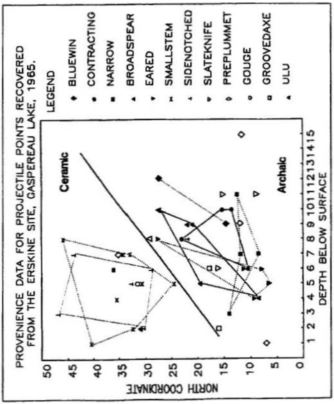

Figure 7. Distribution of diagnostic projectile points and ground stone artifacts at the Gaspereau Lake site (BfDb 5). Provenience data for the North Co-ordinate (in feet) and the Depth Below Surface (in inches) is taken from Erskine 1967. The dashed line represents the approximate division between Archaic and Ceramic Period deposits. Dotted and solid lines link specimens within projectile point groups identified by Erskine within the two deposits (i.e., excluding outliers).

Projectile point groups include 1. Blue-win, 2. Contracting stemmed, 3. Narrow bladed, 4. Broad blades (Broadspear), 5. Eared, 6. Small stemmed and 7. Corner-notched. Ground stone tools include A. atlatl weight, G. gouge, K. slate knife, P. plummet (or pre-plummet), U. ulu and X. fully-grooved axe (after Deal and Rutherford 1991).

It was the discovery of the two Blue-whin projectile points that convinced Erskine to continue excavating at the site. Leading him to uncover two Archaic hearth features that dropped to only a few inches above the glacial lake bottom. It also became apparent that the soil in the Archaic area of the site was well stratified. This was attributed to the site having been water-laid with occasional discontinuous layers of sand or gravel silting up the hearths. Although his methodology did not include excavation by stratigraphic layer their presence suggests that the Archaic portion of the site was undisturbed.

When reconstructing the sequence of site occupation, Erskine cautions that the levels of artifacts can sometimes be unreliable, due to continuous digging of hearths, which often moved artifacts either above or below their relative position. Therefore, artifacts found away from hearths should belong to the level in which they were found, while specimens found close to, or in, hearths can be misleading. These factors, along with the small amount of sediment accumulation, led to poor vertical stratigraphic separation of artifacts, and are important considerations for any interpretation of the site.

Material culture

The Gaspereau Lake site assemblage contains numerous artifacts that are similar to established Archaic Period forms. These similarities, coupled with Erskine's own interpretations and excavation notes, will be used to reinterpret the Archaic component of this assemblage. Originally, all of the recorded artifacts were grouped into categories based on material and technology (chipped stone tools, ground stone, and nonlithic artifacts). Projectile points were further categorized into 12 sequential groups representing the archaeological cultures that had utilized the Gaspereau Lake site. For the purpose of the present discussion, only artifacts associated with the Archaic portion of the site, or artifacts that are considered characteristic of the Archaic Period, will be considered. The following discussion is based on Erskine's original description of the artifacts, and follows his categories. Groups are based on chronology (position within the site), morphology, and cultural affiliation.

The two Blue-whin projectile points make up Erskine's Group 1, the earliest inhabitants of the Gaspereau Lake site. This is based on their position within the site, and the crudity of their manufacture. These included the base of a crude stemmed projectile point (#202; Plate 1) found in Unit B-4 at a depth of nine inches (23 cm), and a stemmed projectile point (#294; Plate 1) with a broken tip found in Unit B-1 at a depth of 12 inches (30 cm), the first was the deepest buried point in Unit B-4, and the latter was found below a Late Archaic hearth with a chopper. The chopper was jammed under a boulder in a way in which Erskine reported that Archaic hearths were lined with tools not worth carrying away (Erskine 1967).

It is likely that the Blue-whin artifacts actually belong to a Late Archaic group. Blue-whin point #294 likely belongs to the Late Archaic Broadspear or Susquehanna group, Erskine's Group 4, of which it not only shares morphological attributes, but was found stratigraphically close to four other Group 4 points. Artifact #202, in its fragmentary state, appears too amorphous to assign it to any specific archaeological culture.

Evidence for a Palaeoindian occupation of the Gaspereau Lake site is inferred on two artifacts whose antiquity is based solely on morphology, not provenience. Neither artifact was originally recognized as Palaeoindian by Erskine (1967). Number 158 is a small fluted chert point with a broken tip and ear (Plate 2). The flutes are clearly visible and the morphology of the point closely resembles specimens illustrated by Bonnichson et al. (1991) from the Amherst Shore, Nova Scotia, and at least one of the points illustrated from Debert (1991:15 Figure 1.2 e and d) where the Palaeoindian occupation has been dated ca. 10,600 B.P. (MacDonald 1968). There is no provenience for this Gaspereau Lake artifact.

The other specimen, #193, is a finely parallel-flaked quartzite point with a broken base (Plate 2). Recorded as being from the Ceramic Period portion of the site, this artifact has been recognized as a Plano style point by David Keenlyside (1984b: slide 7). A similar undated parallel flaked projectile point has been reported from Nova Scotia (Davis and Christianson 1988), while a parallel flaked projectile point fragment from the Blackman Stream site in Maine was recovered from a context predating ca. 8000 B.P. (Sanger et al. 1992). The Gaspereau Lake specimen was found in Unit C-2 at a depth of 4 inches (10 cm). This context is obviously the result of either a disturbance, such as the digging of a hearth, curation, or a combination of the two.

The contracting stemmed points that make up Erskine's Group 2 (Plate 3) were recovered from the oldest areas of the site. Specimens 201 and 308 were found in Unit B-4 at a depth of 6 and 10 inches (15 and 25 cm), respectively, 230 was found in Unit B-2 at a depth of 8 inches (20 cm), and 314 in Unit D-4 at a depth of 10 inches (25 cm), but measurement is less certain since the point was recovered from a hearth. Morphologically, point #308 is more similar to the Late Archaic Susquehanna forms, or Erskine's Group 4, than to the group of contracting stemmed points. Looking at the site map (see Figure 6) specimen 308 appears to be in hearth Feature 4 which may explain its depth, and which in turn, may be the reason for its inclusion in Group 2. Specimen 314 is a large, broad-bladed knife with a contracting stem which was also recovered from a hearth. Its inclusion within a hearth makes it difficult to affiliate it within a definite culture group, but it is somewhat reminiscent of the Susquehanna forms as well.

It is the large contracting stemmed bifaces, #201 and 230, that are the most interesting in Group 2. These closely resemble the Middle Archaic Neville and Stark forms originally identified at the Neville site in New Hampshire (Dincauze 1976), and more recently in collections from Maine (Spiess et al. 1983) and southwestern New Brunswick (Deal 1984). These forms from the Neville site have been dated ca. 7600-

7000 B.P. (Dincauze 1976:106). These two points represent, without a doubt, a Middle Archaic presence at the Gaspereau Lake site.

The third of Erskine's Groups is made up of four narrow bladed style points (Plate 4). Specimens numbered 167, 310, 218, and 203 were found in Units C-5, B-4, D-4, and B-4, respectively. Again, only two of the points in this group are thought to be diagnostic. Number 167, with its straight stem, is more similar to Middle Archaic Merrimack style projectile points illustrated by Snow (1980:175), than to the narrow stemmed points of the Maritime Archaic, or Moorehead phase. Merrimack points from the Neville site date ca. 6000 B.P., while the narrow stemmed points of the Maritime Archaic or Moorehead phase date from ca. 3700 B.P. in New Brunswick (Sanger 1973), and to ca. 4400 from Occupation 2 at the Turner Farm site (Bourque 1995). Specimen 167 also fits better with Dincauze's original description of Merrimack points, including a dull blade, sharp tip, and thinned base (Dincauze 1976:45-47) than to Bourque's Occupation 2 Moorehead phase points that, for the most part, had unthinned bases which still retained the remnants of a striking platform (Bourque 1995:44). Dincauze believed that these points were hafted and used to pierce rather than cut, with many of them having damaged tips. Point 310 also has a thinned base, although slightly expanding, with the tip broken off from an impact fracture, suggesting that it may also fit into the Merrimack category.

The two slate bifaces, #218 and 233 (Plate 4), that Erskine included in Group 3 appear to simply be bifaces that, although they might belong with the straight stemmed points, are not characteristic in any way of either Merrimack or any other archaeological culture. Both are quite thick with broken tips, which is probably more indicative of the quality of their material of manufacture, rather than their being used to pierce.

Group 4 projectile points have stems that are either straight or slightly contracting towards their broad triangular blades (Plate 5). Found at depths between 2 and 10 inches (5 and 25 cm) in Units C-4 (315), B-2 (182), C-5 (165), A1 (264), C-3 (228), B-1 (295), B-2 (190), their distribution includes the oldest areas of the site, but they are distinctly later than the contracting stemmed points (Erskine 1967). Related forms are known from the end of the Late Archaic Period in New Brunswick, Nova Scotia, and New England, dating between 4000–3400 B.P. (e.g. Bourque 1995; Deal 1986; Sanger and Davis 1991; Spiess et al 1983). They are associated with the Susquehanna or Broadspear tradition. With the exception of #190, which appears to simply be a broken biface, all of Group 4 would easily fit within the Susquehanna assemblage from the Mud Lake Stream site in New Brunswick (Deal 1986).

Group 5 from the Gaspereau Lake assemblage is made up of a single leaf-shaped point, # 325 (Plate 6). This point was found at a depth of 11 inches (28 cm) in Unit B-1. This specimen does not have the characteristics of any specific culture and is simply a biface.

Group 6 is made up of six 'eared' and side notched projectile points (Plate 7). Resembling long triangles, Group 6 points are broadest at the base and have dull tips.

They were distributed within the site in Units C-5 (166), D-2 (220), D-4 (217), D-5 (181), C-1 (322), C-5 (168), with all but one in the oldest Archaic area. Depths varied between 4 and 8 inches (10 and 20 cm). These are similar to both Ritchie's (1961) eared-notched Brewerton points and side notched Otter Creek points from New York State which are related to the Laurentian tradition. In Southern New England the side notched 'Otter Creek' type points date ca. 6500-4500 B.P. (Ritchie 1980:89), while the eared-notched type date ca. 5000-4000 B.P. (Ritchie 1980:91).

Groups 7 and 8 each consist of a single projectile points. Group 7 is represented by the tip of a serrated projectile point found at a depth of 2 inches (5 cm) in Unit C-5 (Plate 6) in the same position as a plummet (#2). Lacking a base, it is difficult to attribute this point to any archaeological culture, although the serrations are interesting and reminiscent of Early Archaic forms from Southern New England.

A single side notched point, #240 (Plate 6), makes up Erskine's Group 8. Considered Archaic based on its size, it was recovered in Unit C-2 surrounded by Middle Ceramic Period side notched points. This designation is considered erroneous and therefore Group 8 is not relevant to the present research.

Other than chipped stone projectile points the Gaspereau Lake site assemblage also includes a wide array of artifact forms considered to be diagnostic of the Archaic Period. In the Gaspereau Lake site assemblage these artifacts include choppers, ground slate knives, plummets and pre-plummets, gouges, adzes, grooved axes, and ground stone rods.

Erskine reported a small number of choppers that he described as quartzite and slate chunks with sharp edges. Recovered mainly from the Archaic portion of the site, they were usually cached or discarded in Archaic Period hearths (Erskine 1967). These choppers were considered to be too variable to classify precisely.

Fragments of three ground slate knives were recovered from the Gaspereau Lake site. They included specimens 320, 309, and 210 (Plate 8). Number 320 is rhombic in cross-section and appears to be the oldest, having been found at a depth of 11 inches (28 cm) in Unit C-1. Erskine believed that it was associated with the Archaic occupation because of its depth, and not being associated with any hearth features, even though it was recovered from the Late Archaic portion of the site. Specimen 309 is the tip of a ground slate bayonet with a flat hexagonal cross-section. Recovered from a depth of 11 inches (28 cm) from hearth Feature 4 in Unit B-4, it was found in association with projectile point #308. Specimen 308 (Plate 3) was originally attributed to Group 2 but it should be reassigned to Group 4 (see above). The third, #210, is a medial section of a slate knife with a rhombic cross-section. Found at a depth of 6 inches in Unit D-3, it was not associated with any other artifacts.

