STABLE ISOTOPE EVIDENCE FOR AMERINDIAN SUBSISTENCE IN NEWFOUNDLAND, 2800 B.C. to A.D. 1829

by ©Alison J. T. Harris

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ABSTRACT

Archaeological research has informed on the lifeways of Newfoundland's past Amerindian populations, but their subsistence practices are still poorly understood, particular with respect to the roles played by marine and terrestrial resources. To investigate Amerindian diet, isotope ratios ($\delta^{13}C_{coll}$, $\delta^{15}N_{coll}$) were measured in 86 skeletons from the Maritime Archaic site of Port au Choix-3 (4500 – 4000 cal B.P.), and in 29 skeletons from 12 Recent Indian/Beothuk sites (AD 1000 – 1800). Whole dietary carbon was estimated by measuring carbon isotopes in the enamel of 12 Beothuk skeletons. The Maritime Archaic sample was characterized by the presence of at least two subsistence patterns: one marine-based, and the other mixed marine-terrestrial. These patterns may relate to geographic origin, or to biosocial categories. Recent Indian/Beothuk diet was revealed to be predominantly mixed marine-terrestrial in origin, but characterized by increasing amounts of terrestrial foods in the late historic period.

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RESEARCH CONTRIBUTIONS

Conference papers

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2015 The Social Meaning of Food in a Marginal Environment. Paper presented at the *47th Annual Meeting of the Canadian Archaeological Association*, St. John, NL.

Harris, A., M. Deal, and V. Grimes

2015 Mi'kmaq Diet in the Early Historic Period: New Radiocarbon Dates and Human Stable Isotope Data from Prince Edward Island, Canada. Paper presented at the *1st UPEI Multidisciplinary Graduate Research Conference*, Charlottetown, PE.

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Conference posters

Rand, A., J. Munkittrick, M. Bower, A. Harris, M. Burchell and V. Grimes

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Manuscripts and published reports

Harris, A. and V. Grimes

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Harris, A.

2015 A Bioarchaeological Study of the Human Remains Recovered from West Point Cemetery (CjAf-08), Portugal Cove, NL. *Provincial Archaeology Office Annual Review* 13: 65-70.

Deal, M., J. Campbell, and A. Harris

2015 Preliminary Report on the Boswell Archaeological Project 2014. Ms. on file with the Nova Scotia Museum, Halifax, NS.

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CHAPTER 1: INTRODUCTION

1.1 Overview of the Project

The focus of this thesis is the reconstruction of the subsistence patterns of two temporally separated Amerindian hunter-gatherer populations, known to archaeologists as the Maritime Archaic people (5440-3200 B.P.) and the Recent Indians (2000-200 B.P.) (Renouf 2011). With the permission of the Qalipu and Miawpukek Mi’kmaq First Nations, the Innu, the NunatuKavut and the Nunatsiavut Government, this research utilized a biochemical approach that combined stable isotope analysis and radiocarbon dating of human skeletal tissues to reconstruct the diets of Amerindians within a chronological and archaeological interpretative framework. This research was conducted as part of a three-year collaborative project between Memorial and McMaster Universities. The project aims to combine the isotope and radiocarbon data produced in this thesis with ancient DNA analysis and ethnohistoric research to answer a host of archaeological questions, namely what were the origins of Newfoundland’s Amerindian populations?; how did past populations on the island incorporate resources from the sea and land into their subsistence and settlement patterns?; and, what was the influence of cultural and social factors in shaping past lifeways on the island?

Prior to European contact, the island of Newfoundland was home to at least two distinct cultures of Amerindian descent. These are identified archaeologically as the Maritime Archaic Tradition and the Recent Indian Tradition. The Recent Indian Tradition includes the historic Beothuk people who occupied the island at the time of European exploration and settlement of North America. Beothuk and earlier Recent Indian subsistence practices have been reconstructed from archaeological and limited ethnohistorical lines of evidence (Marshall 1996). Their way of life was based on the use of a diverse range of marine and terrestrial animal resources, food storage, and seasonal mobility (Marshall 1996). The Beothuk culture disappeared in the early 19th century, with the death of Shawnadithit, a woman thought to be the last Beothuk (Howley 1915). The extinction of the Beothuk has been attributed to disease, violent clashes with European fishermen and settlers, and the disruption of traditional Beothuk life- and foodways (Howley 1915; Marshall 1996).

In contrast, much less is known about the subsistence practices of the Maritime Archaic population in Newfoundland. Most interpretations take the form of broad generalizations drawn from archaeological evidence in Newfoundland, Labrador and the Maritime Provinces of Canada (Lacroix 2015; Spiess 1992; Tuck 1971). While most Maritime Archaic sites are found along the coastlines, implying a marine adaptation, a small percentage of sites are also found in the interior of the island, but their significance is not fully understood (Renouf and Bell 2006). A preliminary study of the bone chemistry of Maritime Archaic period human skeletons from the Port au Choix-3 burial site supported a marine adaptation, but revealed variation within the population that has not yet been satisfactorily explained (Jelsma 2000; Wright 2006).

This study employs radiocarbon dating and stable isotope analysis to further reconstruct the subsistence practices of Amerindian people in Newfoundland. Human skeletal remains from the Maritime Archaic burial ground of Port au Choix-3, and 10 Beothuk mortuary sites were sampled for biochemical analyses. Forty-six radiocarbon determinations were made on human bone so that human diet could be linked to a particular cultural or environmental context, and allow the progression of lifeways to be traced through time. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope analysis was conducted on human bone collagen, and $\delta^{13}C$ analysis was conducted on human enamel bioapatite. By analysing collagen, which tracks dietary protein, and bioapatite, which tracks whole dietary carbon, an increasingly comprehensive picture of human palaeodietary can be reconstructed (Ambrose and Norr 1994). Comparative faunal isotope data is critical to this aim (Schwarcz and Schoeninger 1993), therefore $\delta^{13}C$ and $\delta^{15}N$ analysis was also conducted on the bones of archaeological animals. In turn, these data can be combined with evidence from the archaeological and ethnohistoric records to shed light on the roles of different prey taxa and ecosystems in Amerindian subsistence to further elucidate human-environment interactions on the island.

The cultural meanings attributed to food, and to animals in particular, are mutable and can be accessed via the archaeological record through *chaîne opératoire*-style studies of zooarchaeological assemblages, figurative representations of animals, and by studying the diets of humans (Ingold 2000; Jelsma 2000; Jones and Richards 2003). Amongst the Maritime Archaic people of Newfoundland, the cultural attitudes towards seabirds, seals, caribou and beaver have been explored using stable isotope analysis of human bone and archaeological analysis of the mortuary assemblage from Port au Choix-3 (e.g. Jelsma 2000; Tuck 1971). Although previous research has suggested a link between terrestrial food consumption, mortuary patterning, and social status (Jelsma 2000, 2006), this was not found to be the case by the comprehensive sampling protocol employed in this thesis. Human-animal interactions have been hypothesized for the Recent Indian and Beothuk occupations based on zooarchaeological assemblages and ethnohistoric records (e.g. Kristensen 2011). The evidence suggests that both seabirds and caribou held positions of cosmological significance. Seabirds may have mediated between this world in the afterlife (Kristensen and Holly 2013), while the caribou hunt served as a focal point for social aggregation and was instrumental in affirming Beothuk cultural identity (Holly 2000; Howley 1915; Marshall 1996). The findings presented in this thesis provide bioarchaeological support for the current archaeology-based understandings of Beothuk subsistence. Throughout much of the historic period (ca. A.D. 1500-1700), the Beothuk sourced their dietary protein from marine and terrestrial environments, with minor variation occurring between individuals. Towards, and into the 19th century, a gradual decline in the amount of marine protein consumed is detectable in the isotope values of Beothuk skeletons. This is consistent with the archaeological record, which shows a decline in the size of coastal sites, and a greater number of sites along the rivers and lakes found in the forested interior of the island (Holly 2008).

1.2 Research Aims

This research aims to provide a diachronic reconstruction of Amerindian subsistence practices. For the Maritime Archaic period, the aim is to move beyond generalization and provide a nuanced reconstruction of subsistence that can act as a starting point for future investigations of Amerindian lifeways, such as mobility, the influence of social determinants on resource use, and a richer analysis of human-animal interactions. This research is further intended to test the hypothesis of subsistence change over the Recent Indian period. Assuming that the skeletons affiliated with this period are representative of the larger population, Recent Indian dietary practices during the pre- and post European contact periods will be investigated to explore the influence of European settlement on Amerindian lifeways prior to the Beothuk cultural extinction.

1.3 Research objectives

1.3.1. Isotope ecology of Newfoundland

The first objective is to provide a baseline for estimating human diet by characterizing the isotopic variation in marine and terrestrial animal species. This objective employed $\delta^{13}C$ and $\delta^{15}N$ analysis of the collagen from animal bones from archaeological sites in Newfoundland. This provided the foundation for human palaeodietary reconstruction, and was a critical factor for proper calibration of human radiocarbon dates.

1.3.2. Chronological framework

The second objective is to situate the mortuary sites within an absolute temporal framework by radiocarbon dating at least one skeleton from each site. The faunal isotope data from the first objective were used to define region-specific marine and terrestrial isotopic endpoints to allow the relative contributions from the atmospheric and marine radiocarbon reservoirs to human tissue to be quantified. This increased the accuracy of the subsequent calibration of radiocarbon ages from humans with mixed-marine diets.

1.3.3 Human Palaeodietary Reconstruction

The final objective is to estimate the contribution of marine and terrestrial resources to Amerindian diets through $\delta^{13}C$ and $\delta^{15}N$ analysis of human bone collagen and $\delta^{13}C$ analysis of human enamel bioapatite. The results were compared back to the faunal data from the first research objective to estimate the likely species that contributed to Amerindian diet.

1.4 Structure of the Thesis

Chapter 2 introduces the culture history sequence of the region with a focus on the island of Newfoundland in order to situate the aims of this research within the literature. To begin to demonstrate how this study can contribute to archaeological research in Newfoundland, the chapter provides a detailed description of the human skeletal remains that form the focus of this work. Chapter 3 introduces the human skeleton with respect to its development and biochemistry, and after death, its decomposition and the effect of diagenetic processes on the stable isotope composition. The terminology and foundational principles of stable isotope analysis and radiocarbon dating are reviewed, followed by a discussion of the carbon and nitrogen isotope systems. This chapter demonstrates how stable isotope analysis of archaeological skeletons is suited to answering questions of Amerindian subsistence in Newfoundland. Chapter 4 examines the evidence for Amerindian subsistence on the island. The chapter reviews how the modern distribution of species on and around the island, archaeological faunal remains, site locations, material culture, ethnohistory and stable isotope studies have been used to recreate Amerindian subsistence patterns. Chapter 5 describes the methods used to isolate and analyse isotopes of carbon and nitrogen from human and faunal skeletal remains. Additionally, the methods used to measure and calibrate the radiocarbon dates obtained from human bone collagen are described. Chapter 5 closes with a review of the statistical methods used to analyse and develop preliminary interpretations of the isotope data. The radiocarbon and stable isotope results are presented in Chapter 6. The results of the isotopic analysis of faunal remains are presented first to provide a context for the interpretation of the isotope data from humans. The radiocarbon dates obtained from the Maritime Archaic skeletons indicate the cemetery was in use from approximately 4500 B.P. to 3800 B.P. with the greatest intensity of use occurring circa 4000 B.P. The radiocarbon dates obtained from Loci I and V are inconsistent with earlier research and indicate that these loci were in fact older than the largest concentration of burials, Locus II. The $\delta^{13}C$ and $\delta^{15}N$ analysis indicate potential sex-based differences in Maritime Archaic consumption of marine and terrestrial resources, however, doubt over the representativeness of the sample precludes drawing conclusions on the matter. Based on the isotopic variation among the individuals, it is probable that the cemetery sample was drawn from communities with diverse geographic origins. The Recent Indian data indicate the consumption of a broad range of resources with variation occurring over time and appearing to correspond to European settlement of the island. Chapter 7 considers the biochemical data and radiocarbon dates within the context of archaeological and ethnohistoric lines of evidence, and the current hypotheses of Amerindian lifeways. Chapter 8 concludes with a summary of the research contributions made by this work, a review of the limitations of the study, and identification of possible directions for future research.

A complete list of all human skeletal elements sampled during this research is located in Appendix 1. The stable isotope results are presented in tabular form in Appendix 2. Raw and calibrated radiocarbon dates are presented in Appendix 3. More information regarding the reference materials used in stable isotope analysis can be found in Appendix 4, and details of the statistical analyses employed in this research can be found in Appendix 5.

CHAPTER 2: CULTURE HISTORY OF NEWFOUNDLAND

Chapter 2 provides the archaeological context for this MA research. The first section briefly reviews the terminology used to discuss archaeology in Newfoundland, and then provides an overview of the culture history of the province. Particular attention is paid to reviewing the defining characteristics of each cultural group as they are understood in Newfoundland archaeology. The second half of the chapter provides the archaeological context of the skeletons analysed in this study. The mortuary site of Port au Choix-3 is discussed first, beginning with a review of the history of the excavation and moving on to describe the results of previous osteological and artifact analyses of the cemetery. The chapter concludes by reviewing the archaeological context of the 10 Beothuk or Recent Indian sites. The radiocarbon dates cited in the text are uncalibrated, unless otherwise stated. Sites mentioned in the text are pictured in Figure 2.1., and the sites that provided human skeletal remains for this research are depicted in Figures 2.2 and 2.4.

2.1 Culture History

2.1.1 Terminology

The word ‘tradition’ is used by archaeologists practicing in Newfoundland to describe a culture in its entirety; “a unique combination of expressions of those systems generally considered to constitute a cultural whole…” (Tuck 1971: 350). This use of ‘tradition’ deviates from the more conventional usage espoused by Willey and Phillips (1958) and practiced by archaeologists in the Maritime Provinces and New England. In those regions, ‘tradition’ is used to describe a single cultural system, rather than an entire culture (e.g. Bourque 1995). Two Amerindian cultural traditions (Table 2.1) have been described in Newfoundland and Labrador: the Maritime Archaic traditionand the Recent Indian tradition. These can be further broken down into cultures and cultural complexes. People of the Palaeoeskimo tradition are also known to have inhabited the island, between 3000 and 1000 years ago.

Table 2.1 Amerindian cultural traditions of Newfoundland. The Little Passage occupation is understood to have ended at the beginning of the historic period.

Tradition	Culture/Complex	^{14}C years B.P. range	2σ cal B.C/A.D. range
Maritime Archaic	N/A	5440 ± 50 – 3200 ± 90[1]	-4440 – -1260
Recent Indian	Cow Head	2080 ± 40 – 995 ± 85[1,2]	-201 – 1242
	Beaches	1950 ± 100 – 760 ± 110[3,4]	-201 – 1400
	Little Passage	1130 ± 80[5] – Historic	689 – ~1500
	Beothuk		~1500 – 1829[6]

[1]Renouf and Bell (2000); [2]Tuck (1978) (in Hartery 2007); [3]Carignan (1975); [4]Cridland (1998); [5]Penney (1980); [6]Howley (1915)

2.1.2 The Maritime Archaic tradition

The Maritime Archaic tradition is the regional expression of the Archaic Period in Newfoundland, Labrador and the Maritime Peninsula. The Archaic period is broadly divided into Early, Middle and Late Archaic Periods, but the temporal endpoints of these subdivisions vary between New England, the Maritime Peninsula, and Newfoundland and Labrador (Sanger 2006). In Maine and the Maritime Provinces, the Archaic Period extends from 9500 B.P. to 3000 B.P. (Sanger 2006); along the Quebec Lower North Shore, the Archaic Period has been dated from 8500 B.P. to 3500 B.P. (Pintal 2006); in Labrador, the Archaic Period extends at least from 7500 B.P. to 3500 B.P., but may in fact extend further into the past (Fitzhugh 2006; Tuck and McGhee 1975); and in Newfoundland, there is only firm evidence for a Late Archaic Period occupation, known as the Maritime Archaic tradition, spanning from 5500 B.P. to 3200 B.P. (Renouf and

Bell 2000). The entirety of the Archaic Period in Labrador is referred to as the Labrador Maritime Archaic, with divisions into Early, Middle and Late Labrador Maritime Archaic Periods that roughly correspond to Early, Middle and Late/Terminal Archaic Periods in the Maritime Provinces and New England (Fitzhugh 2006; Sanger 2006). In Newfoundland, the Maritime Archaic only represents the Late or Terminal Archaic Period.