Ground slate knives and bayonets are known from all over the Maritime Provinces and Northern New England. Believed to have been used for the killing and processing of marine resources, they are often associated with mortuary contexts. These artifacts are associated with the Late Archaic Moorehead or Maritime Archaic traditions and date ca. 4000-3700 B.P. (Robinson 1996; Sanger 1973). Slate point and other biface forms date back to ca. 6000 B.P. and older in some Maine contexts, however (e.g. Petersen 1991).

Plummets are quite common in the Maritimes and New England in the Late Archaic. They are usually described as net sinkers or bolas stones. A single plummet from the Gaspereau Lake site, #2, was recovered from Unit C-5, at a depth of 1 inch (3 cm). It is made of slate, rounded on one side, flat on the other, with a narrow groove scratched around the neck (Plate 9). Plummets found in dated contexts in Northern New England usually date to the Late Archaic, but they have been found in a context dated ca. 6000 B.P. at the Brigham site, and nearly as old or older at the Sharrow site, both in Maine (Petersen and Putnam 1992:39).

The Gaspereau Lake site assemblage also included three 'pre-plummets' (Plate 9). Erskine believed that these large notched stones, #21, 354, and 231, although not having any resemblance to conventional plummets, served the same purpose. Number 21 was found in Unit C-4 at a depth of 9 inches (23 cm), in the same Archaic hearth as slate knife number 309, 231 was recovered in Unit D-5 at a depth of 5 inches (13 cm) and # 354 in Unit B-4 at a depth of 9 inches (23 cm). Although there are no regional analogies for the pre-plummets in the Maritimes, they do closely resemble the bilaterally notched netsinker from the Sharrow site recovered in Stratum III, dated ca. 7500 to 5000 B.P. (Petersen 1991:112, Figure 85).

The sole artifact included in the gouge category is the bit end of a full-channeled gouge. Number 266 was found at a depth of 5 inches (13 cm) in Unit A1, in the Ceramic area of the site. Erskine reported that this artifact was recovered from undisturbed clay near a deep hearth which may be responsible for its provenience. In Maine full-channeled gouges are associated with the Gulf of Maine Archaic tradition and date as early as ca. 8000 B.P. and later to ca. 6000 B.P. (Robinson 1992, 1996)

There were five adzes and adze blanks recovered from the Gaspereau Lake site (Plate 10). They are from Units B-2 (14), A-2 (44), A-1 (317), D-4 (9), and B-4 (26), all in the Archaic portion of the site. Their context suggested to Erskine that they were cached in hearths between visits to the site (Erskine 1967). These artifacts are rather amorphous. Some seem to be badly weathered and not easily diagnostic. Adzes are associated with all manifestations of the Archaic Period, as well as the Early Ceramic Period.

There are two grooved axes included in the Gaspereau Lake assemblage (Plate 10). Number 6 was found in Unit C-2 at a depth of 6 inches (15 cm) above a Late Ceramic projectile point fragment. Specimen 27, which is shallowly grooved on one face only, was found at a depth of 2 inches (5 cm) in Unit C-3. Both were recovered from the

Ceramic Period portion of the site, which is obviously the result of a disturbance such as the enlarging of hearths, since grooved axes are associated with the Late Archaic.

The last artifact class to be discussed from the Gaspereau Lake site is that of ground stone rods. There are two such artifacts in the Gaspereau Lake site assemblage, sharing the same catalogue number, #28 (Plate 12). Both were recovered from Unit -A-1 with no depth recorded. Both are made of slate and are badly weathered. The specimen at the top of Plate 12 has an oval cross-section and was probably a finished rod at one time, while the bottom specimen may represent a rod preform. Neither would seem out of place among the rods and rod preforms illustrated from the Gillman Falls site in Maine, dating ca. 6300-7300 B.P. (Sanger 1996: Plate 6). Ground stone rods from both mortuary and non-mortuary assemblages associated with the Gulf of Maine Archaic tradition have been dated as early as 9000 B.P. (Robinson 1992, 1996).

Gaspereau Lake Assemblage Reconsidered

The previous discussion has served to review Erskine's chronology, the artifacts responsible for his groups, and other artifacts considered significant. It was felt that including Erskine's original categories would provide better insight into the re-interpretation of the Gaspereau Lake site since they reflect the excavator's thoughts and impressions. The present interpretation closely follows that of Erskine, only with the advantage of the wealth of research that has been accomplished in the three decades since the site was excavated.

Erskine believed that the site's location was chosen because the outlet of the lake formed a natural weir for netting gaspereau, salmon, and eels. This location was also thought to provide canoe access to the coast, other interior lakes, and miles of hunting country (Erskine 1967). Based on the Blue-whin projectile points, that looked older than anything he had seen in his experience, Erskine believed that the Gaspereau Lake site was initially inhabited before 5000 B.P. The Archaic occupation that followed included at least three hearths lined with discarded tools. There was no clear break between the earliest and later Archaic components, with some of the hearths having been used by both. In the Archaic sequence of the Gaspereau Lake site, contracting stemmed projectile points and slate knives gave way to stemmed and eared points as the site moved northward.

In a later projectile point sequence and typology for all of Nova Scotia, Erskine classified the Gaspereau Lake contracting stemmed points (Group 2) and Gaspereau Lake narrow points (Group 3) as belonging to the Archaic Period dating between 7000-5000 B.P. The Gaspereau Lake side notched points (Group 6) and the Gaspereau Lake straight stemmed points (Group 4) were included in his Late Archaic group, ca. 5000 BC to 2500 B.P. (Erskine 1998:88).

There are several reasons to believe that the Gaspereau Lake site was initially inhabited before 5000 B.P. The first is the two Palaeoindian points that apparently represent two separate phases of the Palaeoindian Period in the Northeast. The fluted point (#158; Plate 2) is similar to the smaller fluted points from the Debert site in Nova Scotia ca. 10,600 B.P. Based on form and technology, the Plano point is suggested to date ca. 8000-10,000 B.P. in the Northeast (Doyle et al. 1985:15). The second reason is the presence of the ground stone rods and full-channeled gouge fragment. Both of these artifact classes are considered to be characteristic of the Gulf of Maine Archaic tradition ca. 8000 B.P. (Robinson 1992). This relationship is based solely on morphology since their provenience places them in the Ceramic Period portion of the site. This may be like the Palaeoindian points, the result of low sediment accumulation and disturbances caused by the numerous re-occupations of the site. Characteristic artifact forms of the Gulf of Maine Archaic tradition, aside from ground stone rods and full-channeled gouges, include a core and uniface technology, and the paucity of bifaces of any kind (see Chapter 3). One of the earliest uniface tool forms from the Sharrow site are choppers, described as " made from tabular breaking material with poor conchoidal fracture, roughly shaped, often with relatively blunt edges" that were "expediently made… restricted to the Early and Middle Archaic Period strata" (Petersen and Putnam 1992:39). From the Gaspereau Lake site, choppers and what Erskine considered to be adze blanks recovered from the earliest areas could easily fit into the above description. Adze blank #9 (Plate 10) recovered in

Unit D-4 at a depth of 12 inches (30 cm), would easily fit in with the choppers pictured from the Sharrow site (Petersen and Putnam 1992:41, Figure 10).

Similarities between the Gaspereau Lake site assemblage and that of the Sharrow site are derived on rather speculative evidence, but are intriguing. Based on the artifact forms and their position recovered within the Gaspereau Lake site, an Early Archaic occupation is a definite possibility. The comparison of the rest of the Gaspereau Lake site chronology to that of the Sharrow site may serve to strengthen this comparison.

The two contracting stemmed points that make up Erskine's Group 2 represent the next occupants, chronologically, at the Gaspereau Lake site. These were both found in the earliest portions of the site and are similar to Middle Archaic forms that date ca. 7600-7000 B.P. at the Neville site (Dincauze 1976:106). Their presence establishes, without a doubt, a Middle Archaic occupation of the Gaspereau Lake site.

Similar to the sequence of the Neville site, the next projectile point form from the Gaspereau Lake site is the Group 3 narrow bladed straight stemmed Merrimack style (see Plate 4). Dated ca. 6000 B.P., they are considered to be part of a single developing cultural tradition with the earlier Neville and Stark style points at the Neville site (Dincauze 1976:123). This is also thought to be the case at the Gaspereau Lake site. Unlike the assemblage at the Neville site, however, Erskine has grouped the ground slate knives in with the earliest Archaic inhabitants. This becomes interesting when we again turn to the Sharrow site in Maine.

At the Sharrow site the oldest projectile point recovered in situ is dated ca. 6400 B.P., and is thought to be analogous to Merrimack style points (Petersen 1991:60). Contemporaneous with the Merrimack point were six fragments of ground slate points dated ca. 6300 B.P. and a stemmed point dated ca. 6000 B.P. that is similar to Middle Archaic styles at the Neville site (Petersen and Putnam 1992:39). Together with the two Stark points that were collected from the eroding riverbank at the Sharrow site (Petersen and Putnam 1992:35) it has striking similarities to the assemblage of the Gaspereau Lake site.

Chronologically the next point type at the Sharrow site consists of five side notched points that are similar to the Brewerton and Otter Creek style dated ca. 5800-5300 B.P. This is then followed by several projectile points and primary ovate bifaces attributed to the Late Archaic Susquehanna tradition after 4000 B.P. (Petersen 1991:63). This is also the case for the Gaspereau Lake site.

Upon closer examination, it is believed that Erskine's projectile point Group 4 and Group 6 are in reverse order. Although Group 4 points are, on average, found at greater depths than Group 6 points, the later are found further south in the site (see Figures 6 and 7). It was probably the depth that convinced Erskine to attribute the Eared points as being chronologically earlier than the Broadspear points, and in this case the distribution is definitely more indicative of their true relationship than the depth of the artifacts. This is further strengthened by the fact that typologically in the Northeast, Brewerton eared and side notched points always date earlier than Susquehanna Broadspear types. Peoples associated with Group 4, or the Susquehanna archaeological culture, projectile points were the last Archaic group to use the Gaspereau Lake site.

Conclusion

The Gaspereau Lake site assemblage contains artifact forms that indicate one of the of the longest cultural chronologies in Eastern Canada. The presence of Palaeoindian and Early and Middle Archaic populations is based on artifact form alone, without much contextual data to back it up. But even a conservative interpretation suggests the contracting stemmed points (Group 2) are representative of a Middle Archaic occupation of the site, which in the scope of the present research would accomplish at least part of the main goal, to demonstrate that the Maritimes were inhabited during the early Holocene. The Group 2 stemmed points alone indicate, through their similarity with dated examples from other sites, that the Gaspereau Lake site was occupied by ca. 7600–7000 B.P.

A more liberal interpretation of the Gaspereau Lake site assemblage, as above, would indicate an occupation spanning the entire Holocene epoch. This is based on artifact forms and the similarities between the Gaspereau Lake assemblage and that of the Sharrow site in Maine. The similarities between the assemblages of the two sites is uncanny and it may have only been depositional regimes at work that were different.

The goal of the analysis of the Gaspereau Lake site assemblage was to reevaluate the assemblage in light of the research that has been accomplished since its excavation. The purpose of the present thesis is to reevaluate the 'Great Hiatus' in Maritime Provinces prehistory. A very conservative interpretation would seem to accomplish both these goals, while a more liberal one would prove it beyond a doubt.

CHAPTER 5

COLLECTIONS ANALYSIS

A collections analysis methodology was undertaken in order to identify artifact forms recently established as characteristic of early Holocene cultures in Northern New England. Collections in New Brunswick and Nova Scotia held by museums, educational institutions, provincial government departments, and private collectors were examined, followed by an extensive search of the existing literature. This exercise resulted in the identification of 122 artifacts, in three classes, that are believed to represent the archaeological remains of early Holocene occupation within the Maritime Provinces. The artifacts, their context, distribution, and implications for the archaeological record of the Maritimes are discussed below.

Current Research

In order to demonstrate an occupation of the Maritimes during the early Holocene, an extensive search of regional collections was undertaken. Following an established methodology (e.g. Dincauze and Mullholland 1977; Spiess et al. 1983), existing collections were re-examined in light of new information. The present research was based on the recently defined Gulf of Maine Archaic tradition and the earlier complexes of the recently re-defined Moorehead burial tradition by Robinson (1987, 1992, 1996).

Artifact forms that are considered the most characteristic and most easily recognizable of these traditions were the basis of the collections analysis.

Six weeks were spent traveling in Maine, Nova Scotia, and New Brunswick examining collections held by educational institutions, museums, government departments, and private collectors. In Maine, early Holocene site assemblages were examined and researchers were interviewed. Time in Maine was divided between the University of Maine at Farmington, the University of Maine at Orono, the Maine State Museum, and the Maine Historic Commission. In Nova Scotia, collections held at the Nova Scotia Museum, Yarmouth County Museum, Queens County Museum, and one private collection were analyzed. In New Brunswick, collections held at Archaeological Services New Brunswick, and the New Brunswick Museum's collection housed in the National Exhibition Center were examined.

When analyzing collections, it was primarily full-channeled gouges, ground stone rods, and Neville and Stark style stemmed projectile points that were sought out. These are the most easily recognized and characteristic artifacts of the Early and Middle Archaic Period in Northern New England (Petersen and Putnam 1992; Robinson 1992, 1996). Additional Early and Middle Archaic artifacts from Northern New England include a flaked stone industry which is dominated by core and uniface tools. These were considered too ambiguous for this type of research. Due to the 'crudity' of the core and uniface tools, untrained individuals are unlikely to recognize them as artifacts, in comparison to the more obvious artifacts such as full-channeled gouges and ground stone rods. This difference in identification was a significant factor since almost all of the artifacts used in the present study were surface collected by private collectors.

Artifacts that were examined were photographed, and their basic metric attributes measured. Both black and white and colour slide film was used for the purpose of publication and presentations, and all provenience information available was recorded. This information has since been catalogued on 5 x 3 inch cards that crosslist related slides, prints, negatives, metric attributes, and provenience information.

None of the artifacts in the collections examined from Nova Scotia and New Brunswick were from professionally excavated sites. Provenience information available on the artifacts varied: from Borden numbers from surveys; to individual donor's names; or no provenience recorded (see Appendix A for the available data on the individual artifacts used in this study).

An extensive search of the existing literature was also undertaken. This consisted of reviewing survey reports, documented private collections, and other related literature. Artifacts used in the present study from these sources are indicated in Appendix A. Both the artifacts and some of these sources will be discussed in more detail below.

The only chipped stone artifacts included in the present study were Neville and Stark style projectile points. These large contracting stemmed bifaces were originally identified at the Neville site in New Hampshire (Dincauze 1971, 1976), and more recently in collections from Maine (Spiess et al. 1983) and southwestern New Brunswick (Deal 1984). At the Neville site these forms have been dated ca. 7600-7000 B.P. (Dincauze

1976:106), as noted above. It was the Stark and Neville complexes from the Neville site that were responsible for initially revising an occupational hiatus for the Middle Archaic in New Hampshire and Southern New England (Dincauze 1976). These point forms were also used in two distribution studies which the present research methodology is based on for Southern New England (Dincauze and Mullholland 1977), and Maine (Spiess et al. 1983).

There are seven contracting stemmed Stark style points known from the Maritimes. Of the five points from New Brunswick, four are from the Spednic Lake area and one is from the Grand Lake area (Figure 8). Specimens from Spednic Lake were found by private collectors, whose collections have been catalogued and Borden numbers have been assigned to findspots. Both of the Stark style points from Nova Scotia are from the Gaspereau Lake site (Plate 3). John Erskine mentions that these points are rare in Nova Scotia and that he had seen only one other specimen that was collected at Melanson (Erskine 1967). No evidence of this artifact has been found.

Stark style points are distributed along three of the biggest lake systems in the Maritimes. Their limited numbers make any interpretation of their distribution rather speculative, but what has been observed does suggest strong affinities with Northern New England. Typically, in New England, Middle Archaic Period points cluster at lake inlet-outlet locations (Yesner et al. 1983), interpreted as settlements at optimal locations for the exploitation of anadromous fish (Spiess et al. 1983:237).

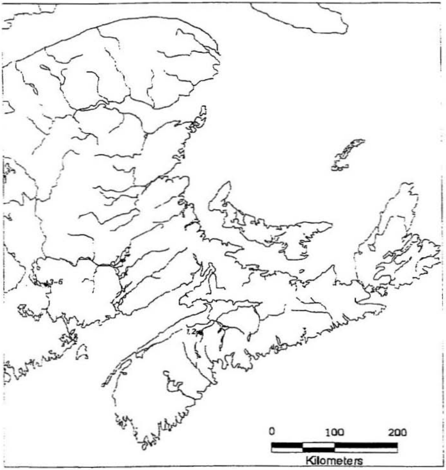

Figure 8. Distribution of contracting stemmed projectile points in the Maritimes: 1-2) Gaspereau Lake site; 3-6) Spednic Lake/Star Island; 7) Grand Lake. See Appendix A for additional information on individual artifacts.

Distribution of Stark and Neville style points in New England, where their numbers dramatically drop from south to north, was originally thought to reflect population differences with northern Maine having been less densely populated. This has recently been re-interpreted as representing the established projectile point distributions bordering an area of contrasting technology, with the Gulf of Maine Archaic tradition, rather then being indicative of population size (Robinson 1992:76). The distribution in the Maritimes is thought to reflect this as well.

It is ground stone, rather than flaked stone, artifacts that form the core of the present study. Specifically, it is the identification and distribution of full-channeled gouges and ground stone rods that is the basis for the early Holocene occupational model developed in the present thesis. Although Robinson states that for the Gulf of Maine Archaic tradition "at present full channeled gouges and long well finished ground stone rods are perhaps most diagnostic of the Gulf of Maine Archaic" (1992:100), and that the "most characteristic artifact types of the Morrill Point burial complex are the full channeled gouges and rods" (1996:104), he quickly warns that "neither tool form is demonstrated to be exclusive to the tradition" (1992:100); it is the combination of broad lithic patterns that form a polythetic set that is considered to be diagnostic of the Gulf of Maine Archaic tradition. This is based on these distinctive ground stone tool forms having been found in comparatively small numbers and typically in fragmentary states (Robinson 1992:100). For the present study, however, circumstances did not permit this broader consideration.

None of the artifacts used in the present study came from professionally excavated sites. Although provenience information places some artifacts as being from the same area, there is, with one possible exception, no evidence of any being found together in what might constitute an assemblage. Most of the artifacts were donated to museums individually by private collectors around the turn of the 20th century.

As previously stated, the flake core/uniface tools, tabular choppers, and adzes that are also considered part of the Gulf of Maine Archaic broad scale technological tradition, and round out the polythetic set, were considered too ambiguous for the present research. Therefore, it is only the distribution of full-channeled gouges and ground stone rods that were used for the present analysis.

It is the sheer number of ground stone full-channeled gouges in the collections of the Maritimes that is the most convincing evidence of an early Holocene occupation. A total of 94 gouges, 34 from New Brunswick, 59 from Nova Scotia and one from Prince Edward Island, were accounted for. Full-channeled gouges are considered one of the most characteristic artifact types of both the Gulf of Maine Archaic tradition (Robinson 1992:100) and the Morrill Point burial complex (Robinson 1992:100, 1996:104). They have been recovered in professionally excavated sites and reliably dated ca. 8000-6000 B.P. (e.g., Petersen and Putnam 1992; Sanger 1996: Sanger et al. 1992).

Twenty-three of the 34 gouges from New Brunswick were found in the collections analyzed, and 11 were from other sources. One of these sources was notes made by Michael Deal (1983) on artifacts from private collections around the Spednic Lake area.

These notes included information on eight full-channeled gouges, two of which were not available in the collections. The other major source was an untitled document from the Canadian Museum of Civilization that consisted of some of William Wintemberg's notes (Wintemberg 1913), including a photograph taken in 1913 of the gouges that were on display then at the Museum of the Natural History Society of New Brunswick. This display included 18 gouges, 12 of them with full channels, of which three were not available in the studied collections. All except one of the specimens in the photo were from the Grand Lake area.

From Nova Scotia there were 59 gouges accounted for, with 18 from the literature. The most significant paper for the present research was Deal and Rutherford's "The Distribution and Diversity of Nova Scotian Archaic Sites and Materials: A Re-examination" (1991). This research expanded on Piers' 1895 article "Relics of the Stone Age in Nova Scotia", and is an inventory of Archaic Period material culture and site locations for Nova Scotia that includes all the available published and unpublished sources to 1990, as well as personally communicated information on private collections. It is interesting to note that of the 365 chipped and ground stone artifacts included, only two were excavated by professional archaeologists and none have associated radiocarbon dates (Deal and Rutherford 1991). Artifacts reported in this study included 29 full-channeled gouges.

Piers' original article was a paper read to the Nova Scotia Natural History Society describing a number of 'aboriginal relics' found in the Nova Scotia Provincial Museum

(Piers 1895). Included in this inventory were 17 gouges, seven of which had full channels, illustrated from the Charles Fairbanks collection. Most of this collection is thought to originate from William King's farm at the head of Grand Lake (Piers 1895:26).

Morphologically, gouges occur in two distinct forms: long parallel-sided gouges with deep rounded channels; and wide flared bit gouges with full channels that are flat in cross-section (Robinson 1996:105). The parallel-sided form is characteristically narrow with a uniform deep channel running the full length of the tool. This channel is usually fully polished with the dorsal side sometimes polished as well (Robinson 1992:86). Flared bit gouges are in the form of an isosceles triangle with the widest point at the bit, and are usually fully polished (Robinson 1992:86-87). Robinson states that although the two forms have occurred together at the Sunkhaze Ridge site, the flared bit forms appear to have a more limited distribution in time and space than the narrow full-channeled forms (Robinson 1992:87). This is also the case in the collections for the Maritimes, where both parallel sided gouge and wide flared bit gouge forms were represented.

Sixty-five of the gouges from the Maritimes were the parallel sided form (21 from New Brunswick and 44 from Nova Scotia) and 19 had wide flared bits (12 from New Brunswick and 7 from Nova Scotia). The parallel form varied and could further be subdivided, upon visual inspection, into those with sides either narrow parallel (n=31), wide parallel (n=22), and slightly expanding towards the bit end (n=12).

Of the 57 gouges that appeared complete, most were well worn, with seven exhibiting obvious evidence of having been hammered on the pole end. Only one, number 16, appears too delicate to have been manufactured for utilitarian purposes. This flared bit gouge is beautifully made, fully polished and consistently approximately 10 mm thick (Plate 13). Although there is evidence of use wear on the bit end of this specimen, it was probably produced as a mortuary artifact. Other gouges that were interesting included two that appeared to have constrictions to facilitate hafting (#7 and 8), and one with deep incised lines that did not appear to serve any function (#29). The specimen from the Rouen Island site (#29) has a wide shallow channel and two grooves pecked into the dorsal side. This artifact was originally identified as an adze but has the characteristics of a full-channeled gouge and was therefore used in this study.