The Maritime Archaic tradition was defined by Dr. James Tuck of Memorial University of Newfoundland, based in large part on the skeletal and material culture assemblage recovered from the Port au Choix-3 (EeBi-2) burial ground in northwestern Newfoundland (Fig.2.2), and on sites on the Labrador coast of the Strait of Belle Isle. Tuck (1971) saw the influence of the coast in shaping the development of a culture that was distinct from the contemporaneous but related Laurentian Archaic. Stone tools were carefully crafted to harvest sea mammals, birds and fish, and these taxa were further represented in non-utilitarian objects, like amulets and combs (Tuck 1971). Mortuary practices of the Laurentian and Maritime Archaic cultural areas both made use of red ochre, but Maritime Archaic burial ceremonialism was more elaborate and featured designated places of burial and diverse grave offerings (Tuck 1971).

In his use of the term ‘tradition’ to describe the Maritime Archaic, Tuck was attempting to define a way of life, or greater cultural tradition that typified the northeast (Sanger 2006). Further archaeological research in the Maritime Provinces, Maine and Newfoundland and Labrador have since taken issue with the use Tuck’s use of ‘tradition’, arguing that it obscures important regional and temporal variations in the expression of Archaic Period cultures (Lacroix 2015; Robinson 1992; Sanger 2006). Sanger (2006), after Willey and Phillips (1958), makes a case for the use of ‘tradition ‘as a description of interacting cultural systems within the Archaic Period, acknowledging repeating patterns in mortuary practices and tool forms that occur throughout the northeastern region, but also noting regional variations in subsistence and settlement patterns.

In Newfoundland and Labrador, two sub-traditions, or branches, of the Maritime Archaic have been described based largely on the morphology of stone projectile points. The northern branch appears, thus far, to be older and is typified by stemmed points, while the southern branch, featuring side-notched and expanding stemmed points, has only been found on sites dating between 5500 to 3200 B.P. (Renouf and Bell 2006). The geographic distinctions drawn between the branches are based on the main locations where the point types have been found, with stemmed points recovered primarily from sites in central and northern Labrador, and side-notched and expanding stemmed points found along the Quebec Lower North Shore (Renouf and Bell 2006). However, both point types have been found on the island of Newfoundland, calling into question the enduring utility of the sub-traditions as a way of understanding the Archaic Period in Newfoundland and Labrador (Lacroix 2015; Renouf and Bell 2006).

The earliest date, 5440 ± 50 B.P. (Beta-148518) associated with the Maritime Archaic Tradition in Newfoundland was obtained from the Gould site, on the Northern Peninsula, adjacent to the Port au Choix and Point Riche Peninsulas (Renouf and Bell 2000). The latest dates were obtained both from the Curtis site, 3200 ± 90 B.P. (GaK-1254) and from the Gould site, 3200 ± 100 B.P. (Beta-132364) (Renouf and Bell 2000; Wilmeth 1978). When these dates are calibrated they indicate a period of occupation stretching from 6319 cal B.P. to 3209 cal B.P. (OxCal v.4.2: Bronk Ramsey 2009). The occupation largely seems to coincide with a period of climate amelioration suggested by climate records, and the end of the occupation with a period of cooling temperatures (MacPherson 1981; Rosenberg et al. 2005). In Labrador, the end of the Late Maritime Archaic occupation also corresponds to the arrival of the people of the Palaeoeskimo tradition (Fitzhugh 1977). The presence of a new culturally and genetically distinct people in northern Labrador has been linked to the development of longhouses and cemeteries approximately 4000 years ago (Fitzhugh 2006, but see Holly 2013), but the connection between the Maritime Archaic people in Newfoundland, and the cross-cultural interactions that may have occurred far to the north are unclear, prompting archaeologists to look to environmental factors to explain the disappearance of the Maritime Archaic culture from the island (Tuck and Pastore 1985).

The material culture defining the Maritime Archaic tradition in Newfoundland is characterized by diagnostic woodworking tools, such as gouges and stone axes, by sea mammal hunting tools, such as toggling harpoons and barbed points, stemmed and corner notched points, and by non-utilitarian items, like animal effigies, and pendants (Tuck 1971). Maritime Archaic habitation sites are few and ephemeral (Renouf and Bell 2011). This is quite a different pattern than that observed in Labrador, where evidence indicates that the Maritime Archaic people built increasingly complex residential structures beginning with small circular pithouses that, over several thousand years, led to the construction of seasonally occupied longhouses (Fitzhugh 1984; Wolff 2008). The Maritime Archaic people in Newfoundland were likely highly mobile and are presumed, on the basis of both material culture and stable isotope analyses of human bone collagen to have relied extensively on marine resources (Jelsma 2000; Spiess 1992; Tuck 1976a).

With this understanding, the significance of the Port au Choix-3 burial ground with respect to its position on the landscape, and its deceased occupants, becomes an intriguing line of enquiry that has been picked up by several researchers (e.g. Lacroix 2015; Renouf and Bell 2011).

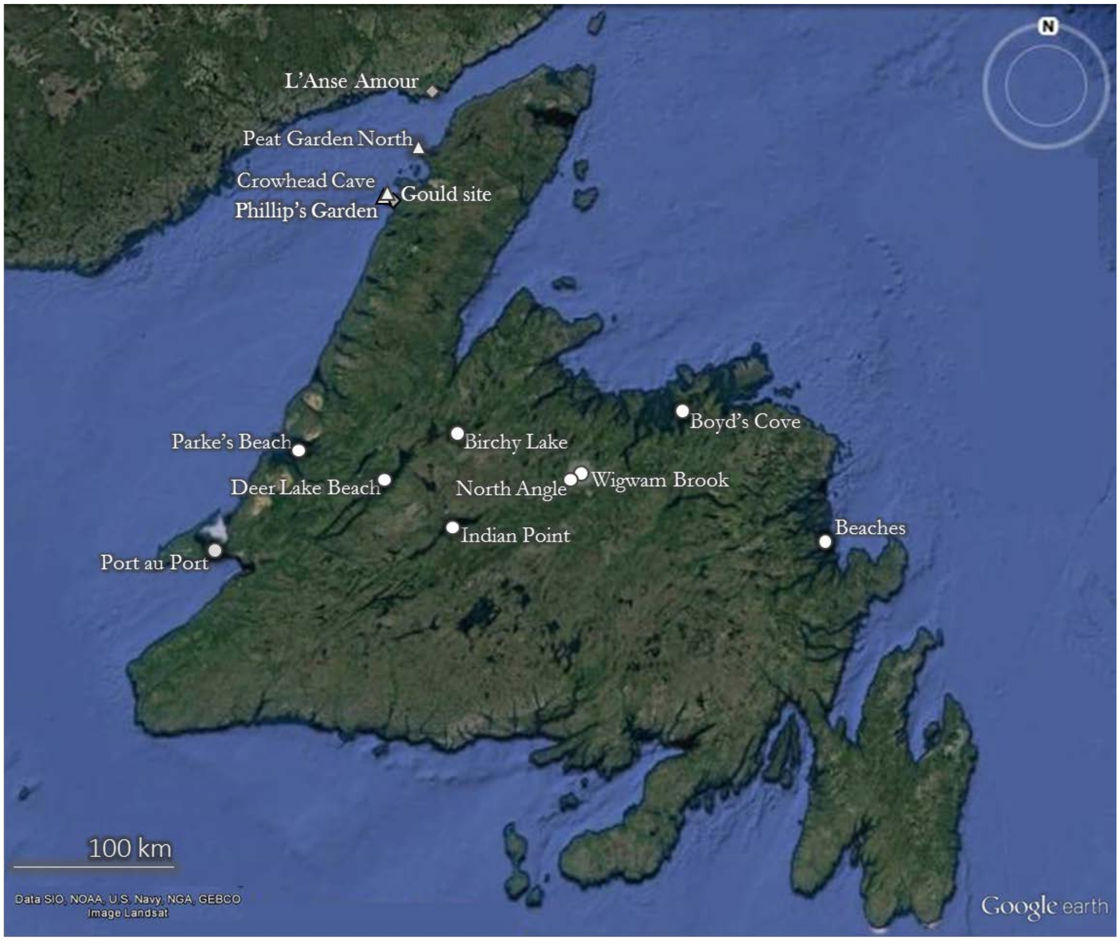

Figure 2.1 Maritime Archaic sites (diamonds), Palaeoeskimo sites (triangles) and Recent Indian sites (circles) mentioned in the text. Image modified from Google Earth

2.1.3. The Palaeoeskimo tradition

The mobile hunter gatherers known archaeologically as the Palaeoeskimo migrated across the eastern Arctic approximately 4000 years ago (Renouf 1993). They were a marine-adapted group, very distantly related to the modern Inuit (Raghavan et al., 2014). On the island of Newfoundland, they reached the southernmost extent of their occupation of the eastern Subarctic, approximately 3000 years ago (Renouf 2011). The Palaeoeskimo tradition in Newfoundland is divided into two cultures, the Groswater culture (3140 – 1720 cal B.P.), and the later Dorset culture (2110 – 1070 cal B.P.) (Renouf 2011). Fitzhugh (1972; 1976) first identified the Groswater cultural complex in central Labrador and likened it to Independence II collections from northern Greenland. Although stylistic differences in the lithic toolkit of the Groswater culture set it apart from the Dorset culture, it also appears to have differed in its settlement and subsistence patterns. The large habitation of Phillip's Garden, in northwestern Newfoundland, with its varied tool assemblage, numerous house pits, and distinct tool morphologies mark the Dorset as a semi-sedentary people, intensively focused on the harp seal hunt (Renouf 1993; Renouf and Bell 2008). Groswater sites in Newfoundland and Labrador are more ephemeral, suggesting small and highly mobile family units with a generalized marine adaptation (Loring and Cox 1986; Renouf 1993; Tuck and Fitzhugh 1986; Wells 2005). The relationship of the Groswater to Dorset culture cannot be portrayed as simple ancestor-descendent relationship due to the chronological overlap of the two cultures in Newfoundland. Raghavan et al. (2014) tentatively proposed population continuity between the Dorset and Groswater from a genetic perspective, but the cultural relationship appears to be more complex (Tuck and Fitzhugh 1986).

The Dorset Palaeoeskimo disappeared from the Newfoundland archaeological record approximately 1000 years ago. Their disappearance has been attributed to environmental change and external social pressures. Hodgetts et al. (2003) and Renouf and Bell (2008) argue that a brief period of sea surface warming, approximately 1500-1000 years ago, may have disrupted sea ice patterns off the northwestern coast of Newfoundland, affecting the reliability and accessibility of the harp seal migration. The Dorset were forced to either diversity their resource base, or leave the island's shores (Renouf and Bell 2008). Hodgetts et al. (2003) reported evidence for a shift in resource use in the late Dorset period of Phillip's Garden that may indicate that the Dorset actually attempted to diversify their diets to compensate for the repeated failure of the harp seal hunt.

Alternatively, Holly and Erwin (2009), Erwin et al. (2005), and Renouf (2003) implicate at least the presence of people from Recent Indian tradition in the disappearance of the Dorset culture. People of early Recent Indian cultures came to Newfoundland approximately 2000 years ago, overlapping with the Groswater and Dorset people in both time and space, although the spatial element was likely carefully negotiated (Holly 2002, 2005; Renouf et al. 2000; Renouf 2003). There is no conclusive evidence for intercultural violence during this period, but patterns in site distribution (Renouf et al. 2000), hunting technology (Erwin et al. 2005), and Dorset mortuary patterns (Brown 2011; Raghavan et al. 2014) may indicate that each group was carefully delineating their territories and identity. The Dorset occupied the outer coastal regions of the island and maintained a marine-focus in their dietary practices, while the Recent Indian people occupied the near-coastal regions and interior and had more diverse dietary practices (Holly 2002; Pastore 1986; Renouf et al. 2000; Renouf 2003; Schwarz 1994). Bone chemistry and ancient DNA analyses have been conducted on skeletal remains recovered from Dorset contexts on the Northern Peninsula. The results support the archaeological findings and suggest that the Dorset Palaeoeskimo consumed large quantities of high trophic level marine protein, and expressed very low genetic diversity (Raghavan et al. 2014). The subsistence and settlement patterns of the Palaeoeskimo in Newfoundland are thus well understood, but questions remain as to the cause of the disappearance of these groups, and the tenor of their interactions with people of the Recent Indian and Maritime Archaic traditions.

2.1.4 The Recent Indian Tradition

The Recent Indian tradition occurs throughout Newfoundland and Labrador. On the island the cultural tradition is represented archaeologically by three pre-European contact cultural complexes and by the historic Beothuk culture. The archaeological research completed over the past 15 years has brought about a marked shift in the understanding of the population dynamics of the island in the period from approximately 2000 years ago to the arrival of European migrant fishermen in the early historic period. Prior to this it was thought that the Palaeoeskimo and Amerindian occupations were discontinuous, with one group arriving after the other had departed or been rendered extinct by harsh environmental conditions (Schwarz 1994; Tuck and Pastore 1985). Radiocarbon dates, excavation, and data syntheses have now revealed that Palaeoeskimo and Recent Indian occupations were contemporaneous for a time, and chronological overlap is known to have occurred between different Recent Indian cultural complexes (Holly 2002). It is difficult to overstate the impact that this new knowledge has had and will likely continue to have on archaeological research in Newfoundland. It has brought about a reassessment of cross-cultural interactions and a reconsideration of the roles of social, environmental and technological factors in contributing to the rise and fall of indigenous fortunes throughout this latter period of Newfoundland prehistory (Erwin et al. 2005; Holly 2002, 2005; Renouf et al. 2000; Renouf 2003). The relevance for this thesis, studying human skeletal remains that in many cases have been divorced from their archaeological context due to amateur excavation or looting, is that cultural affiliation can only be broadly assigned. Given the overlapping chronological distributions of the Recent Indian cultural complexes, these cultural designations have little bearing on the skeletal series. Nevertheless, as the archaeology of Newfoundland has been understood within this framework, each Recent Indian cultural complex will be reviewed below.

Three Recent Indian cultural complexes have been defined, first on the basis of stone tools, but now with the addition of numerous radiocarbon dates and site distribution data. These are described in brief with respect to their likely origins and development, diagnostic material culture, site distribution and hypothesized subsistence patterns. The Cow Head Complex is included here, even though research indicates that it does not form part of the cultural continuum leading from the Beaches complex, or Early Recent Indians through to the Historic Beothuk.

2.1.3.1 The Cow Head Complex

The first artifacts in Newfoundland to be attributed to the Cow Head complex were recovered from the Spearbank site (DlBk-1) by Tuck in the late 1970s. The Spearbank site is located on the Cow Head Peninsula, on the west coast of the Great Northern Peninsula. Similar artifacts were also found at other coastal sites in Newfoundland and Labrador, such as the Gould and Peat Garden North sites (Hartery 2007; Renouf et al. 2011). These, and similar artifact types in Labrador and on the Quebec Lower North Shore were analysed by Hartery (2007) who provided a comprehensive description of the types of stone tools that could be used to define the Cow Head complex. Hartery (2007) identified the morphology of stemmed projectile points and bifaces, the flaking technique, and the presence of pièces esquillées as diagnostic features of the Cow Head Complex. Cow Head complex tools were typically manufactured from local chert, quartzite or rhyolite, with little evidence for long distance trade of lithic materials (Hartery 2007). The function of Cow Head complex coastal sites in Newfoundland seems to have been for lithic procurement, with residential sites set back from the coast (Hartery 2007; Renouf et al. 2011). Hartery (2007) estimated that people of the Cow Head complex probably had low residential mobility, but high logistical mobility and relied on stored foods as evidenced by the presence of ceramics at the Gould site and on the Quebec Lower North Shore.