In New Brunswick most of the gouges are from the southern portion of the province, along the lakes and river systems. They are concentrated in three areas (Figure 9). There are 11 from the Spednic Lake area (#1-11), 13 from the Grand Lake and lower St John River area (#16-28), and four from the Passamaquoddy Bay area (#12-15). There is also a single specimen from the northern part of the province and another from the southeast. One of the specimens from Passamaquoddy Bay (#15) was recovered off the coast of Indian Island at a depth of 38 m by a scallop dragger (Black 1997).

The distribution of gouges in Nova Scotia is also along the lakes and river systems, although not as concentrated as in New Brunswick (Figure 9). Thirty-one of the 46 gouges that have provenience information are from the Lake Rossignol area (#59-72), Gaspereau Lake (#50-54), and Grand Lake (#36-47). Six of the gouges from Lake Rossignol were surface collected by members of the Nova Scotia Museum when the lake

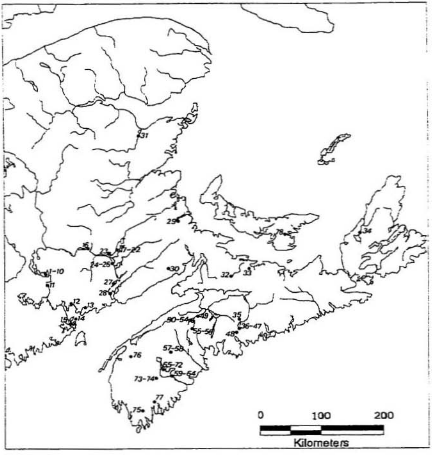

Figure 9. Distribution of full-channeled gouges in the Maritimes: 1-10) Spednic Lake/Palfrey Lake/Diggity Stream; 11) St. Croix; 12) Phil's Beach; 13) Lake Utopia; 14) the Rouen Island site; 15) Off the coast of Indian Island; 16) St. John River above Fredericton; 17-20) Grand Lake; 21-22) Indian Point; 23) French Lake; 24-26) Jemseg; 27) Big Lake Musquash; 28) Westfield Beach; 29) the Wentworth site; 34) Scottsville; 35) Enfield; 36-47) King's Farm, Grand Lake; 48) Lake Thomas; 49) Melanson; 50-54) Gaspereau Lake; 55-56) Salmontail Lake; 57-58) McGowan Lake; 59-64) Indian Gardens; 65-72) Lake Rossignol; 73-74) Shelbourne River; 75) Barren lake; 76) Eel Lake; 77) Clyde River; 78) Montague. See Appendix A for additional information on individual artifacts.

was drained to its pre-dammed levels to facilitate dam repairs (Christianson 1985; Rossignol Survey 1985). Four of the gouges from Gaspereau Lake were from private collections, and one was from the Gaspereau Lake site assemblage. The entire Charles Fairbanks collections that included seven full-channeled gouges was reportedly found on the King Farm at the head of Grand Lake (Piers 1895:26). Also of interest is the gouge from Clyde River (#77) that was reportedly recovered from a depth of 10 feet (3 m) below the surface (Piers 1911:206).

The only specimen from Prince Edward Island was a narrow parallel style gouge that was recently found along the Montague River, near the town of Montague (#78, see Figure 9). This specimen was found by a bottle collector at a reported depth of 5 feet (1.5 meters) below the surface (Cunningham 1998).

Gouges are usually attributed to a heavy wood working industry. Inferred from the present distribution of findspots along rivers and lakes, they may have functioned in a dugout boating technology. Dugout canoes were constructed by continuously charring and scraping a selected log until the desired form was achieved. Preservation factors weigh heavily against the chances of recovering evidence of dugouts but in some cases they have been discovered. Such specimens include three from Savannah Lake in Ohio where the peat bottom has served to preserved them. All three are close to seven meters long and one meter wide and date to the Late Archaic Period (Brose and Gruber 1982). The distribution and number of gouges and round stone rods may represent evidence of a similar technology in the Maritimes.

Ground stone rods are considered the earliest tool forms yet identified for the Gulf of Maine Archaic tradition (Robinson 1992:100). They are also considered characteristic of the assemblages of the two earliest complexes of the recently re-defined Moorehead burial tradition. Rods, especially those with expanded heads and lacking perforations, are considered to be one of the defining characteristics of the Table Land burial complex ca. 8500 B.P. (Robinson 1996:100) and, along with full-channeled gouges, the characteristic artifact types of the Morrill Point burial complex ca. 8000-7000 B.P. (Robinson 1996:104).

Rods found in Northern New England consist of metamorphics that range from friable schists to slate-like stone and occur in two forms: those made from naturally rod-like pebbles with some grinding; and fully ground specimens (Robinson 1992:92). Fully ground specimens are usually widest near the center and contract toward the ends. Cross sections are round, oval, or flattened, and they vary in length, with the longest being 36 cm (Robinson 1992:92). The most variable attribute of the rods is their end treatment. This includes specimens that are semi finished, blunt, contracting to a dull point, beveling of one end, notched, perforated, and having expanded heads (Robinson 1992:92). The expanded head form is thought to be the earliest variant.

Rods are generally identified as whetstones, with their form appearing to facilitate the sharpening of the full-channeled gouges. While this is a possibility for some, Robinson believes that some specimens appear to have been shaped, rather than used to shape something else, and the longer and more highly finished specimens may have been produced as mortuary artifacts (1996:106). This diversity of stone rod forms also suggests the possibility of multiple functions.

Twenty-one ground stone rods were found in the collections and literature from the Maritimes, including 11 from Nova Scotia (four from the literature), and 10 from New Brunswick (one from the literature). Rods with provenience from Nova Scotia are from East Brook on Lake Rossignol, Cook's Falls on the LaHave River, Upper Nine Mile Lake, and with two rods each from Gaspereau Lake, Eel Lake, and Sherbrooke Lake (Figure 10). The distribution of rods in New Brunswick included one from Portobelo Lake, Jemseg River, Phil's Beach on the Bocabec River, Wabski on the Tobique River, and two from Maquapit Lake, Indian Point on Grand Lake, and Spednic Lake, respectively (see Figure 10).

The distribution of rods in New Brunswick is along the larger lakes and rivers, with six from around the Grand Lake area, two from Spednic Lake, and the two remaining from the Tobique and the Bocabec Rivers. The rod distribution in Nova Scotia follows that of New Brunswick, with all of the rods from lakes, except one, #4, from the LaHave River. This is similar to the distribution of the full-channeled gouges to which the rods are ultimately related.

Rods analyzed were mostly fragmentary, with only six apparently complete. The longest complete specimen was #4, measuring 275 mm. Rods examined had both round and oval cross-sections, and four exhibited end treatment. End treatment

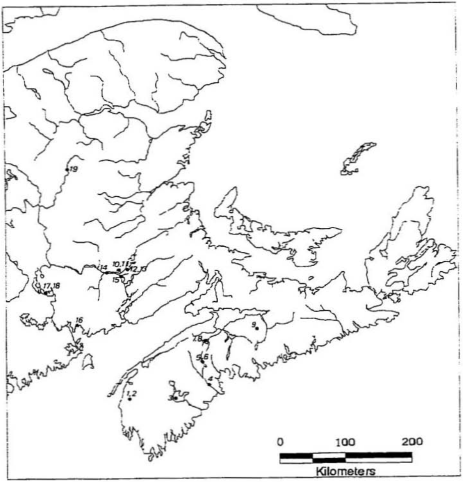

Figure 10. Distribution of ground stone rods in the Maritimes: 1-2) Eel Lake; 3) East Brook; 4) Cook's Falls; 5-6) Sherbrook Lake; 7-8) Gaspereau Lake; 9) Upper Nine Miles Lake; 10-11) Maquapit Lake; 12-13) Indian Point; 14) Portobelo; 15) Jemseg; 16) Phil's Beach; 17-18) Spednic Lake; 19) Wabski. See Appendix A for more information on individual artifacts.

included two with expanded heads from Nova Scotia (#4 and 5), and two with both ends tapering to points from New Brunswick (#17 and 18). As stated above, rods with expanding heads are considered the defining characteristic of the Table Land Burial complex, ca. 8500 B.P., and have been dated at the Weirs Beach site ca. 9000 B.P. (Bolian 1980; Maymon and Bolian 1992). The two rods from Nova Scotia are from Cook's Falls and Sherbrook Lake. The specimen from Cook's Falls appears to be complete and is the longest rod that has been recorded, while the Sherbrook specimen is only the end fragment. From New Brunswick the two rods with tapering ends are both from the same private collection, but from different sites on Spednic Lake. One of the rods, #8, from the Gaspereau Lake site is thought to be a rod preform.

Discussion

Evidence of an early Holocene occupation of the Maritime Provinces is indicated by the number and distribution of contracting stemmed projectile points, ground stone rods and full-channeled gouges. Provenience information on the artifacts used in this study suggest that sites, represented by these artifacts, were almost exclusively situated around the larger lake systems in New Brunswick and Nova Scotia. In New Brunswick, it is the Spednic Lake and Grand Lake areas around which all three classes of artifacts cluster. In Nova Scotia it is only the Gaspereau Lake area where all three classes occur, with Lake Rossignol having both rods and gouges, and Grand Lake having the most impressive number of full-channeled gouges.

With the possible exception of the Fairbanks collection, none of the provenience information for the specimens used in the present study indicates that any of the artifacts were found together, or with other artifacts, in what might constitute an assemblage. In a study such as the present undertaking, artifacts that are associated with assemblages can provide more information on site use and affiliation with archaeological cultures. Artifacts not associated with assemblages may, however, be considered stronger evidence for an early Holocene occupation of the Maritime Provinces, since it is theoretically possible that each artifact represents a different site.

Whether the Fairbanks collection represents the assemblage from a single site, is problematic. The Fairbanks collection was loaned to Harry Piers, prior to his 1895 paper, by Charles R. Fairbanks, who in turn had inherited the collection from his father Charles W. Fairbanks. On examining the collection, Piers commented that there were no labels on the artifacts indicating provenience but "there is no doubt that they are Nova Scotian and probably nearly all were found on Mr. King's farm" (Piers 1895:26). In a later survey of the area, Preston (1974) supports this, reporting that although there were no traces of prehistoric occupations in the area now, he believed that the King Farm is the source of some, if not all, of the Fairbanks Collection (1974:8).

The Fairbanks collection itself is quite substantial consisting of 38 celts or adzes, two plummets, two grooved axes, two large stemmed projectile points, and 17 gouges, all illustrated in Piers (1895). The fact that most of the sites reported from the Grand Lake area are Archaic in age, based on artifact forms, and that Charles W. Fairbanks had been the engineer in charge of the completion of the Shubenacadie Canal during the 1850s make this claim, that all of these artifacts are from the same location, questionable. Both of these factors may have provided Mr. Fairbanks with ample opportunity to add to his collection. This enigmatic situation deserves more attention, and until then considering the Fairbanks collection as a single site assemblage is thought to be premature.

The distribution of the artifacts, whether representing individual sites or not, indicates possible settlement patterns. Sites aggregated around lakes, especially those situated at the inlet-outlets of lakes, are usually interpreted as optimal locations for exploiting anadromous fish. Anadromous species are thought to be an important resource and site location factor for the Early and Middle Archaic sites in New England (Petersen and Putnam 1992; Spiess et al. 1983), as well as Late Archaic site distribution (Turnbaugh 1975). This is thought to be the case in the Maritimes as well.

One of the reasons that the Great Hiatus Model has persisted in Maritime Provinces prehistory has been the traditional approach of using projectile points as cultural and temporal markers. This approach in the Maritimes, as in Northern New England, has proven to give a negative image of occupation. With the recent excavations of well stratified and dated sites in Maine, certain ground stone forms have been recognized as better indicators. Full-channeled gouges and rods have been in the collections of the Maritimes for a long time but have never been found in professionally excavated sites, let alone in well dated contexts.