2.1.3.2 The Beaches Complex

Beaches sites have been found to date as early ~1900 B.P. and as late as 800 B.P., making them contemporaneous with both the Cow Head complex and both Palaeoeskimo cultures (Holly 2002). Similarities of stone tool morphology, lithic raw materials and overlap in radiocarbon dates link the development of the Beaches complex on the island to the Daniel Rattle complex of Labrador, suggesting a probable origin of the Beaches culture on the mainland (Hull 2002; Pastore 1985). The diagnostic lithics of the Beaches toolkit include triangular bifaces, and large side-notched projectile points, but Erwin et al. (2005) noted a degree of stylistic overlap between Beaches and later Little Passage artifacts and cautioned against using a lithic shorthand to distinguish the projectile forms of these complexes. Holly (2002) analysed the distribution of Beaches sites on the island and noted they tended to concentrate along the northern coast, implying the role of harp seal and potentially seabirds in Beaches subsistence. Since Holly's analysis, Beaches sites have increasingly been found in the interior of the province, dotted along the river and lake systems and suggesting an interior component to Beaches subsistence patterns that was probably focused on the caribou and beaver hunt (Holly and Erwin 2009; Reader 1998).

2.1.3.3 The Little Passage Complex

As the tenure of the Dorset drew to a close, an alteration of Recent Indian subsistence and settlement patterns is indicated by changing site distribution patterns (Holly 2002; Renouf et al. 2000) and toolkits (Erwin et al. 2005; Penney 1982). In contrast to the dual economic focus on caribou and seal implied by Beaches complex site distribution, people of the later Little Passage Complex appear to have been marine-adapted generalists (Cridland 1998). The Little Passage Complex was first identified by archaeologist Gerald Penney (1982) in southwestern Newfoundland. Little Passage sites are distributed where a wide variety of terrestrial and marine fauna could be monitored and harvested (Schwarz 1994). Economic diversification between early (Beaches) and later (Little Passage) Recent Indian periods is also implied by the addition of smaller, corner-notched projectile points, indicative of bow-and-arrow technology, to the Recent Indian toolkit (Erwin et al. 2005). Like the Beaches complex, the Little Passage complex seems to have had an analogue in Labrador, in the Point Revenge Complex (Fitzhugh 1978), indicating a regional social network was actively sustained throughout the Recent Indian occupation (Hull 2002).

2.1.3.4 The Beothuk

The Beothuk were the historic period descendants of the Little Passage people (Schwarz 1984). They were among the first Native American groups to encounter Europeans in the early historic period (Howley 1915). Their experience with European settlers in Newfoundland was not characterized by the same type of interactions that occurred in other parts of Canada and the United States (Pastore 1989). The Beothuk incorporated European goods into their material culture (MacLean 1990), and adapted their settlement and subsistence patterns in relation to European activities (Holly 1998), but they did so in ways that maintained their autonomy and cultural identity, even though their actions may have contributed to their cultural extinction in the early 19th century (Pastore 1989). Current understandings of Beothuk lifeways are informed in part by the archaeological record, but the sparse ethnohistoric record, collected by Howley (1915) and Marshall (1996), still holds sway.The research presented here brings a third line of evidence from the human skeletal record to bear upon questions of Beothuk subsistence.

The Beothuk are distinguished from the Little Passage complex by their incorporation of iron and trade goods into their material culture. Early historic Beothuk sites are concentrated among the islands of the Bay of Exploits and Bonavista Bay and down the Exploits River, but are also found on the west coast and Avalon Peninsula (e.g. Devereux 1970; Holly et al. 2015; Pastore 1981, 1984; Reader 1997; Simpson 1984; Tuck 1984). According to Pastore (1989), the Beothuk entered a cultural fluorescence in the early historic period; as the cod fishery was largely migratory, the Beothuk were able to obtain European goods, iron objects, in particular, while still maintaining their way of life and freedom of movement around the landscape. Summarizing his analysis of the faunal assemblage recovered from the 17th to 18th century site of Boyd's Cove, Cumbaa writes,

> "At Boyd's Cove we have a glimpse of a people at ease in their environment and obviously exercising a fair degree of control over use of its resources. The contrasting picture we have a century later of a beleaguered and dwindling population eking out a living on the run from a dominant culture is all the sadder for the comparison." [Cumbaa 1984: 18]

The conclusion of Cumbaa's statement raises the spectre of the Beothuk cultural extinction, which Holly (2000) argued has come to define the Beothuk in the public and academic imagination. At the onset of the 19th century, Beothuk population numbers dwindled and in 1829, the last Beothuk, a woman by the name of Shawnadithit, died of tuberculosis in St. John's (Marshall 1996). Howley (1915) attributed the demise of the Beothuk to disease and violent clashes with Europeans and Mi'kmaq, and supported his argument with historic records and oral tradition. Pastore (1989, 1990) argued that this perspective was too simplistic. The Beothuk cultural extinction needed to be understood in relation to English economic activities on the island, and to the actions taken by the Beothuk in response to the European presence, a stance later taken up by Holly (1998, 2000).

In British North America, the interactions of native groups and Europeans were often mediated by missionaries and Indian agents who each had the goal of directing native behaviours and actions to facilitate European economic interests (Pastore 1989; Trigger 1986). This was not the case in Newfoundland, leading Pastore (1989) to identify the absence of missionaries and Indians agents as symptoms of one of the root causes of the Beothuk extinction, namely the marked lack of economic interaction between the Beothuk and English settlers. Despite initial attempts on both sides to develop a trading relationship early in the British settlement history of Newfoundland, a sustained formal partnership did not ensue (Howley 1915, but see MacLean 1990). Ultimately, trade was not necessary for either party to obtain the materials they needed; the Beothuk were able to obtain modifiable iron objects from abandoned fishing stages, and English settlers made a practice of trapping their own furs (Pastore 1987, 1989).

The willingness of English settlers to participate in economic activities such as trapping and salmon fishing brought them into contact with the Beothuk as they conducted their own hunting and fishing expeditions. Competition for fur and fish resources is reported to have resulted in violent clashes, theft, and further retaliation (Howley 1915; Marshall 1996). During the 18th century, the character of English settlement began to change from one that was seasonal and migratory, to year-round (Pastore 1992). The Beothuk responded to the growing European presence and resource pressure by refusing to engage with settlers and withdrawing from their coastal lands. The Beothuk spent more of the year in the interior of the island along Red Indian Lake, and developed more substantial housing and storage structures (Howley 1915). This strategy, for a time, limited their contact with Europeans, but it also placed restrictions on the resources they could access (Tuck 1976b). Stewart's (1973) analysis of the faunal remains from the terminal Beothuk site of Wigwam Brook has been taken to evidence an attempt by the Beothuk to rely year round on caribou and beaver, although this interpretation, based on fairly limited skeletal evidence, has met with some criticism

(Rowley-Conwy 1990). By the mid-18th century, Lieutenant John Cartwright estimated that the Beothuk population numbered approximately 300 to 500 (Marshall 1996). It cannot be known if this estimation represents a decrease in population, as the size of the population during the precontact period is unknown, although some estimates have placed it at approximately 2000 people (Upton 1977), or between 500 and 1600 (Marshall 1996). Without a comprehensive survey of the entire island, any given estimate ultimately remains a guess (Pastore 1989).

The final years of the Beothuk are largely understood through recorded interactions and interviews with two Beothuk women; through a reconsideration of the archaeological evidence (e.g. Holly 1998); and, through the archival work of Howley (1915) and Marshall (1996). The ethnohistoric works portray the terminal Beothuk period as a time of deprivation and struggle, while the archaeology paints a subtler picture of agency and (failed) adaptation (Holly 1998). Renouf (1999) proposes that the last of the Beothuk may have moved north to live with the Innu of Labrador, with whom they likely had ancestral ties. Her hypothesis is supported by similarity in tools between the Point Revenge complex of Labrador and the Little Passage complex of Newfoundland. It is clear from historic records that the Beothuk did interact on occasion with the Innu, but the tenor of these interactions does not appear to always have been positive (Marshall 1996). Robbins (1989) argues that the Beothuk were cut-off from Labrador by the time they needed their social connections with mainland the most by the presence of European sealers and whalers and Inuit hunters in the Strait of Belle Isle.

2.2. Archaeological Context of the Study Sites

This research is focused on reconstructing the subsistence practices of Newfoundland's culturally extinct Amerindian populations. This project was granted permission to conduct chemical analyses on Amerindian skeletons dating to the Maritime Archaic and Recent Indian occupations of Newfoundland. The study sites are described below, beginning with the large Maritime Archaic burial ground, Port au Choix-3, followed by the Recent Indian and Beothuk sites.

2.2.1 Port au Choix-3 (EeBi-2)

Port au Choix-3 is a large mortuary site (Fig. 2.1) located on an ancient raised beach in the modern town of Port au Choix, on the Northern Peninsula. The site lies between the Northern Peninsula and Strait of Belle Isle ecoregions, and within the northern Boreal zone. The growing season is short and the vegetation predominantly comprised of Tuckamore: thickets of scrub pine (*Picea glauca*, *P. mariana*) and balsam (*Abies balsamea*) (Damman 1983). During the Maritime Archaic occupation in Newfoundland, the region was characterized by slightly warmer air temperatures than at present (Rosenberg et al. 2005), but it is not clear how or if this may have affected past precipitation, or sea surface temperatures. The stratigraphy of the Port au Choix region is relatively young and consists primarily of marine sedimentary rocks (Kluyver 1975). The St. George's Group and Table Head Group form the two stratigraphic units of the Port au Choix and Point Riche Peninsulas and the adjacent coastline of the mainland (Kluyver 1975). Both units date to the Ordovician Period, but vary in their composition with the St. George's group featuring primarily dolostone and the Table Head group dolostone and limestone (Kluyver et al. 1975). During the Maritime Archaic period the coast at Port au

Choix was three to four meters higher than today with the result that the Port au Choix-3 burial ground was located on an island facing the mainland across a narrow expanse, or tickle, of water (Renouf and Bell 2011) Worked periwinkle shells, red ochre and tiny smooth pebbles similar to those recovered from the graves at Port au Choix-3 have also been found at the Gould site, a campsite located within view of the ancient cemetery and thought to be a site used occasionally by Maritime Archaic families to prepare their dead, or pay their respects to the deceased across the water (Renouf and Bell 2011).

Figure 2.2 Location of Port au Choix-3. Image modified from Google Earth.

Human remains were encountered sporadically throughout the 20th century, during the development of the modern town site. A summary of the excavations conducted at Port au Choix-3 can be found in Table 2.2. Collection of the skeletal remains and artifacts was informally undertaken by local residents who broughtthe site to the attention of anthropologist, Elmer Harp, of Dartmouth College, during his survey and excavations in the Strait of Belle Isle region of Newfoundland in the late 1940s (Harp 1951). Harp tested the area and was given a box of human remains and artifacts, but did not look to conduct a complete excavation of the site (Harp 1951). Tuck initiated the formal excavation of the site in 1968, after the remains of 10 individuals were uncovered the previous summer (Tuck 1976a). Tuck later returned when human remains were discovered in the mid-1970s. The excavations have resulted in the division of the burial ground into five burial loci. The site of the 10 individuals recovered in 1967 was designated Locus I; the sites excavated by Tuck and a crew of students during the summer of 1968 were designated Loci II and IV; Locus III is a Dorset site; and the sites of two disturbed burials found in the 1970s were designated Loci V and VI (Kennedy 1980; Tuck 1976a). The site has since been designated a National Historic Site by the Historic Sites and Monuments Board of Canada, hopefully bringing an end to further accidental disturbance of the burial ground. The following section will detail the archaeological and accidental excavations of the burial ground.

Table 2.2 Summary of Port au Choix-3 burials.

Burial/Locus	Year	MNI	Context	Reference
Burial 1	1939	5	Disturbed	Harp 1951
Burial 3	1951	1	Disturbed	Harp and Hughes 1968
Burial 4	1951	1	Disturbed	Harp and Hughes 1968
Locus I	1967	8	Disturbed	Tuck 1976a
Locus I	1967	2	In situ	Tuck 1976a
Locus II	1968	89	In situ	Tuck 1976a
Locus IV	1968	2	Disturbed	Tuck 1976a
Locus V	1971, 1978	7	Disturbed	Kennedy 1980
Locus VI	1969	1	Disturbed	Kennedy 1980

2.2.1.1 Harp's Burials (1, 3-4)

While investigating Dorset and Beothuk origins in Port au Choix, in the summer of 1949, Harp was given a wooden crate containing the remains of two skeletons that had been discovered in the ground beside the barn of a Mr. A. S. Darby 10 years earlier (Harp 1951). The remains consisted of an incomplete adult skeleton, and fragments of a child's skeleton, both covered with traces of red ochre (Harp 1951). Darby also gave Harp six incised bone needles that had been recovered with the remains. Harp returned to Port au Choix over the following five years, but was unluckily never encountered a Maritime Archaic (then known as Boreal Archaic) burial *in situ*. Instead, Harp was given more human remains by a local family, the Billards, who uncovered them in various places around their property (Harp and Hughes 1968). Harp and David Hughes (1968) designated each site as a burial, and each recovered individual as a unit. Burial 1 included units A through E, Burial 3 featured only unit H, and burial 4 unit G. Burial 2 is the nearby Dorset mortuary site of Gargamelle Rockshelter (Harp and Hughes 1968).

Burial 1 comprised the first skeletons discovered in 1939, and given to Harp in 1949 (Harp and Hughes 1968). Harp's initial estimation of two individuals proved to be an underestimation and upon inspection by Hughes, five individuals were counted: two adult males, one probable adult male, one adult of unknown sex, and one juvenile between the ages of seven and 10 years old (Harp and Hughes 1968). Burial 3, comprising the post-cranial remains of an adult male, was found in 1959 by Pius Billard as he was preparing to construct a semi-subterranean ice house behind his dwelling. Burial 4 uncovered by Romeo Billard, brother and neighbour of Pius, as he was bulldozing an area of land for his driveway (Harp and Hughes 1968). He collected and gave the skull and mandible of an adult male to Harp in 1961 and allowed Harp to re-excavate the post-cranial remains, and grave offerings which he had reburied beneath his driveway (Harp and Hughes 1968). Harp transported the skeletal remains to Dartmouth College, but at some point in the past, the bones of at least three individuals (NP 275, 276 and 277) were returned to Newfoundland and are currently curated in the Department of Archaeology at Memorial University of Newfoundland. The partial cranium designated NP 277 appears to match the photograph of Burial 4 (Unit H) published by Harp and Hughes (1968) but it is not clear which burials are represented by NP 275 and 276.

2.2.1.2 Locus I

The formal excavation of Port au Choix-3 was prompted by the discovery of the remains of 10 individuals during the construction of movie theatre and billiard parlour in 1967 (Tuck 1976a). The discovery occurred south of the area that yielded burials 1, 3, and 4 on a stretch of the ancient beach (Tuck 1976a). The skeletal remains of one adult male, three adult females, two adolescent females, two juveniles and one adult of indeterminate sex were found covered with ochre and, according to the accounts of onlookers, arranged in a rough circle (Tuck 1976a). Two burials were found intact, one a double interment containing an adult and adolescent female, the latter so tightly flexed as to suggest a bundle burial (Tuck 1976a). No grave offerings, but for a polar bear canine and the remains of a small dog were recovered from the burial, in contrast to the disturbed burials of Locus I which were accompanied by slate points, whale bone and antler harpoon foreshafts, antler blanks, and chipped and pecked stone tools (Tuck 1976).