In Northern New England full-channeled gouges have been erroneously attributed to the Vergennes phase of the Laurention tradition based on its definition in New York State and Vermont (Ritchie 1965, 1968). The Vergennes concept is still used in Northern New England by some (Cox 1991; Sanger et al. 1977) but thought to be problematic, at least in some areas (Petersen and Putnam 1992; Robinson 1987:37; Sanger 1996). Barring the large side notched Otter Creek points that are characteristic of the Vergennes phase, the rest of the assemblage, as well as settlement and subsistence patterns, is very similar to the Gulf of Maine Archaic tradition (Cox 1991; Petersen and Putnam 1992). Therefore, Otter Creek points being found in the same contexts as full-channeled gouges and ground stone rods may be the result of site preservation factors resulting in compressed stratigraphy, rather than representative of single components (Petersen and Putnam 1992). The range of variation through time for full-channeled gouges is poorly known, although they appear to be widely distributed in the Northeast (Robinson 1992:86). As it stands, their exclusive association with the Gulf of Maine Archaic tradition is still questionable, but neither are they exclusively associated with the Vergennes phase as previously believed.

This research suggests that the early Holocene occupants of the Maritimes were very similar to those of Northern New England. The distribution of artifact classes used in the present study follows that of contemporaneous sites in Northern New England, with evidence of occupation along the major lakes and rivers and a lack of sites along the coast. There is no doubt that there were similar cultures throughout the Maritime Peninsula and Northern New England.

CHAPTER 6

PROPOSED MODEL

An early Holocene occupation of the Maritime Provinces is proposed. This model is based on the present research and thought to be compatible with the Gulf of Maine Archaic tradition. Hypotheses previously proposed to explain the Great Hiatus in Maritime Provinces prehistory are briefly discussed in light of this information. Data on site location and preservation factors from sites in Maine are reviewed and possible implications for the archaeological record of the Maritimes are discussed.

Proposed Model

The primary goal of the present research was to devise a working model of Early and Middle Archaic cultural manifestations in the Maritime Provinces. The three previous chapters have reviewed the existing literature on the paleoenvironment, re-interpreted the Gaspereau Lake site assemblage, and reported the results of a collections analysis of the available materials in New Brunswick and Nova Scotia. It is through the culmination of this research that a model of early Holocene occupation of the Maritimes will be based.

Paleoenvironmental evidence suggests strong affinities with Northern New England. An analogous environment with that of Northern New England, where there is well documented evidence of an Early and Middle Archaic presence, allows for the possibility of an early Holocene occupation in the Maritimes. The existing literature for the Maritimes has, for the most part, suggested that a non-productive environment was responsible for the perceived population hiatus. The history of relative sea level change and how it has affected the geography of the Maritimes suggests that the shoreline ca. 10,000 to 5000 B.P. was vastly different than contemporary shorelines. This would have resulted in the inundation of any sites located along the coast and erased most of the archaeological evidence of such an occupation.

The analysis of the Gaspereau Lake site assemblage provides concrete proof of a Middle Archaic Period, ca. 7000 B.P., occupation in Nova Scotia. The Stark style projectile points recovered from the earliest portion of the site, stratigraphically below two other groups of well known Late Archaic forms, are undeniable evidence for this. The full-channeled gouge fragment and ground stone rods suggest the possibility of an Early Archaic Period utilization of the site. Similarities that are perceived between the Gaspereau Lake site assemblage and that of the Sharrow site in Maine strengthen this interpretation.

The results of a collections analysis, looking at three artifact forms considered characteristic of Early and Middle Archaic cultures in Northern New England, has further demonstrated solid evidence of an early Holocene occupation of the Maritimes. Provenience information suggests the importance of lakes and river systems with all three artifact classes having similar distribution patterns, although they were recovered separately. Similarities in site distributions and artifact forms demonstrate a strong relationship with the Gulf of Maine Archaic tradition.

Based on this research it is proposed that the Maritime Provinces were occupied during the early Holocene. The distribution of Stark style projectile points suggests a Middle Archaic presence, while the full-channeled gouges and ground stone rods indicate an Early and Middle Archaic occupation. The distribution of the latter indicates that the southern portion of New Brunswick and most of Nova Scotia were populated during the early Holocene by people associated with the Gulf of Maine Archaic tradition. Based on artifact form alone, rods with expanding heads from Nova Scotia could possibly represent an occupation as early as 9000 B.P., as they have been dated in New Hampshire (e.g., Bolian 1980; Maymon and Bolian 1992). Both rods and gouges, although treated separately in the collections analysis, are believed to represent an occupation ca. 8000-6000 B.P. in the Maritimes, as they do in Maine (Petersen and Putnam 1992; Sanger 1996; Sanger et al. 1992).

The artifacts analyzed represent habitation sites almost exclusively. Mortuary artifacts associated with the Moorehead burial phase usually consist of finely made tools that appear too delicate for utilitarian purposes, covered in red ochre, often ritually broken, and found in assemblages. There was no residue of ochre on any of the artifacts analyzed, and most of the gouges and rods appear to have been well used, except specimen #16 (Plate 13), which may have been manufactured for mortuary purposes. With the exception of the Fairbanks collection as possibly representing one assemblage, about which the author has reservations, none of the artifacts were recovered in associations similar to the assemblages that have defined the Morrill Point and Table Land burial complexes.

The distribution of full-channeled gouges and ground stone rods suggests a settlement pattern influenced by the exploitation of anadromous fish species, or at least a focus on waterways. Sites along lakes and rivers, especially in the confluence of the two, would be prime locations for such resources. Sites situated along waterways would also have facilitated travel by boat providing access to both the interior and coast. The seasonal nature of anadromous fishing and ease of travel by water serve to both explain and question the pattern that is interpreted from the artifact distribution.

It is believed that the distribution of the artifacts in the present study reveals only part of a multiple site or station settlement and subsistence pattern. The exploitation of anadromous fish species only represents part of a seasonal round which included the capitalisation of marine resources along the coast. It would be hard to imagine coastal resources not being important to people who inhabited the Maritimes, especially with the prominent role they have played in settlement strategies in later times, such as the during the Ceramic and Historic periods. The submerging of the coastline in the Maritimes at a rate of approximately 30 cm per century (Grant 1975; Scott and Greenburg 1983) would have long inundated any sites situated along the coast dating from the early Holocene. Evidence of a coastal settlement pattern is almost non-existent, with only one gouge (#15) being dragged up off the coast of Indian Island (Black 1997). If this artifact is representative of a site along the paleocoastline, and not an overboard loss, when plotted on the sea level curve given for the Gulf of Maine and Bay of Fundy (a la Crock et al. 1993, Figure 5) it would indicate a site along the shore ca. 7500 B.P.

Sea mammal exploitation during the winter months may also have played a role in subsistence activities during the early Holocene. There is overwhelming evidence for the importance of seals to the prehistoric inhabitants of Newfoundland and Labrador (e.g., Erwin 1995; Fogt 1998; LeBlanc 1996; Murray 1992; Renouf 1993) and it continues to be an important resource today in Newfoundland and Labrador, as well as on Prince Edward Island and the Magdalene Islands. One of only three areas in the world where harp seals whelp, mate, and molt is on the pack ice in the Gulf of St. Lawrence (Sergeant 1991). Marine biologists believe that seal migration patterns have not changed drastically in the last 10,000 years (Sergeant 1991), and seals would therefore have been available to Early and Middle Archaic inhabitants of the Atlantic coast. This situation may be somewhat analogous to that in Labrador, where for thousands of years Maritime Archaic people flourished on the resources of the sea coast with their backs to a forest (Tuck 1991:41). The importance of marine resources to the Palaeoindian inhabitants of the Maritimes has also previously been proposed (Keenlyside 1985a, 1991; Tuck 1984). Unfortunately, evidence to support these claims has more than likely long been inundated by the sea.

Material culture of the early Holocene inhabitants of the Maritimes is thought to mirror that of the Gulf of Maine Archaic tradition. This has been demonstrated in the use of full-channeled gouges, ground stone rods, and stemmed projectile points found during the collections analysis, and in the perceived similarities between the Gaspereau Lake and

Sharrow site assemblages. It is hypothesized that the assemblages of well stratified early Holocene sites in the Maritimes, when they are discovered and excavated, will be similar to the sites excavated in Northern New England. It can be expected that sites will reveal assemblages including flaked stone tools characterized by a core and uniface technology, as well as ground stone forms. The flaked stone industry would include steep-edged quartz unifaces, irregular cores, flake tools, and flakes, with the selection of high quality quartz being a characteristic attribute, as it is in the early assemblages in Maine (Robinson 1992).

A wide ranging bone and antler tool industry is also expected. Preservation factors will dictate what will be recovered, but the nature of calcined bone has served to preserve over 60 individual fragments of bone tools ca. 6000-5800 B.P. from the Sharrow site in Maine. In the Maritimes faunal assemblages from interior sites are rare, and those that are recovered are almost exclusively calcined (Murphy and Black 1996:2). Poor preservation factors will also bias evidence of the proposed dugout boat technology.

Mortuary sites may also exist undisturbed in the Maritimes. These would again be analogous to those of the Table Lands and Morrill Point complexes of the Moorehead burial tradition. Morrill point complex cemeteries are said to occur on sand and gravel knolls and ridges, separate from occupation sites (Robinson 1992, 1996). They are characterized by red ochre deposits containing a variety of ground stone tool forms, including certain artifact forms thought to be indicative of age.

The model proposed for the Maritimes for the early Holocene is that people akin to the Gulf of Maine Archaic tradition lived along some of the larger lakes and rivers, perhaps as early as 9000 B.P., and that the Maritimes were populated throughout the Great Hiatus and continuously from Palaeoindian times, as Tuck (1975) has previously suggested. Artifact distributions suggest that sites were located along the major lake systems but marine resources are also believed to have been an important attraction (see Figure 11 in Chapter 7 for a summary of the proposed model). In light of the current research the hypotheses proposed to account for a rapid attenuation of archaeological evidence for the early Holocene will be discussed.

Earlier hypotheses

The lack of apparent evidence for an Early and Middle Archaic presence in the Maritime Provinces has led to the formulation of many different hypotheses that attempt to explain this phenomena. These have, for the most part, relied on environmental factors such as paleoenvironmental reconstructions and relative sea levels, but have also included the lack of surveys and the non-recognition of diagnostic artifact forms. These are be reviewed in light of the present research. While none of the proposed hypotheses can be completely discounted, some are shown to be more likely than others.

The most popular of the explanations is known as the Ritchie-Fitting Hypothesis. This proposes that a major hiatus in the archaeological record was the result of the paleoenvironment not having the carrying capacity to support an archaeologically significant population. The available data on paleoenvironmental reconstructions for the

Maritimes does not, alone, either validate or reject this hypothesis. Instead, it is the similarities between the reconstructed paleoenvironment of the Maritimes and that of New England, where there is significant evidence for an early Holocene occupation, that suggest that this is not a factor. This is further strengthened by the number and distribution of the artifact forms from the collections analyzed in the present study. If the fishing of anadromous species was a key factor in early Holocene settlement and subsistence strategies, then changes in the regional fauna would not have effected their availability as it would have for terrestrial resources. As is the case in Maine (Petersen and Putnam 1992:19-20), the Ritchie Fitting hypothesis is no longer valid in the Maritimes.

Other hypotheses that suggest environmental factors contributed to an occupational hiatus include Sanger's hypothesis that the Gulf of Maine, or Bay of Fundy, was too shallow (Sanger 1975) and his River Gradient Hypothesis (Sanger 1979). Both suggest that environmental conditions led to the impoverishment of biotic resources. The literature concerning the history and development of the Bay of Fundy and its tidal systems is quite contradictory (Turnbull 1988:95), and does not address the resources that might have been available. Instead, the distribution of artifacts from the collection analysis will be used to address this hypothesis.

Three of the gouges from New Brunswick, and most of the gouges and rods found in Nova Scotia, are located on river systems that drain into the Atlantic (see Figure 9 and 10). It has been suggested that seasonal settlement on the Atlantic coast would provide easy access to marine resources. This suggests that fluctuation in the biotic resources of the Bay of Fundy did not have any influence on a portion of the population. Evidence for people living along the lakes and rivers that drain into the Bay of Fundy also suggests that productivity was not debilitating.

The River Gradient Hypothesis has not been properly addressed in the present thesis. The development of the river systems since deglaciation has been affected by so many factors, such as isostatic rebound, lake formation and collapse, changes in relative sea levels, etc., that general statements, such as falls making rivers unusable to certain anadromous species, are problematic. Due to this complexity, these kinds of statements should be reserved for specific systems where evidence of these processes can be definitely demonstrated. Although this hypothesis may hold true for some river systems in the Maritimes, artifact distributions demonstrate that it does not hold true for the majority. Understanding the histories of individual river systems is, however, paramount to finding and understanding early Holocene sites in the Maritimes.

The Drowned Site Hypothesis is thought to be valid in light of the present research, albeit based on negative evidence and limited in explanation to coastal sites. Changes in the geography of the Maritime Provinces since early Holocene times is a result of the changes in the relative sea level. Sites along the shore between 10,000 and 5000 B.P. would be 18–16 meters and 58–8 meters below contemporary sea level according to sea level curves for the Maritimes (Grant 1975) and the Gulf of Maine (Sanger 1988), respectively. The full-channeled gouge found off the coast off Indian

Island is the only evidence for inundated coastal sites in the present study, but other evidence does exist. There have been numerous ulus, as well as other artifacts forms in smaller numbers, that have been dragged up off the coast of the Northeast and reported by archaeologists (e.g., Crock et al. 1993; Keenlyside 1984a; Turnbull and Black 1988). Ulus are the most suitable to such a recovery strategy since morphologically, they share the most attributes of any artifact forms with shellfish. Therefore, they are not believed to be very representative. Ulus are usually associated with the Late Archaic Vergennes phase of the Laurentian tradition (Cox 1995:151; Petersen 1995:218; Turnbaugh 1977), but some may well predate the Vergennes phase.

The Data Too Incomplete hypothesis (Sanger 1979) is also still valid in light of the current research. As suggested, pre 5000-year old artifacts are different than previously believed, and interior surveys of the Maritimes have been, for the most part, preliminary in nature, consisting of walking surveys and private collection analyses. Evidence for sites having been washed away was not presently addressed, but it is likely the case that they were at least mixed up if the same fluvial geomorphology and site preservation factors are in play in the Maritimes, as in Maine.

Site Preservation Factors

The premise of the present study is that the early Holocene occupants of the Maritimes are related to those of Northern New England. It is believed that people belonging to the same archaeological culture, using the same technologies, and living in similar environments lived in the Maritimes and Northern New England. Continuing in this vein, the comparative wealth of information on site preservation and location in Maine will be reviewed in order to perhaps better understand the situation in the Maritimes.

In Maine, well stratified early Holocene sites have survived in deeply buried contexts. In fact, 17 of the 22 dated early Holocene sites in Maine are situated within relatively deep riverine alluvium (Petersen and Putnam 1992:27). In the case of the Sharrow and Brigham sites, the relative stability of the river channels and the natural constriction in the river at the down stream end of the large confluence pool, have ensured regular and deep alluviation from the late Pleistocene epoch onward (Petersen and Putnam 1992:33). This has resulted in separating cultural deposits with regular sediment aggradation, thus allowing over 55 cultural features, usually interpreted as short-term events, to be defined. As part of the Piscataquis Archaeological Project, the Brigham and Sharrow sites have been extensively studied. The results of this interdisciplinary research are thought to shed some light on the archaeological record of the Maritimes.

It is locations along rivers with aggrading alluvium and stable river channels that serve to bury deeply, and thereby preserve, early Holocene sites in Maine. Without sediment accumulation the remains of multiple occupations at a site become a mixture of poorly separated, often inseparable assemblages (Pertersen and Putnam 1992:23). River channels that are not stable tend to meander and may bury cultural remains well away from modern river channels or, alternatively, erode them altogether. The historic damming of lakes in Maine has also affected site preservation, causing sites to be reworked into collections of artifacts (Petersen and Putnam 1992:24).

Across Eastern North America the most influential change in fluvial systems during the Holocene occurred before ca. 7000 B.P., although the record is variable from river system to river system. Recent research suggests that various drainages were likely unstable in northern Maine ca. 10,000-7000 B.P. (Petersen and Putnam 1992:24). These factors make discovery and testing of suitable archaeological contexts for early Holocene sites difficult in many riverine systems. Where evidence is preserved, contexts include deeply stratified sites, short-term deposits such as single occupation sites, and graves (Petersen and Putnam 1992:23). However, identification of these site types is generally difficult, demanding exceptionally deep excavation and close interval testing (Petersen and Putnam 1992:23). A sampling program would have to be designed to look at the specific places where stratified alluvium would be.

Assuming that circumstances are similar in Maine and the Maritimes, this information has many implications. With only two exceptions, the sites that artifacts represent in the collections are most likely from locations that have not been deeply buried by aggrading alluvium. Provenience information on full-channeled gouges and ground stone rods indicates that they were surface collected. The two exceptions are the gouges from the Montague River on Prince Edward Island and from the Clyde River in Nova Scotia. Both of these were reported to have been found buried in riverbank deposits at depths of five and 10 feet (1.5 and 3 m), respectively. This represents evidence that early Holocene sites do exist in the Maritimes, deeply buried along rivers.

The Gaspereau Lake site assemblage, with its cultural sequence from Palaeoindian times onward, may best be explained as the result of both a low amount of sediment accumulation and historic damming. This is suggested by both the horizontal distribution of the artifacts and shallow depths in which they were found. If not for the encroaching forests, which caused the inhabitants of the site to move northward over time, there would probably be no separation of the components at all.

The poor stratification of sites is also thought to explain why full-channeled gouges have been recovered in what is believed to be in association with Brewerton side notched points. This has caused their erroneous placement within the Late Archaic Vergennes phase of the Laurentian tradition in the Northeast.

It is suggested that the majority of artifacts examined do not constitute actual assemblages because of certain geological processes. These processes are a low accumulation of sediments which is caused the erosion and reworking of lakeshore sites. Furthermore, this lack of sedimentation and subsequent shallow burial most likely facilitated the chance curation of these artifacts by passing collectors. Evidence for an absence of sedimentation is illustrated by the shallow and subsurface position of the Gaspereau Lake artifacts, and the surface collection of gouges at Lake Rossignol.

Therefore, it is deeply-buried sites, awaiting to be discovered in burial contexts possessing a long history of aggrading alluvium, that hold the key to a better understanding of the archaeological record of the Maritimes ca. 10,000-5,000 B.P.

Stemming from multidisciplinary research in Maine, favourable contexts for the preservation of early Holocene sites in the Maritimes may be located using combined methods from archaeology, geology, and remote sensing.

CHAPTER 7

CONCLUSIONS AND DISCUSSION

The goal of the present research was to devise a working model of Early and Middle Archaic cultural manifestations in the Maritime Provinces. This research included a review of the paleoenvironmental literature, a reanalysis of a semiprofessionally excavated site, and data obtained from a collections analysis, and resulted in a preliminary model of an Early and Middle Archaic occupation in the Maritimes. Furthermore, several questions related to this problematic period in the archaeological record were addressed.

According to the model presented here, there was no occupational hiatus in the Maritimes Provinces during the early Holocene. At present, the model consists of information on material culture, settlement patterns, and subsistence strategies (see Chapter 6 and summary in Figure 11). Early and Middle Archaic material culture from archaeological sites and surface collections suggests a close affinity to the Gulf of Maine Archaic tradition. It should be noted that this model is preliminary in nature, and is intended as a tentative framework for structuring future research into the Early and Middle Archaic period in the Maritimes.

Material Culture:	•Ground stone tools, including grounds stone rods, full-channeled gouges, among other forms.
	•Paucity of bifaces, although some stemmed forms may occur after ca. 6500 B.P.
	•Quartz core and uniface flake technology.
	•Bone and antler technology.
	•Specialized mortuary artifacts.
Settlement Pattern:	•Interior lacustrine, along the lakes and major rivers.
	•Coastal, based on negative evidence.
Subsistence:	•Terrestrial mammals.
	•Anadromous and catadromous fish species.
	•Sea mammals, as well as other marine resources.

Figure 11. Characteristics of the proposed model.

Other than suggesting strong affinities with the Gulf of Maine Archaic tradition, the model does not address regional relationships. Since the study area is located between the Gulf of Maine Archaic tradition peoples in Northern New England, and the Maritime Archaic peoples living along the Strait of Belle Isle by 8000 B.P. and the Island of Newfoundland by 5000 B.P., it may some day reveal possible relationships between the two culture areas. Indeed, researchers from both regions have suggested this, especially between the Late Archaic Maritime Archaic and Moorehead traditions, as well as the earliest burial complexes of the recently redefined Moorehead burial tradition

(Robinson 1992, 1996). However, such comparisons may have to be put aside until early Holocene sites have been excavated in the Maritimes.

Ample evidence for in situ early Holocene cultural deposits in the Maritimes does exist. From the present analysis, the two gouges that were reportedly found deeply buried in riverbanks in Nova Scotia and Prince Edward Island indicate a great potential for more sites. Perhaps the best evidence may be the Kitchen site (CaDu-1), located high up on the bank of the St. John River in New Brunswick. This site was initially tested by Sanger in 1967, and recently reinterpreted as having produced artifacts reminiscent of early Holocene sites in Maine (Sanger 1996:23). This area is still accessible today, and could easily be retested. Although a radiocarbon assay had returned a modern date, the artifacts reported were buried beneath fluvial deposits, below the modern plowzone, indicating their considerable age (Sanger 1996:23). As well, the possibility of locating early Holocene sites that have long been inundated by the rising sea levels may also someday play a significant role, following contemporary research in locating and excavating sites along the North American Continental Shelf (e.g., Stright 1990). It will only be the discovery and excavation of stratified, well dated sites in the Maritimes that will serve to finally fill in the Great Hiatus. The information from the present study, coupled with research from Northern New England, will be paramount for accomplishing this.

Future Research

The wealth of research into the early Holocene in Northern New England, especially that resulting from the Piscataquis Archaeology Project, is the basis for the suggested future research strategies. Methods to find sites of this age in the Maritimes may include starting out with a broad regional analysis of late Quaternary geomorphology. This would include an aerial photograph analysis of the terrain detailing drainage patterns, late glacial landforms, and surficial deposits (Putnam 1994:474-475). In Maine, aerial photographs of the area surrounding the Sebec and Piscataquis River confluence, the location of the Brigham and Sharrow sites, were analyzed using standard methodologies (Way 1973). Drainage patterns were found to be generally coarse textured and angular dendritic, indicating that the river channel has been controlled by joint fractures, or bedding planes, in the underlying metasedimentary bedrock (Petersen et al. 1986). This resulted in the channel control that is responsible for maintaining the Sebec and Piscataquis rivers in their present position throughout the span of the Holocene epoch. Coupled with regular sediment alluviation, this has served to preserve well stratified sites, such as Brigham and Sharrow. Similar situations may also exist in the Maritimes, such as is known for the younger Ceramic Period Oxbow site (Allen 1981).