2.2.1.3. Locus II

Tuck returned to Port au Choix-3 the following summer with a group of students, during which period the majority of the Port au Choix-3 burial ground was excavated. The results of these excavations are detailed in two articles (Tuck 1971, 1972) and one monograph (Tuck 1976a). The excavations focused on the area of the burial ground designated Locus II which yielded the remains of 89 individuals (Tuck 1976a). The burials of Locus II appeared to be roughly arranged in three clusters (Fig. 2.2) and referred to as Group or Cluster A, B, and C (Tuck 1976a). Functional grave goods are roughly equally distributed between burial clusters, but there are differences in the distribution of non-utilitarian objects. Gull bones and bills were found to occur more frequently in Cluster A, while great auk bills were found to occur more frequently in Cluster C (Tuck 1976a).

Most graves were found with a burial covering constructed of large boulders of flat pieces of stone (Tuck 1976a). No particular orientation, either towards points of the compass, or the ocean, appeared to dictate the placement of the graves (Tuck 1976a). The majority of the graves occurred as roughly circular pits dug into the sand and many of the burials exhibited a degree of disturbance that ranged from slight disarticulation resulting from subsequent internments of bodies to the absence of skeletal elements, or of complete skeletons (Tuck 1976a). Single, double, triple and one mass burial were found. Most adult skeletons were found flexed, and several appeared to have been interred after the process of decomposition was advanced, while still others were clearly bundle burials.

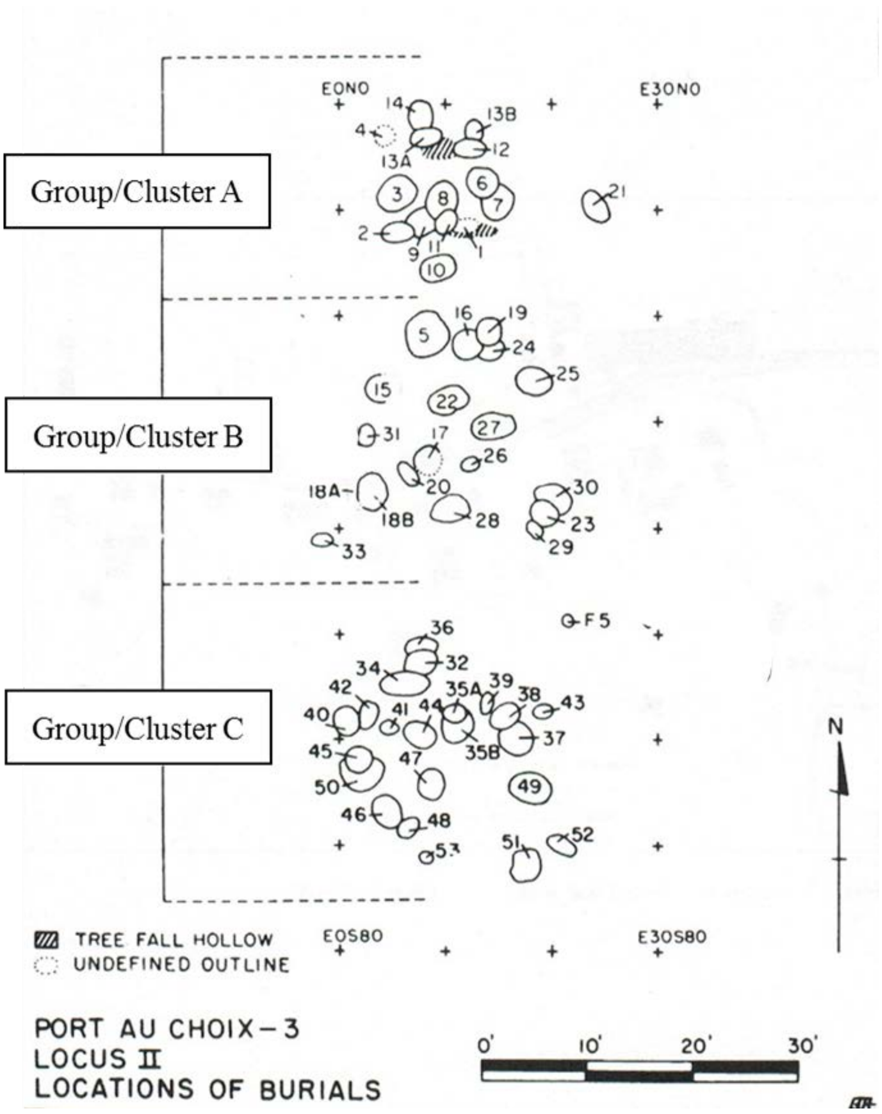

Figure 2.3 Spatial distribution of burials, corresponding to clusters, in Locus II of Port au Choix-3. Image modified from Tuck (1976a).

Tuck did not seem to place a great deal of significance in the burial clusters, citing too much disturbance, little difference in artifact assemblages between clusters and lack of superposition of one cluster over another (Tuck 1976a). He suspected, based on the relative homogeneity of the artifact assemblages between burial clusters, that Locus II was used intensively for a relatively short period of time (Tuck 1976a). Some superposition of graves was evident within each cluster, however, at the time of excavation, radiometric dating methods were not sensitive enough to capture temporal differences of the magnitude Tuck expected to find. Later radiocarbon determinations obtained by Jelsma (2000) on human bone collagen samples selected from three individuals from each burial cluster revealed no significant differences in the span of time occupied by each cluster.

2.2.1.4 Locus IV

The two infant skeletons designated Locus IV were uncovered approximately 165m north of Locus II in the spring of 1969 during excavations to bury a waterline (Tuck 1976a). The skeletal remains were not noted until later in the summer when Tuck and his students were working in the area (Tuck 1976a). Although, the archaeological context was disturbed, burial 1 was less affected than burial 2, and Tuck was able to make some observations regarding the position of burial 1 and the accompanying grave offerings (Tuck 1976a). The skeleton was flexed and accompanied by caribou incisors, small quartz pebbles, two carnivore canines, bird bones and a scraper fashioned from a caribou scapula (Tuck 1976a). Burial 2 was disturbed, but it was clear that the infant had been buried with red ochre, and its grave offerings including an antler harpoon with drilled holes, an antler gouge, beaver incisors, bird bones, fragments of birchbark and several limestone pebbles (Tuck 1976a).

2.2.1.5 Locus V

The skeletal remains of up to nine individuals were found near the southern corner of the Roman Catholic cemetery in Port au Choix, between the years 1971 and 1978, during the construction of two neighbouring houses (Tuck cited in Kennedy 1980). These remains were designated Locus V (Kennedy 1980). The archaeological context of the Locus V remains was badly disturbed, and also never officially reported. The remains seem to have been treated as a comingled assemblage, and sex estimation was only possible for one individual. The locus is composed of at least one adult female, six adults of indeterminate sex, one juvenile, and two infants (Kennedy 1980).

2.2.1.6 Locus VI

The skeletal remains of one adult male were found about 160m northwest of Locus V in 1976 during the town's waterline excavation (Tuck in Kennedy 1980). This locale was designated Locus VI.

2.2.1.7 Biological Profile of the Port au Choix-3 Skeletal Assemblage

The recreation of the demographic profile of the burial ground has been complicated by divergent results obtained by past researchers using different morphological and molecular-based sex estimation techniques. Anderson (1976) and Kennedy (1980) each came to the conclusion that the ratio of adult males to adult females was roughly equal by using sex identification techniques based on morphological differences between male and female skeletons. Later, Jelsma (2000) determined that the ratio of adult males to adult females was approximately 2:1 using a combined approach of odontometrics and molecular sexing techniques. Jelsma (2000) analysed Y-chromosome repeats and the length of the amelogenin gene from the extracted nuclear DNA of nine individuals. His approach indicated that biological sex had been misidentified for ten individuals by the earlier work of Anderson and Kennedy (Jelsma 2000). The validity of Jelma's DNA and odontometric results cannot, at this time, be verified. The morphology-based approach taken by Anderson and Kennedy is not without its own suite of complications. Morphology-based techniques must take into account the completeness of the skeleton, choice of a comparative collection, inter- and intraobserver error, sexual dimorphism in the population under study compared to any comparative collection, the influence of other factors – environmental or genetic – on the morphological characteristics of interest, the accuracy of the techniques employed, and the experience of the analyst (Buikstra and Ubelaker 1994; France 1998; Krogman 1962; Spradley and Jantz 2011; Williams et al. 2006). Anderson and Kennedy were doubtlessly aware of these issues and the consistency of their results, obtained at least five years apart, support their determinations of sex in the Port au Choix-3 population. The choice of sex-estimation is particularly relevant for the interpretation of social structure as inferred by the biological profile of the burial ground. The skewed sex ratio, found by Jelma (2000), implies that males and females had differential access to the burial at Port au Choix-3, and in particular, to burial cluster C. This has been used as supporting evidence, in addition to mtDNA and artefact analyses, for status distinctions between the burial clusters. With regards to food and potential sex-based differences in diet, no significant difference was noted in this research between Andersen and Jelma´s sex estimations. While the results of the statistical analysis of the isotope data for both sex estimations are reported in Appendix 5, for the purpose of later discussion of the data, Anderson´s estimations are used as these have been supported by Kennedy´s work.

The general health of the Port au Choix-3 population is estimated to have been good. Anderson (1976) found a very low incidence of pathology, trauma or non-specific stress indicators. Evans (1991) studied the presence of growth arrest lines in the tibiae of 10 individuals from Loci I and II and noted that most individuals appeared to have experienced a period of stress of unknown severity late in infancy, and again between the ages of eight and 12. Dental attrition was extensive, but the rate of caries very low among the individuals with preserved teeth (Anderson 1976). The dental attrition was attributed to a coarse and/or fibrous diet, combined with the use of the teeth and jaw in cultural practices, such as hide-softening (Anderson 1976; Reader 1990). Anderson (1976) noted degenerative joint changes associated with arthritis that affected the upper limbs and vertebra more than other regions of the skeleton and Marshall (1990) found that the pattern of degenerative joint disease in the Port au Choix-3 population differed from other northern maritime-adapted populations.

One of the infant skeletons recovered from Locus V presented with a number of osteolytic lesions attributed to Langerhans cell histiocytosis X, a rare condition (Kennedy 1989). Differential diagnoses for this disease include metastatic carcinoma and tuberculosis (Wasterlain et al. 2011). If Kennedy's diagnosis is correct, this would be one of the earliest recorded occurrences of the disease in North America (e.g. Colombo et al. 2015).

2.2.1.8 The chronology of Port au Choix-3

Nineteen radiometric and AMS dates on charcoal, human and faunal bone collagen have been obtained in past research (Tuck 1976a; Jelsma 2000; Robinson 2006). Seven of these are reported below in Table 2.3. Only five of the dates are cited regularly in the literature, due to irregularities in radiocarbon measurement and concern over the marine reservoir effect on the human collagen dates (e.g. Renouf and Bell 2011). In the late 1960s and early 1970s, Tuck submitted a sample of human bone from Locus I (I-4677) and from burial 50B of Locus II (I-4678), a piece of charcoal from burial 22 of

Locus II (I-3788, I-4682, Y-2608), a piece of bog iron containing datable wood from Locus II (Y-2609), and a piece of carbonized tree bark from Locus IV (I-4380). The date from the wood-containing bog iron was quickly dismissed as it predated all of the other radiocarbon dates from the site (Tuck 1976). Two of the dates (I-4682 and Y-2608) from the charcoal sample from burial 22 were also dismissed, leaving one charcoal date from burial 22, the two dates from human bone, and the date from the carbonized tree bark to determine the chronology of the site. Although the dates were not calibrated, it was determined that Locus II, the largest and most elaborate part of the cemetery, was the oldest with a date from burial 50 being the most reliable, at 3930 ± 130 B.P. Loci I and IV were considerably younger with dates ranging from 3230 ± 220 B.P. to 3410 ± 100 B. P. (Tuck 1976a).

Table 2.3. ^{14}C dates on charcoal and bone collagen from Port au Choix-3 burial ground (Canadian Radiocarbon Database, 2016). Calibration used OxCal v. 4.2 (Bronk Ramsey 2009) against IntCal13 (Reimer et al. 2013).

Lab No.	**Material**	**^{14}C Age B.P.**	**Error ± yrs**	**Median cal B.P.**	**2σ range cal B.P.**
I-4682	Charcoal, burial 22	3690	90	4035	4377-3730
I-4678	Human bone; burial 50	3930	130		
I-4677	Human bone, Locus I	3410	100		
I-4380	Bark, Locus IV	3230	220	3461	4066-2880
AA-29482	Caribou bone, burial 35B	3825	60	4231	4417-4012
AA-33919	Beaver bone, burial 35B	3777	44	4151	4295-3985
AA-33920	Caribou bone, burial 35B	3826	38	4226	4406-4095

Three decades later, three more dates were obtained from the bone collagen of terrestrial mammals that overlapped with the human bone collagen date from burial 50, and the accepted charcoal date from burial 22 (Robinson 2006). The human bone collagen dates cannot be effectively calibrated without a carbon isotope measurement, but working from the calibrated dates of the charcoal from burial 22, Robinson’s terrestrial animal dates, and the date on tree bark, the burial ground dates to between 4417 cal B.P. to as late as 2880 cal B.P.

2.2.2 Recent Indian and Beothuk sites

The Amerindian burials (Fig.2.3) attributed to the Recent Indian or Beothuk archaeological cultures and sampled for this study were recovered from the north and northeastern coasts of Newfoundland.

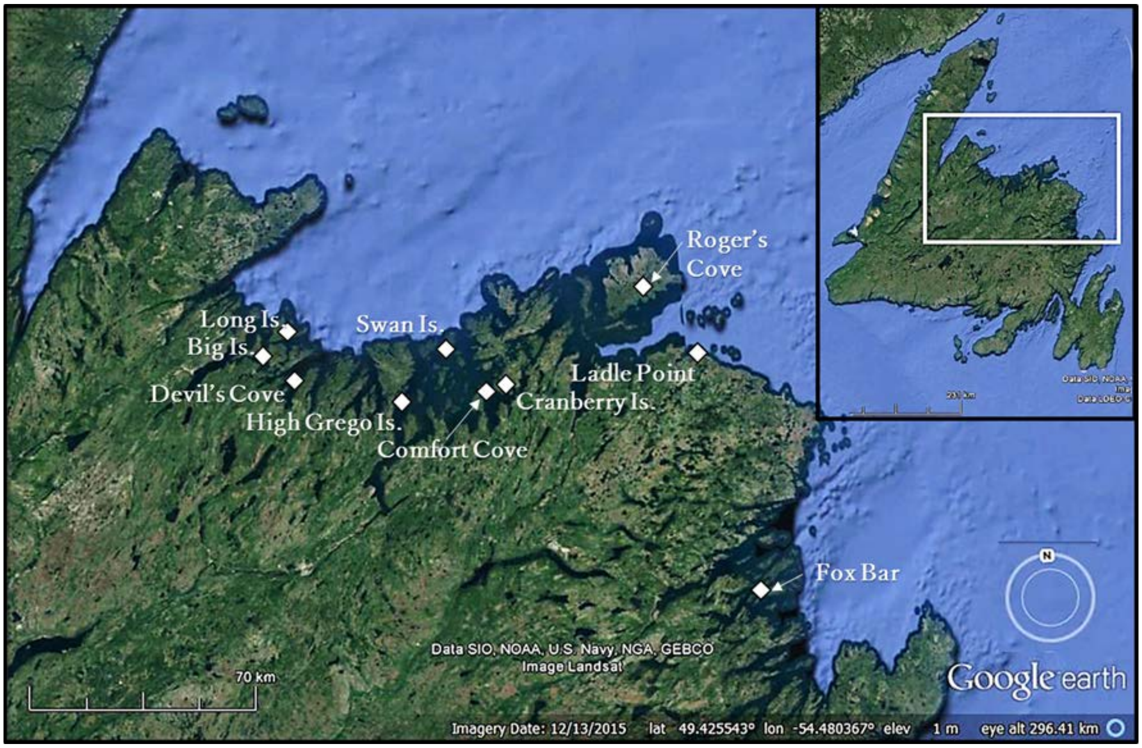

Figure 2.4 Locations of Beothuk and Recent Indian sites sampled in this study. Charles’ Arm and Western Indian Island are not pictured. Site locations provided by S. Hull of the Provincial Archaeology Office. Image modified from Google Earth.

The sex and age of each individual was assessed by Dr. Sonja Jerkic and recorded in the Human Remains inventory of the Department of Archaeology at MUN. Marshall (1996) assigned a designation of authenticity to those with sufficient evidence to support a Beothuk cultural affiliation. The selection criteria included burial location (often on the coast, in a cave or rockshelter), placement of the deceased, grave offerings (bone pendants, utilitarian objects), and the presence of red ochre (Marshall 1996: 399-400). Of the burials listed below (Table 2.4), all but one can be affiliated with the Beothuk culture with a reasonable degree of certainty based on the recovery of Beothuk artifacts. Roger's Cove is the exception as the site did not produce diagnostic Amerindian cultural material, but the radiocarbon date and isotope data obtained from the skeleton (presented in Chapter 6) support the designation of this individual as Amerindian.

Table 2.4 Summary of Recent Indian/Beothuk burials recovered from Newfoundland. Estimated time period based on recovered artifacts and radiocarbon dated human bone.

Site	Time period	# sampled	Context	Reference
Big Is.	Historic	2	Disturbed	Patterson 1892; Howley 1915
Charles' Arm	Historic	4	Disturbed	Marshall 1996
Comfort Cove	Historic	3	Disturbed	Marshall 1996; Spence 1964
Cranberry Is.	Historic	1	Disturbed	Marshall 1984
Devil's Cove	Precontact-historic	2	Disturbed	LeBlanc 1973
Fox Bar	Historic	6	Disturbed	Carignan 1973
High Grego Is.	Historic	1	Disturbed	Devereux 1966
Ladle Point	Historic	1	Disturbed	Howley 1915
Long Island	Historic	4	Disturbed	Jenness 1929
Roger's Cove	Precontact-Historic	1	Disturbed	No reference
Swan Is.	Historic	3	Disturbed	Howley 1915; Marshall 1996
Western Indian Is.	Historic	1	Disturbed	MacLeod 1966

2.2.2.1 Big Island, NP 240 (DjAw-17), NP 265 (DjAw-18)

The remains of two individuals, one adult (NP 265) and one juvenile (NP 240), were recovered from Big (formerly Burnt) Island in Notre Dame Bay in AD 1882 (Marshall 1984). The remarkable preservation of the child has made it the focus of a study by Dr. Sonja Jerkic and colleagues (1995). The juvenile, aged approximately four years, was found partially mummified. CT scans (Fig. 2.4) of the skull confirm the individual's age.

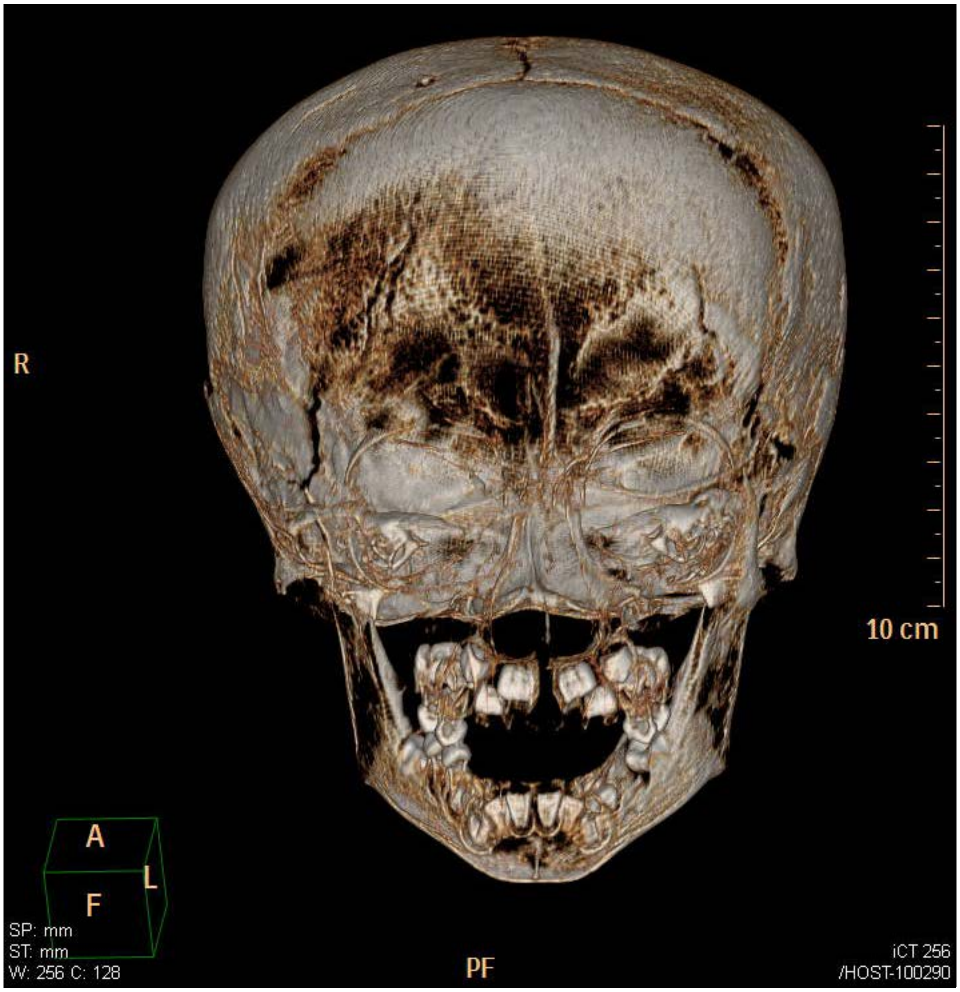

Figure 2.5 CT-Scan of NP 240 showing anterior view of skull and dentition. Image courtesy of the Janeway Hospital.

The child was found dressed or wrapped in a caribou skin with numerous grave offerings including model canoes, birch bark vessels, and red ochre (Howley 1915; Patterson 1892). Contact period items, including a knife blade and axe head, were recovered with the adult (Marshall 1996). NP 265, dated to 500 ± 25 B.P. (UCIAMS-129844), is represented only by a well-preserved adult skull enclosing a small amount of dried brain tissue (Grimes et al. 2011). There are no traces of red ochre on the skull. It is expected that if red ochre had been applied, and then subsequently cleaned at some point during its curation, that some colour would still adhere to the sutures, but this does not seem to be the case.

2.2.2.2 Charles' Arm, XIII-A-13a, XIII-A-13b, XIII-A-14

Located in Notre Dame Bay, Charles' Arm is a burial site excavated by Devereux in 1965. The disturbed remains of an adult and child were recovered (Devereux 1969). The remains were found under a rock overhang, wrapped in birchbark and dusted with red ochre (Marshall 1996).

2.2.2.3 Comfort Cove, NP 152, NP 294, NP 296 (DiAr-01)

The remains of three individuals were recovered from a cave on Comfort Island in the Bay of Exploits (Marshall 1996). The nearly complete remains of an adult male (NP 152) were recovered in a remarkable state of preservation, soft tissue held together the bones of the left hand and arm. The recovery of this individual was reported in the Twillingate Sun (1888) “Relict of a Red Indian”. Marshall (1996) reports that contact period artifacts were recovered from the site, and radiocarbon dates on human bone collagen ranging from 610 ± 25 B.P. (UCIAMS-129841) to 590 ± 15 B.P. (UCIAMS-125898) place the site within the historic period (Grimes et al. 2011). The other two individuals represented in the assemblage are incomplete and fragmentary, but one appears to have been an infant based on the state of formation of deciduous teeth and the small size of recovered cranial bones. The recovery of carved bone pendants, in the style of the Beothuk, strongly suggests that the skeletons are those of Beothuk people.

NP 152 is represented by a nearly complete, well preserved and robust skeleton. The teeth are worn, with some evidence for linear enamel hypoplasia on the anterior mandibular and maxillary teeth. The mandibular teeth exhibit an uneven wear pattern with the left canine and incisors exhibiting a greater degree of wear than the right incisors and canine. The skeleton was articulated for display in the past and almost all of the bones bear small drill holes. Apart from the enamel defects, no other indications of stress, trauma or illness have been noted (Jerkic n.d.). NP 294 and 296 were recovered by Donald Locke in the 1970s. NP 294 is represented by a fragment of rib, two phalanges and a metatarsal. There is evidence of ochre on the bones. The remains attributed to NP 296 consist of a broken mandible and seven teeth. There is a small amount of ochre on several of the teeth. The mandibular bone appears well preserved. There is little wear on the third molars, but exposed dentine is present on the first molars and on the single canine.

2.2.2.4 Cranberry Island, NP 151 (DiAr-8)

Cranberry Island (or Musselbed Island), in the Bay of Exploits, was the burial site of one adult individual, found by Kayward Manuels in 1973 and recovered by Jerkic and Tuck in 1974 (Balsom et al. 2006; Marshall 1984). The site had been disturbed, but a contact period whaling harpoon was recovered from the site (Marshall 1996). The individual is a probable male, between the ages of 35 and 55 years (Jerkic n.d.). A radiocarbon date of 655 ± 15 B.P. (UCIAMS-125899) places this individual within the historic period (Grimes et al. 2011). NP 151 is represented by an incomplete, fragmentary skeleton. The bones are covered with red ochre and are quite weathered with exposed spongy bone, although the preservation is variable across the elements represented. The teeth are worn with exposed dentine across all teeth. Enamel hypoplasias are visible on all maxillary teeth and anterior mandibular teeth.

2.2.2.5 Devil's Cove, NP 299, XIII-A-12a (DjAw-16)

LeBlanc (1973) recovered the disturbed remains of two individuals from beneath a rock overhang near Robert's Arm in Notre Dame Bay in 1971. LeBlanc (1973) reported an absence of grave goods and red ochre, but noted that the site had been severely disturbed. A human maxilla and bone pendant were donated to the Provincial Archaeology Office in 1998, and more human teeth and bone fragments were donated to the PAO in June, 2006. The samples in this study come from the maxilla and have been dated to 1335 ± 15 B.P. (UCIAMS-170517) (Grimes et al. 2011).

2.2.2.6 Fox Bar, NP 270A-E, G (DeAk-02)

The Fox Bar burial site is located in Bonavista Bay, east of the Beaches archaeological site (DeAk-1). The mortuary site was found beneath a rock overhang approximately 20 feet above sea level and had been previously disturbed prior to the salvage excavation led by Paul Carignan in 1973. Excavators recovered the fragmentary remains of at least three individuals, aboriginal artifacts and those of European origin (Carignan 1973; Jerkic n.d.). The latter category included a French kaolin pipe that Carignan (1973) dated to the late 16th century. Radiocarbon determinations from the bone collagen of NP 270A, B, and C ranged from 700 ± 20 B.P. (UCIAMS-134696) to 555 ±

20 B.P. (UCIAMS-134694) (Grimes et al. 2011). The presence of red ochre and bone pendants are consistent with Beothuk burials elsewhere and Marshall (1996) includes this site in a list of authenticated Beothuk burials.

The Fox Bar skeletal remains are heavily coated with ochre. NP 270A appears to represent the remains of a young adult or adolescent male, based on the morphological traits of nearly intact innominate bones and the state of epiphyseal fusion of the post cranial skeletal elements present (Schaefer et al. 2009). NP 270B is very poorly preserved and weathered, but appears to represent an adult individual. A mandible attributed to NP 270B is present, however the bone is very weathered and all teeth have been worn down to the level of the mandible by taphonomic processes. The mandible attributed to NP 270C was found in a similar condition. NP 270D appears to have been a juvenile, and NP 270E a newborn. Although the assemblage was commingled, the isotopic and radiocarbon results, reported in Chapter 6, support the MNI.

2.2.2.7 High Grego Island, NP 290 (DiAt-03)

A single individual was discovered, wrapped in birch bark in a small cave on the south side of High Grego Island. The skeletal remains were located between 1935 and 1940 by local residents and subsequently removed by a medical doctor practicing in a nearby town (Devereux 1965a). The remains were returned to the provincial museum of Newfoundland in 2005 from the Canadian Museum of History. NP 290, dated to 545 ± 15 B.P. (Grimes et al. 2011), is represented only by postcranial elements. These have the appearance of well-preserved bone and were treated with some type of shiny, yellowing lacquer. It does not appear that the bones were treated with ochre, but the colour of the lacquer obscures the true colour of the bones.

2.2.2.8 Ladle Point, NP 266 (DiAm-01)

Ladle Point is located on the Straight Shore of northeastern Newfoundland. This coastal region lies between the Bay of Exploits to the northwest and Bonavista Bay to the south. Howley (1915) reports that a skull, femur, scapula and small bones were recovered by a Dr. Winter in 1834. The individual was recovered from a grave, beneath which was found a circular, birch bark lined storage pit holding an ochre stained spear shaft and two pieces of iron pyrite (Howley 1915). Howley indicates that the skull and femur were curated by the Newfoundland Geological Museum, however, at the time of this study, only the skull was available for analysis, the other skeletal material having been lost. The gracile features of the skull suggest that it belonged to a female individual. The left zygomatic process and left eye orbit incurred damage at some point (Fig. 2.5). Howley (1915) reported that this damage may have occurred perimortem and potentially represents a bullet wound. Marshall (personal communication, 2016) expressed doubt that the curated remains actually represented the same individual discussed by Howley, but the description reported by Howley (1915: 335) appears consistent with the morphological features of the skull, and with the damage he described. Grimes et al. (2011) obtained a radiocarbon date of 315 ± 25 B.P. (UCIAMS- 129838), the most recent date obtained from any of the putative Beothuk sites.

2.2.2.9 Long Island, XIII-A-1, XIII-A-2-1, XIII-A-2-2, XIII-A-8 (DiAs-6)

The remains of four individuals were discovered by Diamond Jenness under a cliff on the western side of Long Island during a survey for the Canadian Department of Mines in 1927 (Jenness 1929). The pelvis and cranium of a female and the cranium of a juvenile were recovered with the nearly complete remains of an adult male. European and

Beothuk artifacts were recovered including metal spoons, fragments of copper basins, iron pyrite, bone pendants and red ochre (Jenness 1929).

Figure 2.6 Ladle Point (NP 266). Image of bone damage referenced by Howley (1915). Image by author.

2.2.2.10 Rogers Cove, NP 268 (DjAp-02)

In 1997, the Royal Canadian Mounted Police surrendered the skull of a probable male to the Rooms Provincial Museum for curation. The skull was recovered from Rogers Cove, located on the southwestern tip of Fogo Island off the coast of northeastern Newfoundland. The skull had been found in a small rock crevice with no associated artifacts that would point to a definitive cultural or biological affiliation, however, the pattern of marked attrition on the skull’s teeth suggest the individual was of Amerindian descent (Jerkic n.d.). The context was inconsistent with known Beothuk burial patterns, and suggested that the skull had been moved from its original resting place. Jerkic assigned an age range of 35 to 55 years based on dental attrition and suture fusion. Four samples were taken from the skull for isotopic, radiocarbon, and ancient DNA analysis. The radiocarbon date of 770 ± 20 B.P. (UCIAMS-129845) indicates that this individual lived in the late precontact/early historic period (Grimes et al. 2011). The identification of this individual as Beothuk is only tentative, given the lack of archaeological context, and rests on the relatively early radiocarbon date and dietary isotope data which indicates a largely marine-based diet.

2.2.2.11 Swan Island (DiAs-09), NP 291, 292, XIII-a-15

The remains of two individuals were recovered from beneath a birch bark canopy in a cave on Swan Island, in the Bay of Exploits, in 1886 by J. P. Howley (Howley 1915). The remains are largely fragmentary, but organic preservation of bone artifacts, including hair combs, gaming pieces, and bone pendants, was excellent. The interment was thought to have occurred after European contact, as contact period items, such as kaolin pipe fragments, were found with the skeletal remains. Devereux returned to the site in 1965 and recovered six more fragments of human bone (Devereux 1965b).