Thus a remote sensing methodology can be used to find high potential areas for early Holocene sites in the Maritimes. Locations that display potential could then be tested by high resolution column sampling. Sampling would indicate if the location had aggrading sediments, possibly how long, and may even provide cultural evidence indicating site potential.

Although surveys of lakes and river systems in the Maritimes are likely to uncover many more artifact forms that are characteristic of the Early and Middle Archaic, it will only be the excavation of dated, well stratified sites that will refine the proposed model. When these sites are found, it is expected that the assemblage of the earliest levels, ca. 9000-8000 B.P., will be dominated by thick quartz cores and scrapers, tabular choppers or knives, and ground stone rods similar to the earliest levels in the occupation sites in Northern New England (Bolian 1980; Maymon and Bolian 1992; Petersen and Putnam 1992). This may be followed by the addition of full-channeled gouges, celts, ground slate points, and plummets to the assemblages ca. 8000-6000 B.P., similar to the Brigham and Sharrow sites (Petersen 1991; Petersen and Putnam 1992). Although the paucity of bifaces of any kind are one of the characteristics of the above levels, after ca. 6500 B.P. some stemmed point forms may occur that are similar to Middle Archaic forms defined at the Neville site (Dincauze 1976).

Excavating such sites in the Maritimes would not only add to the local archaeological record, but to our present knowledge of the Archaic period in the Northeast in general. The location of the Maritimes place it in a very important position when looking at both interregional and intraregional culture relationships during the Archaic Period. Excavated sites may also contribute to ongoing research into the early Holocene occupations of Maine by providing insights into questions relating to subsistence strategies (Spiess 1992) and the nature and timing of plant domestication (Petersen and Asch Sidell 1996; Petersen and Putnam 1992).

Evidence presented in this thesis strongly suggests an early Holocene presence in the Maritimes. The present research may well provide the structure for future projects that are focused on finding and excavating Early and Middle Archaic sites. Given that similar settlement patterns persisted throughout the Archaic period, it is likely that any such sites excavated in the future will be multicomponent sites. Therefore, future research will likely contribute to the knowledge of the entire Archaic period and not just the Early and Middle Archaic portions thereof.

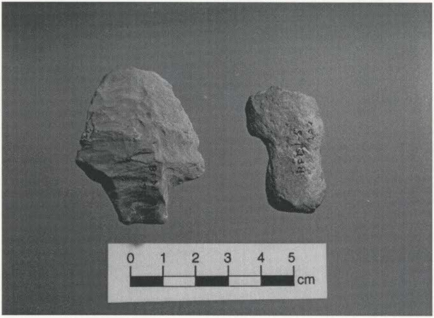

Plate 1. Artifacts that Erskine attributed to his Blue-whin phase but have been reclassified as Late Archaic. From left to right # 294, and 202.

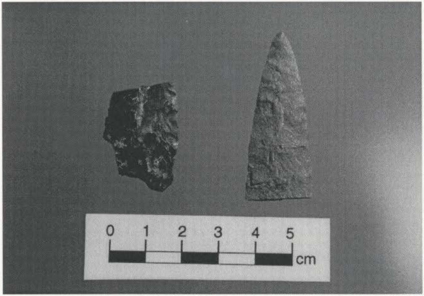

Plate 2. Palaeoindian projectile points. From left to right #158, and 193.

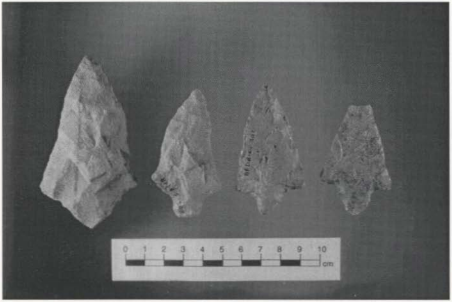

Plate 3. Erskine's Group 2 projectile points. From left to right #314, 308, 201, and 230. Specimens 314 and 308 have been reclassified as belonging to Group 5, while #201 and 230 are similar to Stark style forms

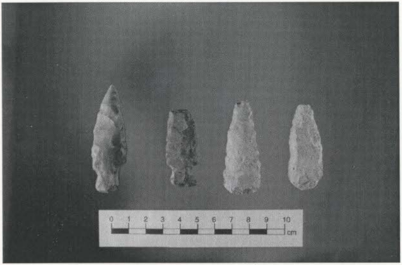

Plate 4. Erskine's Group 3 projectile points. From left to right #167, 310, 218, and 203. Specimens 167 and 310 are similar to Merrimack style points, while # 218 and 203 are thought to be too amorphous to classify precisely.

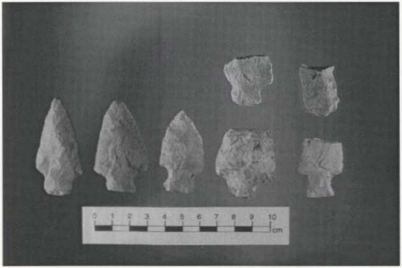

Plate 5. Erskine's Group 4 projectile points. Bottom row from left to right #315, 182, 165, 264 and 228. Top row #295, and 190. These points are associated with the Susquehanna or Broadspear tradition.

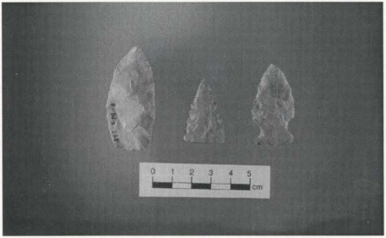

Plate 6. Projectile points from various groups. From left to right #325 (Erskine's Group 5), 169 (Erskine's Group 7), and 240 (Erskine's Group 8).

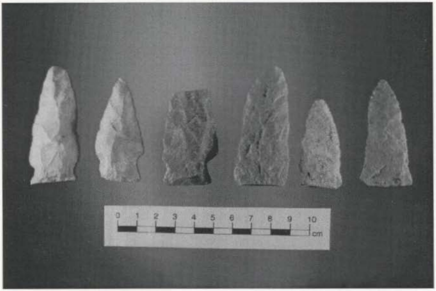

Plate 7. Erskine's Group 6 projectile points. From left to right #166, 220, 217, 181, 322, and 168. These points are associated with the Laurentian tradition.

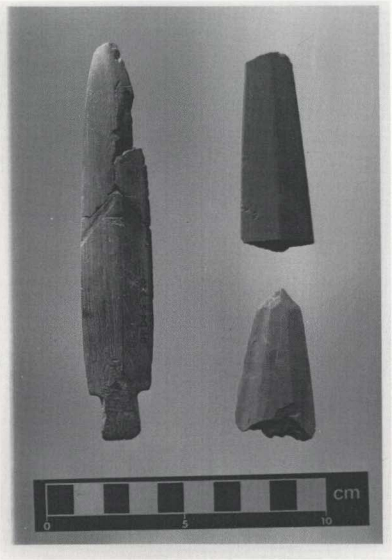

Plate 8. Ground slate knives from the Gaspereau Lake site assemblage. Clockwise from left #320, 210, and 309.

Plate 9. Pre-plummets and a plummet from the Gaspereau Lake site assemblage. From left to right #21, 354, 2, and 231.

Plate 10. Miscellaneous ground stone artifacts from the Gaspereau Lake site assemblage. Top row from right to left #14 (adze blank), 44 (adze), 317 (adze), 9 (adze blank). Bottom row from right to left # 26 (adze blank), and 266 (bit fragment of a full-channeled gouge).

Plate 11. Grooved axes from the Gaspereau Lake site assemblage. Left to right #27, and 6.

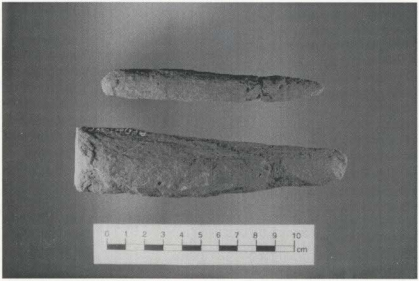

Plate 12. Ground stone rod and rod preform from the Gaspereau Lake site. Catalogue number for both artifacts is #28.

Plate 13. Full-channeled gouge, #16 in appendix, found along the St. John River above Fredericton.

APPENDIX A

ARTIFACTS MENTIONED IN THE TEXT

\# provenience; artifact's location or source if not located (accession # and any other information that is written on the artifacts): other sources; attributes and miscellaneous information.

Contracting Stemmed 'Neville' and 'Stark' Style Points (n= 7)

1. Gaspereau Lake (BfDd-5); Gaspereau Lake site assemblage (BfDd-5:230); Erskine 1967, also see Keenlyside 1984b: slide 7.

2. Gaspereau Lake (BfDd-5); Gaspereau Lake site assemblage (BfDd-5:201); Erskine 1967, also see Keenlyside 1984b: slide 7.

3. Spednic Lake (BkDw-3); Archaeological Services New Brunswick collection (JBG:11/516/BkDw-3); also see Tuck 1991:39, figure 2.2.

4. Spednic Lake (BkDu-29); Archaeological Services New Brunswick collection (JBG:130/413); in a box labeled BjDv-29.

5. Spednic Lake (BjDv-10/11); In Armstrong 1982:15 (JBG 385); Unable to locate this artifact.

6. Star Island, Palfrey Lake (BkDu-3); In Tuck 1991: Figure 2.2; From Lounder collection.

7. Grand Lake; Archaeological Services New Brunswick collection (5332HG/5332); collected by John Gunter near the mouth of Jemseg.

Full-Channeled Gouges (n= 94)

1. Palfrey Point (BjDu-16); In Allen 1983:7, figure 16a; expanding parallel.

2. Diggity Stream (BjDu-4); In Allen 1983:11, figure 16h; flared.

3. Spednic Lake (BkDw-7); In Deal 1983 (JBG 908); parallel.

4. Spednic Lake (BgDu-7); In Deal 1983 (JBG 63); parallel.

5. Spednic Lake (BjDv-8); In Armstrong 1982 (JBG 332).

6. Spednic Lake (BjDu-7); Archaeological Services New Brunswick collection (JBG 62/328/ BjDu-7); also in Armstrong 1982:3, and Deal 1983; flared, incomplete.

7. Spednic Lake (BjDu-13); Archaeological Services New Brunswick collection (RML 75); also in Deal 1983; wide parallel, incomplete, evidence of hammering on butt end, constricted for hafting.

8. Spednic Lake (BjDu-13); Archaeological Services New Brunswick collection (RML 80); also in Deal 1983; flared, constricted for hafting.

9. Spednic Lake (BjDu-13); Archaeological Services New Brunswick collection (RML 82); also in Deal 1983; flared.

10. Spednic Lake (BjDu-29); Archaeological Services New Brunswick collection (JBG 927); also in Deal 1983; flared.

11. St. Croix ; Archaeological Services New Brunswick collection (JBG 880/St. Croix); also in Deal 1983, wide parallel, incomplete, evidence of hammering.

12. Phil's Beach, Bocabec River (BgDr-25); Archaeological Services New Brunswick collection (BgDr-25:123/979.74.74); flared, incomplete.

13. Lake Utopia; New Brunswick Museum collection (stone gouge, Lake Utopia, L Y MacLearen Esq. Feb. 1900); also in Wintemberg 1913; wide parallel, evidence of hammering on the butt end.

14. Rouen Island site, Marble Island (BfDr-8); Archaeological Services New Brunswick collection (BfDr-8:3); wide parallel, two grooves on the dorsal surface.

15. Off the coast of Indian Island; In Black 1997; parallel, found at a depth of 38m.

16. Fredericton; New Brunswick Museum collection (5211 HHH); also in Wintemberg 1913; flared, found on St. John River above Fredericton.