NP 291 is represented by three vertebral fragments, several fragments of rib bone, three tarsals, and five phalanges. The bones are darkly stained, potentially from a combination of red ochre and humic acids from the burial environment. NP 292 appears to have been a juvenile and is represented by a small zygomatic bone and two deciduous incisors. The bones have a similar dark colouration as NP 291.

2.2.2.12 Western Indian Island, NP XIII-A/3c

Western Indian Island, or Phillip's Island, is located in eastern Notre Dame Bay. The remains of one individual were found by Roland Hoddinott in 1948 (Marshall 1996). The disturbed burial site was recorded by MacLeod in 1966 (Marshall 1996). The remains, found wrapped in birchbark and dusted with ochre, consisted of several cranial fragments (Marshall 1996). Historic period artifacts were also recovered from the site, including a knife blade and axe head (Marshall 1996).

2.3. Chapter summary

In one respect, archaeological research into this time period has benefited immensely from the excellent preservation of organic artifacts from the Port au Choix-3 site, but the reconstruction of the subsistence practices of these ancient people has had to cope with the scarcity of faunal remains from non-mortuary sites. This forms a significant knowledge gap that the research presented in this thesis can begin to fill with a broad sampling of the human remains from Port au Choix-3. The radiocarbon dates, which will be presented in Chapter 6, will serve to anchor the comprehensive stable carbon and nitrogen isotope dataset obtained from human skeletons and will facilitate the identification of diachronic patterning. The human remains that are affiliated with the Recent Indian Tradition span the historic period, suggesting the potential for a diachronic reconstruction of Recent Indian diet.

CHAPTER 3: PALAEODIET AND THE ARCHAEOLOGICAL SKELETON

Living bone and dental tissues are composed of organic and inorganic material that work together to store essential minerals, provide support for muscles, protection for internal organs, and produce red blood cells (White and Folkens 2005). These tissues are composed of elements derived from diet and as such, they act as an archive of palaeodietary data. To facilitate an understanding of how diet contributes to the isotopic composition of an individual, this chapter will begin by reviewing the biology of bones and teeth with a focus on molecular composition, growth, and metabolism. Next, the basic principles of stable isotope analysis will be introduced, followed by an in depth discussion of the stable isotopes of carbon and nitrogen. This discussion will focus on the cycle of carbon and nitrogen in the environment, their presence in animal tissues and in bone collagen and enamel bioapatite in particular, and how these characteristics enable them to be used to recreate the dietary practices of past human populations. The chapter will close with a consideration of analytical methods and tissue diagenesis.

3.1 Bones and teeth at the molecular level

Bone and teeth are composite tissues characterized by inorganic and organic fractions. The inorganic fraction is composed of biomineral and water, while the organic fraction consists of various proteins and lipids. Together, the fractions function to lend strength and responsiveness to bones and teeth. The following section will present the molecular building blocks of bones and teeth, bioapatite and collagen, and will briefly discuss the composition of lipids and non-collagenous proteins that also play a role in bone and tooth metabolism.

3.1.1. Bioapatite

The inorganic mineral fraction is comprised of carbonated calcium phosphate (hereafter termed bioapatite), similar in formula to hydroxyapatite, but highly substituted (Trueman and Tuross 2002). The molecular formula, taking the possibility of substitutions into consideration, is thus written as: $Ca_{10}(PO_4)_{6-x}(OH)_{2-y}(CO3)_{x+y}$ (Pellegrini et al. 2011). Bioapatite precipitates from extracellular fluid, but the processes that govern precipitation are not well understood (Glimcher 2006). In bone, bioapatite forms small, plate-like crystals that are interfaced with the organic fraction, collagen, by glue-like non-collagenous proteins (Bala and Seeman 2015; Elliott 2002; Kim et al. 1995). The size of bone bioapatite crystals reflects the plasticity of bone. The small crystals have a large surface-area-to-volume ratio that increases their reactivity with compounds in the extracellular fluid (Glimcher 2006). The bioapatite crystals in mature human enamel are larger and more organized than those found in bone or dentine and reflect the need for stability in enamel as this tissue, once formed, does not undergo subsequent remodeling (Currey 2002; Elliot 2002).

For palaeodietary studies, the principal compound of interest in bioapatite is carbonate as this compound can inform on the source of carbon in the whole diets of past populations (e.g. Ambrose et al. 1997; Ambrose et al. 2003; France and Owsley 2015; Harrison and Katzenberg 2003; Prowse et al. 2005; Sullivan and Krueger 1981). Bioapatite can contain up to 6 weight percent of carbonate, which is located in three places: in the β position, where it substitutes for the phosphate anion; in the α position where it substitutes for the hydroxide ion; and it may also be found adsorbed onto the surfaces of bioapatite crystals (Biltz and Pelligrino 1977; Kohn and Cerling 2002; Rey et al. 1989).

3.1.2 Collagen

The organic fraction of bone and dentine is composed primarily of the triple helical protein, collagen (Pritchard 1972; Veis 1984). Collagen contains 18 amino acids, routed directly and indirectly from dietary protein and, to a lesser extent, from dietary lipid and carbohydrates (Ambrose and Norr 1993; Tieszen and Fagre 1993). These are incorporated into a polypeptide composed of repeating amino acid triplets that take the form of $(\text{Glycine-X-Y})_n$, where X and Y are usually the non-essential amino acids, proline and hydroxyproline, but can be substituted with other amino acids, such as leucine, phenylalanine and methionine (Ramachandran and Ramakrishnan 1976). Non-essential amino acids compose ~80% of the collagen polypeptide while essential amino acids, or those with essential precursors, compose the remaining ~20% (Jim et al. 2006). Glycine composes one third of the amino acid residues in Type I collagen and its particular orientation and elemental composition are crucial to the formation of the triple helix (Herring 1972). The collagen triple helix consists of two α1(I) chains and one α2(I) chain that form fibrils of collagen, approximately 1000 amino acid residues in length (Miller 1984; Ramachandran and Ramakrishnan 1976). The helix is stabilized by hydrogen bonds that form between nitrogen, oxygen, and hydrogen, and by the presence of hydroxyproline and proline (Collins et al. 1995; Ramachandran and Ramakrishnan 1976). The majority of bone bioapatite is packed around the collagen fibrils, with smaller amounts of disorganised calcium phosphate found in the intrafibrillar spaces (Schwarcz 2015).

3.1.3 Non-collagenous proteins and lipids

Bone contains two main groups of non-collagenous proteins. The first function as precursors to bone mineralization, while the second are present prior to bone resorption (Roach 1994). The presence of these proteins has been used to estimate the rate of bone turnover in humans (e.g. Garnero et al. 1996; Mora et al. 1999), and recently the presence of osteocalcin, a protein signifying bone resorption, has been used as a non-specific stress indicator to estimate the health status of an assemblage of Medieval skeletons (Scott et al. 2016). There have also been attempts to relate the isotopic composition of osteocalcin to diet (e.g. Ajie et al. 1991).

Lipids from archaeological bones and teeth are of interest due to their influence on stable carbon isotope ratios of collagen (Guiry et al. 2016; Lidén et al. 1995; Logan et al. 2008; Post et al. 2007), and their relationship to dietary carbon (Colonese et al. 2015; Jim et al. 2004; Stott et al. 1999; Tieszen et al. 1983). Lipids are shown to constitute approximately 1% of the organic matrix of cortical bone and are present as triglycerides, fatty acids, cholesterols, and phospholipids (Dirksen and Marinetti 1970; Pietrzak and Woodell-May 2005). The abundance of lipids in bone can be influenced by pathological conditions and individuals with osteoarthritis have been shown to have greater concentrations of bone lipids (Plumb and Aspden 2004).

Finally, trace amounts of the protein amelogenin are contained in mature tooth enamel (Hillson 2005). Amelogenin composes the organic precursor of enamel and has a different amino acid composition than bone and dentinal collagen (Glimcher 2006). The constituent amino acids in amelogenin are leucine, proline, glutamic acid and histidine (Glimcher 2006).

3.2 The Growth and Maintenance of Skeletal Tissues

Teeth and bone incorporate chemical elements from diet as they develop, but after childhood, the rate of incorporation differs between these tissues, therefore, the timing and processes involved in bone and tooth development are important considerations for stable isotope-based approaches to palaeodiet reconstruction. Bone tissue continues to change throughout life at a molecular and cellular level, while tooth enamel, once formed, is essentially chemically inert. The following section reviews the processes of bone and dental tissue development.

3.2.1 Skeletal growth and maintenance

The processes of bone growth and maintenance are mediated by three specialized types of bone cell. Osteoblasts, derived from bone-lining cells in the periosteum, produce the collagenous organic matrix (Currey 2002). Following mineralization of the organic matrix, osteoclasts become osteocytes connected via small gaps in the bone matrix called canaliculi (Currey 2002). The last cell type is the osteoclast which is a large cell responsible for breaking down living bone prior to bone remodeling.

Bones begin their growth in one of two ways: endochondral ossification, such as that which occurs at the ends of long bones, ribs and vertebra, involves the complete replacement of a cartilaginous model with bone tissue; and membranous ossification, which occurs in the flat bones of the skull when undifferentiated mesenchymal stem cells differentiate into osteoblasts that begin to build bone tissue onto a thin membrane (Currey 2002). During fetal development and infancy, bones increase in length through progressive endochondral ossification of the ends of long bones, and in width through appositional growth (Lewis 2007). In appositional growth, osteoblasts lay down new organic matrix on the external surfaces of bone, and osteoclasts remove material from the internal surfaces of bone, allowing the bone to grow in diameter (Lewis 2007). Bone growth does not occur as a constant state in children, but rather occurs over restricted periods (e.g. growth spurts) that vary according to sex and nutritional status (Branca et al. 1992; Lewis 2007; Rauchenzauner et al. 2007). Rauchenzauner et al. (2007) measured the concentration of non-collagenous proteins in the urine of children and adolescents aged from 2 months to 18 years and found that the presence of these proteins peaked in infancy, signifying a period of growth, and again early in puberty with an earlier onset in girls than in boys, a finding also noted by Mora et al. (1999).

Bone metabolism in adulthood functions only in a maintenance capacity. The formation of bone tissue during bone remodeling begins as osteoblastic activity produces a collagen matrix which mineralizes five to 10 days after initial formation (Boivin et al. 2009). The osteoclasts differentiate to osteocytes, forming basic structural units (BSUs), which then become progressively mineralized over a period of 24 to 30 months through the multiplication of bioapatite crystals within the organic matrix (Boivin et al. 2009; Glimcher 2006). Therefore, it can be expected that newly formed BSUs will be less well mineralized than older BSUs. The rate of bone turnover in adults directly influences the degree of bone mineralization as faster bone resorption destroys BSUs before secondary mineralization is complete (Boivin and Meunier 2002). For example, in older adults, the rate of bone turnover increases with the result that older adults have less mineralized bone tissue (Garnero et al. 1996).

Glimcher (2006) posited that the total bone mass of the skeleton is replaced every five to six years, and that the rate of turnover varies between skeletal elements, like rib and femoral bone, and within a single element as mechanical loading and stress linked to muscle and ligament attachment sites will result in a greater rate of bone remodeling.

In bioarchaeology, more conservative estimates of the turnover rate of human bone collagen are typically cited. Estimates can vary from five to 10 years for rib bone collagen (e.g. Richards and Hedges 1999) to greater than 10 years for femoral collagen (Hedges et al. 2007). Using radiocarbon isotopes as a tracer, Hedges et al. (2007) demonstrated that collagen turnover occurred more quickly in males than females, and in juveniles than adults.

3.2.2 Tooth structure

The layered structures of differing organic/inorganic composition that compose teeth closely reflect the function of dental elements. Mammalian teeth are composed of an inner pulp chamber, which supplies the blood and nervous tissue to the tooth, mineralized dentine forming the crown and root of the tooth, and an enamel cap that covers the crown and is composed almost entirely of inorganic calcium phosphate (Hillson 2005). The interface of dentine and enamel is referred to as the enamel-dentine junction. Dentine and enamel are discussed in more detail below.

3.2.3 Dental development and maturation

The growth and mineralization of teeth involve the separate processes of dentine growth and mineralization, and enamel secretion and mineralization. Primary crown dentine begins to form slightly before enamel, and continues to grow in conical layers to form the root of a tooth after the tooth is in occlusion (Hillson 2005). Dentine formation is driven by the activity of odontoblasts, cells that perform a similar function as the osteoblasts in bone. The development of a tooth crown begins as odontoblasts lining the inner pulp chamber of the tooth secret an organic collagen matrix (Linde and Goldberg 1993). Following the secretion of the organic matrix, crystals of bioapatite precipitate and are seeded into the matrix (Hillson 2005). Mineralized dentine has a lower ratio of organic to inorganic material than bone, and unlike bone, mature dentine does not contain living cells (Currey 2002).

Mature enamel is composed almost entirely of bioapatite, containing only trace amounts of protein and water, and yet, like bone, enamel begins as an organic matrix secreted by specialized cells called ameloblasts (as opposed to osteoblasts) (Hillson 2005). Each ameloblast is responsible for secreting the organic matrix, composed largely of amelogenin, and then replacing it with bundles of bioapatite crystals (Hillson 2005). The process begins at the tooth crown and proceeds down the sides of the tooth, similar to the production of dentine, however, in humans, enamel mineralization does not seem to follow the same pattern (Crabb 1959). The timing of enamel maturation can be roughly predicted based on tooth formation and eruption times, but the actual period represented by enamel mineralization, which is of interest as this is when stable isotopes are incorporated into enamel, is poorly understood as the onset of mineralization is not detectable with radiographs (Reid and Dean 2006).

Humans have two sets of teeth during their lifetime. The deciduous dentition begins to form in utero and is shed in childhood, and the permanent dentition begins to form in the first year of life and can continue to develop into young adulthood (Ubelaker 1979). Dental elements develop and mature in a regular progression that seems to correspond to particular ages although some variation between human populations, and between sexes has been observed in the time it takes for teeth to reach maturity

(Liversidge 2003; Reid and Dean 2006). The variation observed in tooth formation times can also equate to a difference in chemical input between teeth. For example, the deciduous dentition that forms in utero incorporates chemical elements from the mother's diet. The permanent teeth, such as the first molar or the incisors, form while an infant is breastfeeding and will be synthesized from elements in breastmilk, while later-forming teeth, like the second molar or premolars, will reflect elements consumed during childhood (e.g. Lidén and Eriksson 2014; Wright and Schwarcz 1999).

3.3 Stable isotope analysis

Stable isotope-based approaches in archaeology make use of natural differences in bone and tooth chemistry that relate to diet, physiology and the environment. This section will begin with a brief introduction to the conventional terminology used by biomolecular archaeologists, and will also introduce the basic principles that govern the application of stable isotope analysis. The following subsections will detail the two isotopes used in this research, with a focus on their presence in the environment and in animal tissues, and on expectations for the stable isotope ecology of Newfoundland, based on research conducted to date in the province, and in other boreal and coastal environments.

3.3.1 Terminology and notation

Each element on the periodic table possesses a fixed number of protons, however, elements can have a variable number of neutrons, resulting in a slight variation of mass between atoms. Atoms of a single element with a different number of neutrons are termed 'isotopes'. For example, the element carbon has three isotopes: Carbon-12 (^{12}C) with six protons and six neutrons; Carbon-13 (^{13}C) with six protons and 7 neutrons; and Carbon-14 (^{14}C) with six protons and 8 neutrons. ^{13}C and ^{14}C have heavier masses than ^{12}C and are thus dubbed heavier isotopes (to be distinguished from heavy elements) (Schoeller 1999). These isotopes of carbon can be further distinguished: ^{12}C and ^{13}C are stable, while ^{14}C is a radioisotope, meaning that it undergoes radioactive decay into Nitrogen-14 (^{14}N). Stable isotopes differ in their natural abundance as lighter isotopes of an element are more common than heavier isotopes (Hoefs 2009). Stable isotopes are expressed as a ratio of the heavier isotope to the lighter, and are measured relative to a standard with the result expressed as a delta value, e.g. δ^{13}C, using per mil (‰) or parts per thousand units (Schoeller 1999). The conventional formula for a calculated stable isotope measurement is:

$$\boldsymbol{\delta X(‰) = (\frac{Rsample}{Rstandard} - 1) \times 1000}$$

X is the isotope measurement of interest (δ^{13}C, or δ^{15}N), and R is the ratio of the heavy isotope to the light (e.g. ^{13}C/^{12}C, or ^{15}N/^{14}N) for either an unknown sample or a standard of known isotopic composition. However, as noted by Hayes (1993), it is not a single isotope ratio that is of interest, but the difference in ratios between different analytical materials. The difference between an isotope ratio in one material, and that of another, occurs through the process of isotopic fractionation, introduced below.

3.3.2 Isotopic fractionation

Archaeological studies of palaeodiet and mobility rely on natural offsets that arise between the isotope values of food/water and those of a consumer. These differences generally arise from a combination of equilibrium/thermodynamic and kinetic isotope effects (Hayes 1993). Equilibrium isotope effects concern the back and forth exchange of isotopes in a chemical reaction and arise due to the differences in bond strength between molecules containing a heavy isotope and those containing a light isotope (Schoeller 1999). Greater energy is required to break a bond between a heavy isotope and another atom, therefore, in an equilibrium reaction, the heavy isotope will be exchanged less frequently (Schoeller 1999). Kinetic isotope effects occur because heavy isotopes react more slowly than light isotopes in unidirectional reactions, resulting in differences in the ratio of light and heavy isotopes before and after the reaction (Hayes 1993; Schoeller 1999). Equilibrium and kinetic isotopic fractionation result in isotopic discrimination. If a reaction discriminates against the heavy isotope, then the product of the reaction will be isotopically lighter and will have a lower isotope value (Hayes 1993; Schoeller 1999). Discrimination against the lighter isotope will have the opposite effect with a heavier product being produced (Schoeller 1999).

3.3.3 Natural abundance and standards

The element carbon has two naturally occurring stable isotopes: ^{12}C which has a natural abundance of ~98.9% of carbon atoms, and ^{13}C which is far less abundant at only 1.1% (Hoefs 2009). A third, radioactive isotope, ^{14}C, occurs only in trace amounts (Hoefs 2009). Carbon isotope ratios (^{13}C/^{12}C) are measured as δ^{13}C values relative to the Vienna PeeDee Belemnite (V-PDB) scale which is defined using the IAEA primary standard, NBS 19 (δ^{13}C = 1.95‰) (Brand et al. 2014).

Nitrogen has two stable isotopes: ^{14}N with a natural abundance of 99.6% and ^{15}N making up the remaining 0.4% (Hoefs 2009). Nitrogen isotopes are measured relative to atmospheric nitrogen, or AIR (Ambient Inhalable Reservoir), which defines the nitrogen isotope scale with a value of ~0‰ and is considered to be homogenous within current analytical uncertainty (Brand et al. 2014).

3.4 Stable carbon isotope analysis

Carbon isotopes are measured to shed light on the main sources of dietary carbon for past populations and are well suited for estimating relative contributions of marine and terrestrial foods to human diet (e.g. Chisolm et al. 1983; Tauber 1981). The carbon isotope composition measured in human or faunal skeletal remains relates to the source of carbon synthesized by primary producers. Plants that have evolved to withstand different atmospheric concentrations of CO_2 utilise different photosynthetic pathways (Ehleringer and Monson 1993). The particular pathway affects the amount of fractionation that occurs in the carbon that is incorporated during the photosynthetic process (O'Leary 1984). Consumers in marine environments have access to an alternate source of carbon which is reflected in their higher carbon isotope composition relative to terrestrial plants (Hoefs 2009). The differences that occur at the base of the foodchain are carried on through herbivores, omnivores and carnivores and allow for different dietary strategies to be investigated (van der Merwe 1982). As carbon is bound in both the inorganic and organic fractions of bones and teeth, there exist opportunities to investigate input from different macronutrients, allowing a more complete palaeodietary reconstruction to be achieved (e.g. Ambrose et al. 1997; Jim et al. 2006).

3.4.1 Carbon isotopes in the terrestrial environment

The $\delta^{13}C$ value of modern atmospheric carbon dioxide ranges from -8‰ to -6‰ (Keeling et al. 1979). As carbon dioxide is incorporated into plant tissues, the carbon isotopes undergo fractionation. Plant $\delta^{13}C$ values have been found to range from -1 to -38‰, with higher values found in C_4 plants and lower values in C_3 plants (Bender 1971; Smith and Epstein 1971). C_3 plants are the major plant group in the Northern Hemisphere and are the predominant vegetation source in the Boreal forest of Canada with modern carbon isotope values averaging -29‰ (Brooks et al. 1997). Two other photosynthetic pathways exist, those of C_4 plants and crassulacean acid metabolism (CAM) plants, however, these have not been found to occur in Newfoundland and Labrador (Cerling and Quade 1993) and will not be a focus of the following discussion. The C_3 photosynthetic pathway uses the rubisco enzyme (RuBP) to fix CO_2 in the Calvin cycle (Park and Epstein 1960a; O'Leary 1981). The $\delta^{13}C$ value of C_3 plants is a function of several factors: the rate of photosynthesis, the reaction of CO_2 with RuBP, the conductance of plant stomata, and the contribution from mesophyll, respiration and photorespiration (Ubierna and Farquhar 2014). The greatest fractionation occurs in the reaction of CO_2 with RuBP which results in a product with a $\delta^{13}C$ value that is lower than atmospheric CO_2 by -27 to -30‰ (Roeske and O'Leary 1984; Ubierna and Farquhar 2014).

The fractionation associated with different photosynthetic processes have largely been based on experimental observations that occurred at 25°C, however observations of wild-growing plants have revealed that the carbon isotope composition of C_3 plants is subject to a variety of factors that may influence isotopic fractionation, including temperature (O'Leary 1984). These factors further include the concentration of CO_2 (Park and Epstein 1960b) and the canopy effect (Medina and Minchin 1980; Vogel 1978), water availability (Farquhar et al. 1989), soil salinity (Downton et al. 1985), latitude, and altitude (Körner et al. 1991; Morecroft and Woodward 1990). Additional differences in $\delta^{13}C$ values have also been noted between different species within the same environment, and between the tissues of an individual plant, such as between leaves and tubers, or fruiting bodies (Brooks et al. 1997; Heaton 1999). Critically, some of these factors have been linked to greater global processes and have been shown to vary over geological and archaeological timescales, complicating the interpretation of the isotope values of faunal and human consumers and leading several authors to emphasize the importance of obtaining a temporally specific comparative faunal baseline for palaeodietary reconstructions (Casey and Post 2011; Heaton 1999).

Newfoundland lies at the southernmost extent of the boreal forest and as such, the vegetation probably has low carbon isotope values similar to those observed in other regions of the boreal ecosystem (e.g. Brooks et al. 1997). It is expected that local fauna will have similar values reflecting the direct (herbivores) and indirect (carnivores) consumption of boreal plant types. For example, beaver are expected to have $\delta^{13}C$ values that reflect the seasonal consumption of alder (*Alnus* spp.), birch (*Betula* sp.) and soft woods (e.g. *Picea*, *Pinus*, *Abies*) in the winter, and on aquatic plants in the summer (Northcott 1971). Caribou $\delta^{13}C$ values may vary, or be higher than expected due to the consumption of lichens and mosses. Although caribou diet in the spring is characterized by the consumption of new growth, particularly sedges (e.g. *Carex* spp.); from summer to winter, their diets are characterized by increasing contributions from lichens (Bergerud 1972). Lichens, depending on their species of algal symbiont, can have higher $\delta^{13}C$ values relative to other C_3 plants with seasonal variation occurring in relation to water availability (Brooks et al. 1997; Lange et al. 1988; Shomer-Ilan et al. 1979). The pattern of increased lichen consumption by caribou over the winter was observed in sequentially sampled dentine from caribou in subarctic Quebec and Labrador (Britton 2007). The $\delta^{13}C$ values of these caribou increased during the cooler months of the year, as indicated by correlation with oxygen isotope analysis, suggesting the consumption of lichens during the fall and winter (Britton 2007). A similar pattern was noted in some Arctic caribou with high $\delta^{13}C$ values from caribou dentinal collagen, relative to the carbon isotope composition of boreal and arctic trees and forbs, and attributed to the consumption of lichens (Drucker et al. 2012). Given the composition of faunal assemblages recovered from Recent Indian contexts (e.g. Cridland 1998), it is unlikely that Amerindian populations would have relied solely on either beaver or caribou, thus any differences arising in the isotopic composition between beaver and caribou will not be distinguishable in measurements of human bone collagen.

3.4.2 Carbon isotopes in marine and freshwater environments

Some of the earliest uses of stable carbon isotope analysis in archaeology were to distinguish marine- and terrestrial-based diets (e.g. Chisolm et al. 1982; Richards and Hedges 1999; Schoeninger and DeNiro 1984; Tauber 1981). The primary source of carbon in marine environments is marine bicarbonate which has a $\delta^{13}C$ value of ~0‰ (Hoefs 2009). Initial equilibrium and kinetic fractionation occurs between the carbon in surface ocean water and atmospheric carbon dioxide (Hoefs 2009). As marine phytoplankton incorporate this carbon, it undergoes further fractionation through carbon fixation, resulting in a depletion of 10 to 18‰ (Tauber 1981). Phytoplankton $\delta^{13}C$ values have been shown to average -21‰, but variation occurs depending on the source of inorganic carbon, and the process by which particular marine autotrophs fix the carbon (Fry and Sherr 1988). Further isotopic separation has been observed in the marine environment between pelagic (open water) and benthic (sea bottom) zones. Benthic fish caught in the waters off Newfoundland have been shown to have muscle $\delta^{13}C$ values of ranging from -19.7‰ to -17.5‰, while those of pelagic fish range from -21.4‰ to -

19.7‰ (Sherwood and Rose 2005). It can be expected that actual muscle tissue isotope values from these species would be higher, as Sherwood and Rose (2005) did not extract ^{13}C depleted lipids from the muscle tissue prior to analysis.

Freshwater and estuarine systems can be quite variable in the carbon isotope values that characterize their lowest trophic levels. Estuarine systems have inputs of terrestrial carbon from emptying rivers and are influenced by marine sources of carbon so that transect sampling of particulate organic matter (POM) in these systems reveal a gradient of δ^{13}C values that reflect declining contributions from terrestrial carbon with increasing distance from the coast (Fry and Sherr 1988). POM samples collected from freshwater systems in Newfoundland have δ^{13}C values ranging from -24.4‰ to -25.7‰, while POM and macroalgae measured off the northern coast of Newfoundland had a slightly higher average values of -24.3‰ and -21.5‰, respectively (Ostrom and Macko 1992). The same study noted a seasonal effect of the enrichment in ^{13}C in the Bay of Exploits resulting in a 3‰ increase over the annual average of -25.5‰. Although the δ^{13}C values measured in this study were likely effected by modern pollutants, they indicate that faunal samples taken from near- and offshore environments may have different carbon isotope values that will be useful for estimating the contribution of nearshore and offshore species to ancient human diet.

3.4.3 Carbon isotopes in animal tissues

The δ^{13}C values of primary producers are passed to the tissues of their consumers, with minimal fractionation occurring between plant tissue and consumer tissue (McCutchan et al. 2003). Theoretically, this allows the source of primary productivity to be tracked based on the isotopic value of consumer tissues (Schoeninger and DeNiro

1984). However, animals that can feed in different ecotones can incorporate different sources of carbon, complicating reconstruction of their diet, as Fry and Sherr (1988) revealed in a review of trophic level offsets. The trophic level increase in $\delta^{13}C$ values was demonstrated to be quite variable, with the exception of marine ecosystems which showed consistent 1‰ increase by trophic level (Fry and Sherr 1988).

The measured average offset between the isotopic composition of collagen and that of diet is approximately 5‰, but variation has been observed ranging from 2‰ to 10‰ (Ambrose and Norr 1993; Tieszen and Fagre 1993). The isotopic composition of collagen depends upon the isotopic composition of its amino acids, which are supplied predominantly from dietary protein, and to a lesser extent from dietary carbohydrates and lipids (Ambrose and Norr 1993). Uncertainty remains about exactly how much carbon is routed from dietary protein, with estimates ranging from 50% (Jim et al. 2004) to 75% (Fernandes et al. 2012) and whether the amount is dependent on the amount of protein in the diet (Jim et al. 2006; Kellner and Schoeninger 2007; Tieszen and Fagre 1993). This variation is likely due to direct versus indirect routing of amino acids to collagen synthesis (Ambrose and Norr 1993; Jim et al. 2006). The offset between collagen and diet can further vary if dietary macronutrients have different isotopic compositions (Ambrose and Norr 1993; Tieszen and Fagre 1993).

Non-essential amino acids (NEAAs) compose the bulk of Type I collagen (Ambrose and Norr 1993). The incorporation of NEAAs to collagen does not follow a direct route from diet to collagen. Instead, NEAAs can be synthesized *de novo* from constituent elements from the diet that are sourced from all macronutrients. The creation of the carbon backbones for new NEAAs involves more biosynthetic steps than direct routing of essential amino acids (EAAs) from diet to collagen (Fogel and Tuross 2003). The greater complexity in the creation of these molecules results in greater isotopic fractionation and thus a larger offset between synthesized NEAAs and the original amino acids taken in through diet (Fogel and Tuross 2003). By contrast, EAAs measured in collagen tend to have $\delta^{13}C$ values that approximate their source as they undergo little isotopic fractionation between the time of their consumption, and their incorporation into new collagen peptides (Fogel and Tuross 2003). The isotopic composition of collagen taken as a bulk measurement should reflect a balance of all of the constituent amino acids, and as collagen is predominantly composed of NEAAs which incorporate carbon from the whole diet, the isotopic composition of collagen should be weighted toward that of whole diet rather than dietary protein, but experimental and modelled results have shown that this is not the case (e.g. Ambrose and Norr 1993; Fernandes et al. 2012; Froehle et al. 2012; Jim et al. 2004; Jim et al. 2006; Kellner and Schoeninger 2007; Tieszen and Fagre 1993). The leading explanation for this is that even though collagen is composed of NEAAs, it make more sense from the perspective of energy conservation to directly route NEAAs from diet to collagen than to synthesize them, especially if NEAAs are in plentiful supply in the diet (Jim et al. 2006). Ambrose and Norr (1993) found that by increasing the amount of dietary protein fed to laboratory mice, the $\delta^{13}C$ value of collagen could be made to track that of protein with greater fidelity, however, by modeling the results of archaeological and experimental studies on a variety of animals, Fernandes et al. (2012) found that dietary protein made a fixed carbon contribution of ~75%, with the remaining ~25% representing a scrambled $\delta^{13}C$ value of all dietary carbon sources.

The carbon atoms in bioapatite carbonate represent an average of all dietary carbon inputs (Fernandes et al. 2012; Froehle et al. 2012). Carbonate precipitates from blood bicarbonate which is in isotopic equilibrium with expired CO_2 and the $\delta^{13}C$ value of diet (Ambrose and Norr 1993; Passey et al. 2005; Schoeller et al. 1984). The isotopic composition of bone carbonate has been shown repeatedly to correlate with that of whole diet with an approximate correlation coefficient (R^2) of .95 (Ambrose and Norr 1993; Kellner and Schoeninger 2007; Tieszen and Fagre 1993). Measured and modelled isotopic offsets between bone carbonate and whole diet range from ~9‰ to 10‰, a small range relative to diet-collagen offsets (Ambrose and Norr 1993; Fernandes et al. 2012; Tieszen and Fagre 1993). However, this thesis, due to the propensity of bone carbonate to become diagenetically altered, sampled carbonate from tooth enamel. Passey et al. (2005) found diet-enamel carbonate offsets in excess of 10‰ in pigs raised on controlled diets. While Kellner and Schoeninger (2007) suggest that the difference in offset between enamel and diet, and between bone carbonate and diet results from differential isotopic fractionation between these tissues, Passey et al. (2005) attribute it to the digestive physiology of pigs compared to other species. Enamel carbonate values are frequently preferred over bone carbonate values in human palaeodietary reconstruction (e.g. Kusaka et al. 2015).