17. Grand Lake; New Brunswick Museum collection (10L.G.); also in Wintemberg 1913; parallel.

18. Grand Lake; New Brunswick Museum collection (5332 JG/198); also in Wintemberg 1913; wide parallel.

19. Grand Lake; New Brunswick Museum collection (WM 14/201); also in Wintemberg 1913; flared.

20. Grand Lake; In Wintemberg 1913 (5332 J.G.); parallel.

21. Indian Point; New Brunswick Museum (D.B. 15/202/Indian Point, D. Balmaiq, Aug. 1901); also in Wintemberg 1913; flared.

22. Indian Point; In Wintemberg 1913 (5340 D.B.); wide parallel.

23. French Lake; In Wintemberg 1913 (524 0/F.T.B.); parallel.

24. Jemseg; New Brunswick Museum collection (5407 WM); flared, incomplete.

25. Mouth of Jemseg; Archaeological Services New Brunswick collection (RPG 644); also in Wintemberg 1913; parallel.

26. Upper Jemseg; New Brunswick Museum collection (20.955/ Upper Jemseg, W.M.); flared, incomplete.

27. Big Lake Musquash; New Brunswick Museum collection (Big Lake Musquash/X8002-80FHS); flared, evidence of hammering on the butt end.

28. Westfield Beach; New Brunswick Museum collection (Westfield Beach, Mr. Samuel Lyons, Aug. 15 1896); also in Wintemberg 1913; parallel.

29. Richibucto River; New Brunswick Museum collection (32/285); also in Wintemberg 1913; parallel, has deep incised lines.

30. Wirrell, King's County; New Brunswick Museum collection (29615 Charles Perkins, Wirrell); wide parallel.

31. Nipisiquit River; In Wintemberg 1913; Accession 78 Cat. No. VII-D-I; parallel; 1 ½ miles above Bathurst.

32. River Philip; In Deal and Rutherford 1991; parallel.

33. Wentworth site (BkCv-3); In Deal 1996; Sunrise Trail Museum.

34. Scottsville, Margaree River; Nova Scotia Museum (26.94.4/5925/Gouge, Scottsville, Inn. Co. N.S.); also see Deal and Rutherford 1991; expanding parallel.

35. Enfield (BfCv-10); Nova Scotia Museum collection (4014/ 1/2 mile south of Enfield/1318); also see Preston 1974:24, and Deal and Rutherford 1991; wide parallel.

36. Grand Lake, King Farm (BfCv-17); Nova Scotia Museum collection (1/4.70); also in Piers 1895:Figure 70, and Deal and Rutherford 1991; wide parallel, from the Charles Fairbanks collection.

37. Grand Lake, King Farm (BfCv-17); Nova Scotia Museum collection (07.4.68); also in Piers 1895:Figure 68, and Deal and Rutherford 1991; parallel, incomplete, from the Charles Fairbanks collection.

38. Grand Lake, King Farm (BfCv-17); Nova Scotia Museum collection (07.4.69); also in Piers 1895:Figure 69, and Deal and Rutherford 1991, parallel, from the Charles Fairbanks collection.

39. Wellington, Grand Lake (BfCv-17); Nova Scotia Museum collection (884/02.116/Wellington, Grand lake, N.S.); parallel.

40. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 56; also in Deal and Rutherford 1991; expanding parallel, incomplete, from the Charles Fairbanks collection.

41. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 57; also in Deal and Rutherford 1991; wide parallel, from the Charles Fairbanks collection.

42. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 58; also in Deal and Rutherford 1991; wide parallel, from the Charles Fairbanks collection.

43. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 60; also in Deal and Rutherford 1991; parallel, from the Charles Fairbanks collection.

44. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 66; Deal and Rutherford 1991; parallel, from the Charles Fairbanks collection.

45. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 67; also in Deal and Rutherford 1991; parallel, from the Charles Fairbanks collection.

46. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 71; also in Deal and Rutherford 1991; wide parallel, from the Charles Fairbanks collection.

47. Grand Lake, King Farm (BfCv-17); In Piers 1895:Figure 72; also in Deal and Rutherford 1991; wide parallel, incomplete, from the Charles Fairbanks collection.

48. Lake Thomas (BeCv-5); Nova Scotia Museum collection; (32.79/74080); parallel, collected by Neil McQuarrie c. 1880, Lake Thomas, Halifax County.

49. Melanson; Nova Scotia Museum collection (73.180.430); parallel, incomplete.

50. Gaspereau Lake (BfDd-5); Gaspereau Lake site assemblage (BfDd-5:266); in Erskine 1967; parallel, incomplete.

51. Gaspereau Lake (BaDf-4); Jim Legge collection (BaDf-4); expanding, incomplete.

52. Gaspereau Lake (BaDf-4); Jim Legge collection (BaDf-4); parallel.

53. Gaspereau Lake (BaDf-4); Jim Legge collection (BdDf-4); flared, incomplete.

54. Gaspereau Lake (BaDf-4); In Deal and Rutherford 1991; also in Deal 1991, unable to locate in the Jim Legge collection.

55. Salmontail Lake; In Deal and Rutherford 1991; also in Deal 1991; from the Jim Legge collection.

56. Salmontail Lake; In Deal and Rutherford 1991; also in Deal 1991; from the Derek Redden collection.

57. McGowen Lake (BeDg-2); St. Mary's University collection (BeDg-2:366); flared.

58. McGowen Lake (BeDg-2); St. Mary's University collection (BeDg-2: 278); parallel, incomplete.

59. Indian Gardens; Queen's County Museum collection (THR 27); wide parallel, incomplete.

60. Indian Gardens; Queen's County Museum collection (THR 25); parallel.

61. Indian Gardens (BaDg-2); Queen's County Museum collection (BaDg-2); wide parallel.

62. Indian Gardens (BaDg-2); In Kemp 1987:20 (THR 24).

63. Indian Gardens (BaDg-2); In Deal and Rutherford 1991.

64. Indian Gardens, Low Terrace site (BaDg-2); In Kemp 1987 (BaDg-2:114); also see Deal and Rutherford 1991; flared.

65. Lake Rosignol, Mersey River (BaDf-5); Nova Scotia Museum collection (BaDf-5:12); also in Myers 1973; parallel.

66. Lake Rosignol, Mersey River (BaDf-5); Nova Scotia Museum collection (BaDf-5:11); also in Myers 1973; expanding parallel, evidence of hammering on the butt end.

67. Lake Rosignol (BaDh-2); Nova Scotia Museum collection (BaDh-2:8); also in Rosignol Survey 1985; parallel, incomplete.

68. Lake Rosignol (BaDh-1); Nova Scotia Museum collection (BaDh-1:19); also in Rosignol Survey 1985; wide parallel, incomplete.

69. Lake Rosignol (BaDh-1); Nova Scotia Museum collection (BaDh-1:5); also in Rosignol Survey 1985; wide parallel.

70. Lake Rosignol (BaDh-2); Nova Scotia Museum collection (BaDh-2:4); also in Rosignol Survey 1985; parallel, incomplete.

71. Lake Rosignol (BaDh-15); Nova Scotia Museum collection (BbDg-15:7); also in Rosignol Survey 1985; flared, incomplete.

72. Lake Rosignol (BaDg-2); In Rosignol Survey 1985 (BaDg-2:121); also see Deal and Rutherford 1991.

73. Shelburne River; Queen's County Museum collection (86:42:12); expanding parallel, incomplete, Shelburne River is possible location Inness 1997.

74. Shelburne River; Queen's County Museum collection (86:42:12); expanding parallel, incomplete, Shelburne River is possible location Inness 1997.

75. Barren Lake (AlDk-2/5); Yarmouth County Museum collection (WTS 370); parallel, provenience Powell 1997.

76. Eel Lake (BbDm-5); Nova Scotia Museum collection (BbDm-5:24); also in Davis 1991; flared; incomplete.

77. Clyde River, Shelburne County; In Piers 1911:206; also in Deal and Rutherford 1991; found at a depth of 10 feet.

78. Montague PEI; Cunningham 1998: parallel.

79. No provenience; Queen's County Museum collection; expanding parallel.

80. No provenience; Nova Scotia Museum collection; parallel.

81. No provenience; Nova Scotia Museum collection; parallel.

82. No provenience; Nova Scotia Museum collection; flared.

83. No provenience; Nova Scotia Museum collection (01186); flared, incomplete.

84. No provenience; Nova Scotia Museum collection (0.191 A); wide parallel.

85. No provenience; Nova Scotia Museum collection (3574/10.6); expanding parallel.

86. No provenience; Nova Scotia Museum collection; parallel, evidence of hammering on the butt end.

87. No provenience; Queen's County Museum collection (83-043.7); parallel, incomplete, evidence of hammering on the butt end.

88. No provenience; Queen's County Museum collection (86.23); wide parallel, incomplete.

89. No provenience; Yarmouth County Museum collection; wide parallel.

90. No provenience; Yarmouth County Museum collection; wide parallel.

91. No provenience; Yarmouth County Museum collection; expanding parallel.

92. No provenience; New Brunswick Museum collection; (X8002.2); expanding parallel.

93. No provenience; Archaeological Services New Brunswick collection; expanding parallel.

94. No provenience; In Wintemberg 1913 (33/2262 Gesner); wide parallel.

Ground Stone Rods (n= 21)

1. Eel Lake (BbDm-5); Nova Scotia Museum collection (BbDm-5:32); also in Davis 1991:74; incomplete.

2. Eel Lake (BbDm-5); Davis 1991:74; unable to locate artifact.

3. East Brook, Lake Rosignol (BbDg-12); In Rosignol Survey 1985 (BbDg-12:11); also in Deal and Rutherford 1991.

4. Cook's Falls, LaHave River; Nova Scotia Museum collection (00.10.9/Cook's Falls, LaHave River, Bridgewater); expanding head, complete, 275 mm long.

5. Sherbrook Lake (BeDd-1); Nova Scotia Museum collection (BeDd-1:7); expanding head; incomplete.

6. Sherbrook Lake; Jim Legge collection; found near the head of the LaHave River.

7. Gaspereau Lake (BfDd-5); Gaspereau Lake site assemblage (BfDd-5:28); also in Erskine 1967.

8. Gaspereau Lake (BfDd-5); Gaspereau Lake site assemblage (BfDd-5:28); also in Erskine 1967; preform?.

9. Upper Nine Mile Lake, Hants County; In Deal and Rutherford 1991; also in Preston 1991.

10. Maquapit Lake; New Brunswick Museum collection (slickstone/73/Maquapit Lake); incomplete.

11. Maquapit Lake; Archaeological Services New Brunswick collection (5184 DB); incomplete.

12. Indian Point, Grand Lake; New Brunswick Museum collection (DB 979.62.28); incomplete, collector lived near Indian Point Laroque 1997.

13. Indian Point, Grand Lake; New Brunswick Museum collection (979.62.27 DB); incomplete, collector lived near Indian Point Laroque 1997.

14. Portobelo; New Brunswick Museum collection (5335); incomplete.

15. Jemseg (BkDm-14); Archaeological Services New Brunswick collection (BkDm-14:783); incomplete, found in test pit 1 Jeandron 1997.

16. Phil's Beach, Bocabec River (BgDr-25); Archaeological Services New Brunswick collection (BgDr-25:3/74/battered slickstone); incomplete.

17. Spednic Lake (BjDu-7); Archaeological Services New Brunswick collection (JBG: 375); also see Armstrong 82:7, and Deal 1983; complete, both ends taper to points.

18. Spednic Lake (BjDu-10); In Armstrong 1982:7 (JBG 427); also in Deal 1983; both ends taper to points, unable to locate this artifact.

19. Wabski; New Brunswick Museum collection (44.41 ETA); incomplete, from site W-1.

20. No provenience; Yarmouth County Museum (WTS 635); incomplete.

21. No provenience; Davis 1997 (WTS 688); rod in the Wilbur Sollows collection.

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