Lee-Thorp et al. (1989) demonstrated that among archaeological fauna, herbivore collagen was offset from bone carbonate by ~7‰, and carnivore collagen was similarly offset from carbonate by ~4‰, which they argued could potentially allow the degree of carnivory or omnivory to be assessed in past populations. The dissimilar offsets have since been thoroughly investigated and can be attributed to two factors, namely dietary macronutrients with distinct isotopic values, and dietary physiology that causes fractionation of CO_2 (Ambrose and Norr 1993; Hedges 2003; O'Connell and Hedges 2016).

Experimental data have been used to show that the $\delta^{13}C$ of muscle tissue is offset from that of bone collagen by approximately 2‰ (Ambrose and Norr 1993; Tieszen and Fagre 1993). This offset has been attributed to the greater number of glycine residues in collagen than in muscle tissue (Tieszen and Fagre 1993), as glycine is typically enriched in ^{13}C (Corr et al. 2005; Hare et al. 1991; Honch et al. 2012; Webb et al. 2015). Tieszen and Fagre (1993) found that the $\delta^{13}C$ values of other amino acids held in common between muscle tissue and bone collagen had very similar isotopic values and posited that the amino acids relegated to protein synthesis came from the same body pool. Lipids, similar to bone carbonate, are synthesized from total dietary carbon (Howland et al. 2003; Jim et al. 2004; Stott et al. 1997), but are depleted relative to carbonate and collagen in animals (Tieszen et al. 1983; Tieszen and Fagre 1993). The amount that lipids are offset from other animal tissues seems to vary between species. Ramsay and Hobson (1991) found an 8‰ offset between ringed seal muscle tissue and lipids; Logan et al. (2008) argued for a 3‰ offset for fish muscle and lipids, while McConnaughey and McCroy (1979) found a 6‰ difference for fish tissues; and the lipid $\delta^{13}C$ values of seabirds have been found to be offset by ~8‰ from muscle (as calculated from liver $\delta^{13}C$ values) (Thomson et al. 2000).

In summary, the $\delta^{13}C$ value of human bone collagen tracks that of dietary protein, while the $\delta^{13}C$ of bone and enamel bioapatite tracks whole dietary carbon. These analyses can thus be used to reconstruct the average sources of carbon in past human diets. As distinct differences are known to occur in the carbon isotopic composition of marine and terrestrial animals, it can be expected that $\delta^{13}C$ analysis of human bone collagen and enamel bioapatite will be an ideal method for investigating the reliance of Newfoundland Amerindian populations on marine and terrestrial food resources.

3.5 Radiocarbon analysis

Radiocarbon dates from human bone are rarely utilised by Newfoundland archaeologists due to concerns over the marine reservoir effect (e.g. Renouf and Bell 2011). However, radiocarbon dates from human bone allow biological and chemical information to be better incorporated into frameworks of archaeological interpretation. Significant advances in the calibration of dates from human bone have occurred that allow for correction of the marine reservoir effect. The following section briefly outlines the principles of radiocarbon dating and details the commonly used methods to calibrate bone collagen dates from marine-adapted humans.

3.5.1 Principles

Radiocarbon, or ^{14}C, is produced up the upper atmosphere through a reaction of nitrogen with thermal neutrons and cosmic rays (Bronk Ramsey 2008). Upon formation, it may bond with oxygen to form isotopically heavy CO, which is oxidized to form CO_2, or it will form carbon dioxide directly (Bronk Ramsey 2008). Once radiocarbon is bound as CO_2, it can enter the food chain as carbon fixed during photosynthesis by marine and terrestrial plants. From there, the process of incorporation into animal tissues is similar to that of other carbon isotopes with the exception that, due to its heavier mass, ^{14}C is subject to a greater degree of isotopic fractionation during metabolic processes (Bronk Ramsey 2008). Atmospheric ^{14}C is in dynamic equilibrium with carbon in surface ocean water, however, given the much slower turnover of carbon in the ocean compared to the atmosphere, ocean water is depleted in ^{14}C relative to the atmosphere by 5% (Bronk Ramsey 2008). This corresponds to an average offset of -400 years between contemporaneous marine and terrestrial samples (Stuiver et al. 1977). Local deviations, introduced through differential ocean circulation patterns, influxes of freshwater, and local climate, are termed the delta (Δ)R and can result in age offsets that are more or less than the average of 400 years (Stuiver et al. 1986). These local deviations are best determined through the use of paired contemporaneous marine and terrestrial samples, taking care that the marine samples are obtaining carbon from the water column and not from a geological substrate that is likely much older (Ascough et al. 2005; Cook et al. 2015; Russell et al. 2012).

The utility of radiocarbon in dating archaeological materials lies in its regular decay to ^{14}N. Radiocarbon isotopes have a half-life of 5730 years. A radiocarbon age is the measurement of the concentration of ^{14}C in a sample of unknown age which is then compared to the concentration of the isotope in a sample of known age. This measurement is not the equivalent of a calendar date, but rather, it is an age estimate (Malainey 2011). Radiocarbon dates are expressed as conventional radiocarbon ages with the following assumptions: 1) the concentration of radiocarbon in global reservoirs has remained constant; 2) the half-life of radiocarbon is 5568 years; and 3) years before present refers to years before A.D. 1950 (Malainey 2011). Conventional radiocarbon ages are produced relative to modern standards and are corrected for isotopic fractionation (Malainey 2011). The assumptions inherent in the production of conventional radiocarbon ages reduce the precision of radiocarbon dating and require the ages to be calibrated against a radiocarbon curve developed from samples of known age (Banning 2002).

The analysis of radiocarbon samples follows a similar procedure to stable carbon isotope analysis, discussed further in section 3.7 Samples of wood charcoal or bone are cleaned of visible debris and crushed or powdered. The samples are then treated with an acid to remove carbonates, an alkali solution to remove soil humics, and another acid treatment to remove modern atmospheric CO_2 that was absorbed during the alkali washes (Olsson 1986). The samples are then converted to graphite and the relative abundance of ^{14}C is determined using an accelerator mass spectrometer. The accuracy of the resulting radiocarbon age depends upon the preservation of the sample, and on the possibility of contamination with modern carbon. The preservation of the sample can be evaluated by assessing the atomic ratio of carbon to nitrogen (DeNiro 1985; van Klinken 1999), and as such, most radiocarbon laboratories will also produce a separate measurement of the carbon and nitrogen isotope ratios and elemental weight percentages.

3.5.2 Calibration of mixed-marine samples

For charcoal or samples of marine shell, the choice of calibration curve is straightforward, but there are situations where the provenance of the sample, and the source of carbon in the sample differ. The most obvious example of this, and the one that concerns this thesis, is a sample of bone collagen from a human with a mixed marine-terrestrial diet. In this case, atmospheric carbon and marine carbon, which differ in their abundance of ^{14}C, are both ingested and incorporated into new bone collagen. To effectively calibrate the date, the sample must be calibrated against both the marine and atmospheric curves at the same time, but weighted towards the greater source of dietary carbon (Arneborg et al. 1999). The carbon contributions from each source must therefore be quantified. The percentage of carbon from different reservoirs has been estimated using linear mixing models (e.g. Arneborg et al. 1999; Barrett and Richards 2004; Raghavan et al. 2014) and simple and complex Bayesian models (e.g. Fernandes 2015a, 2015b), and while the results from each method generally differ in their estimation of percent marine carbon consumption, the impact on the calibration of the radiocarbon age may not be significant.

Hedges (2004) noted that there was an approximate linear relationship between human bone collagen δ^{13}C values and the consumption of marine protein wherein every +1‰ increase in δ^{13}C corresponded to a roughly 10% increase in marine intake. In their analysis of the collagen of victims of the Vesuvius eruption, Craig et al. (2013) used a simple mixing model to demonstrate a linear relationship ($r^2 = .84$) between the radiocarbon offset caused by marine protein consumption and human collagen δ^{13}C values. Mixing models are widely used to estimate the relative proportions of marine and terrestrial carbon to human diets, and they vary in their complexity. Most make use of linear interpolation by assigning marine and terrestrial δ^{13}C endpoints, and then calculating where a human δ^{13}C value falls in relation to either endpoint, using the equation below:

$$\%\text{Marine intake}=\frac{\text{Terrestrial }\delta^{13}\text{C-Sample }\delta^{13}\text{C}}{\text{Terrestrial }\delta^{13}\text{C-Marine }\delta^{13}\text{C}}$$

Craig et al. (2013) estimated their endpoints using local, contemporaneous sheep and fish collagen. The choice of appropriate endpoints is an important consideration as the percent marine carbon can be changed by adjusting the marine and terrestrial endpoints. Endpoints can be estimated from local faunal $\delta^{13}C$ values, or they can be estimated directly from human $\delta^{13}C$ values.

The first method determines endpoints in one of two ways: 1) endpoints can be determined by analysing the meat of local animals, correcting the data for the Suess effect (the modern depletion in ^{13}C of atmospheric CO_2), and adding a diet-tissue fractionation factor to estimate the $\delta^{13}C$ values of humans consuming only those animals (e.g. Dewar and Pfeiffer 2010); 2) Endpoints can be determined by analysing the bone collagen of a variety of archaeological animals from marine and terrestrial ecosystems, averaging the data from each ecosystem, and adding a fractionation factor (usually +1‰) to reflect the trophic shift between prey and consumer collagen (e.g. Raghavan et al. 2014).

The second method determines the endpoints directly from human $\delta^{13}C$ values by selecting either individuals within the population whose $\delta^{13}C$ value is consistent with a typical terrestrial and marine diet, (i.e. ~ -21‰, and -12‰), or by taking average values from other populations with known diets (e.g. Arneborg et al. 1999; Dewar and Pfeiffer 2010). The latter method is arguably more accurate, as it avoids incorporating the uncertainty from estimating fractionation factors, however, it is dependent on the analyst having prior knowledge of $\delta^{13}C$ values of pure terrestrial and marine consuming humans in the population under study, or assuming that the $\delta^{13}C$ values of another population will be representative. Isotopic studies of modern and archaeological ecosystems provide ample evidence that baseline carbon shifts readily occur between regions and over time (e.g. Hedges et al. 2004), therefore comparative datasets should be selected with great care (Casey and Post 2011).

To deal with uncertainty in diet-tissue isotopic fractionation and macronutrient routing, new approaches have adopted more complex mixing models from ecology, such as IsoSource or Stable Isotope Analysis using R (SIAR), or have developed Bayesian models that are capable of dealing with multiple sources of carbon, dietary routing from different macronutrients, and the incorporation of multiple dietary isotopic proxies (e.g. Fernandes et al. 2014). These models were initially greeted with enthusiasm, as they promised to provide more accurate dietary reconstructions for populations consuming isotopically similar foods from different reservoirs. However, for populations consuming C_3 plants and herbivores, and marine resources, they do not offer a clear advantage (Commendador et al. 2014).

To calibrate bone collagen data from Rapa Nui Islanders, Commendador et al. (2014) applied both a sophisticated (IsoSource) mixing model using multiple isotope proxies ($\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$) and a simple carbon isotope linear interpolation model and found that interpolation consistently gave a greater percent marine intake than did IsoSource. However, when the resulting percent marine intakes were used to calibrate the collagen radiocarbon dates, the calibrated results did not differ with any statistical significance. Fernandes (2015) conducted a similar experiment using the Food Reconstruction Using Isotope Transferred Signals (FRUITS) model. Two treatments were administered to the dataset: the first estimated percent contributions of different food sources to a collagen isotope signal independent of macronutrient concentration, or routing of different macronutrients to collagen. The second incorporated the concentration of protein, carbohydrates and lipids in the food sources, the differential routing of these macronutrients to collagen, and the isotopic offset of each macronutrient from collagen. Despite the increased information incorporated into the second model, the results of each model agreed relatively well, although there was greater uncertainty in the estimated source contributions to the target isotope signal using the simpler model (Fernandes 2015).

These case studies serve to highlight an important point about the use of complex statistical models and radiocarbon calibration; as Craig et al. (2013) point out, the goal of dietary reconstruction is not synonymous with estimating the percentage of marine carbon in bone collagen, therefore it should be expected that complex Bayesian models will provide a different estimation of percent marine intake than linear interpolation models. For the purpose of estimating percent marine carbon calibration in regions where there are only two distinguishable reservoirs of carbon, the linear interpolation model is entirely sufficient (Craig et al. 2013; Commendador et al. 2014).

Calibrated radiocarbon measurements are presented as probability density functions with confidence limits that vary in size depending on several factors. Radiocarbon measurements of mixed-marine samples are prone to have larger confidence limits than samples from a single reservoir, regardless of the uncertainty associated with the initial radiocarbon measurement. This is due to uncertainty in the mixing of different curves (Bronk Ramsey 2008), in the estimate of the ΔR (Stuiver et al. 1986), and on the slope of the calibration curve (Banning 2002).

Before a radiocarbon date from a mixed-marine sample can be calibrated, an uncertainty must be assigned to the estimation of percent marine carbon intake or contribution (Bronk Ramsey 2008). Typically, a 10% error is assigned to account for isotopic variability within the environment which, in calibration, equates to an added uncertainty of approximately 40 years (Bronk Ramsey 2008). The selection of an appropriate ΔR is also an estimate that should be based on the most likely source of marine carbon in human diets. For example, marine species with small local ranges may incorporate a different ΔR than those who migrate long distances (e.g. Dyke et al. 1996). To account for Palaeoeskimo consumption of the migratory harp seal, Raghavan et al. (2014) applied a ΔR correction of 140 ± 50 years, an average of several measurements from the Strait of Belle Isle, and the Labrador coast. Additional consideration should be given to temporal variability in the ΔR. The ΔR of a particular region does not remain constant over time, but will fluctuate with climatic factors, and alterations in oceanic circulation (Ascough et al. 2009). Ideally, each region would develop ΔR histories to account for this variability (e.g. Grier et al. 2015), but unfortunately, for many regions ΔR measurements are few and literally far between (McNeely et al. 2006).

The final source of uncertainty lies in the calibration curve itself; the concentration of radiocarbon in the atmosphere has not remained constant, but is subject to short-term and long-term fluxes that are recorded as ‘wiggles’ or plateaus in the calibration curve (Banning 2002). Samples that intersect with one of these areas have larger confidence limits than do samples that intersect where the slope is steep (Banning 2002). Such a plateau occurs in the early historic period, reducing the precision of calibrations (Reimer et al. 2013). As an example of this, Figure 3.1 depicts the results of a calibrated radiocarbon determination from a sample of human bone recovered from a historic cemetery in Placentia Bay, Newfoundland. The δ^{13}C value from the sample indicated that the individual did not consume marine protein, so the sample was calibrated only against the atmospheric curve determined for the northern hemisphere

(Reimer et al. 2013), reducing the uncertainty associated with the calibration. Even so, uncertainty is introduced by the intersection of the radiocarbon determination, on the y-axis, with the calibration curve. The determination hits the curve at multiple points, as is clear by the probability associated with the one sigma (68.2%) range. A similar problem is likely to ensue with the radiocarbon dates from historic period Beothuk, and the confidence limits are expected to be larger than those depicted in Figure 3.3 as the calibration will require incorporating the uncertainty from the ΔR and from the percent marine carbon intake estimation. Fortunately, the slope of the calibration curve is much steeper for the Maritime Archaic period, although there is a wiggle between 5000 B.P. and 4500 B.P. (Reimer et al. 2013) that may increase the confidence limits for any dates that fall within that span of time.

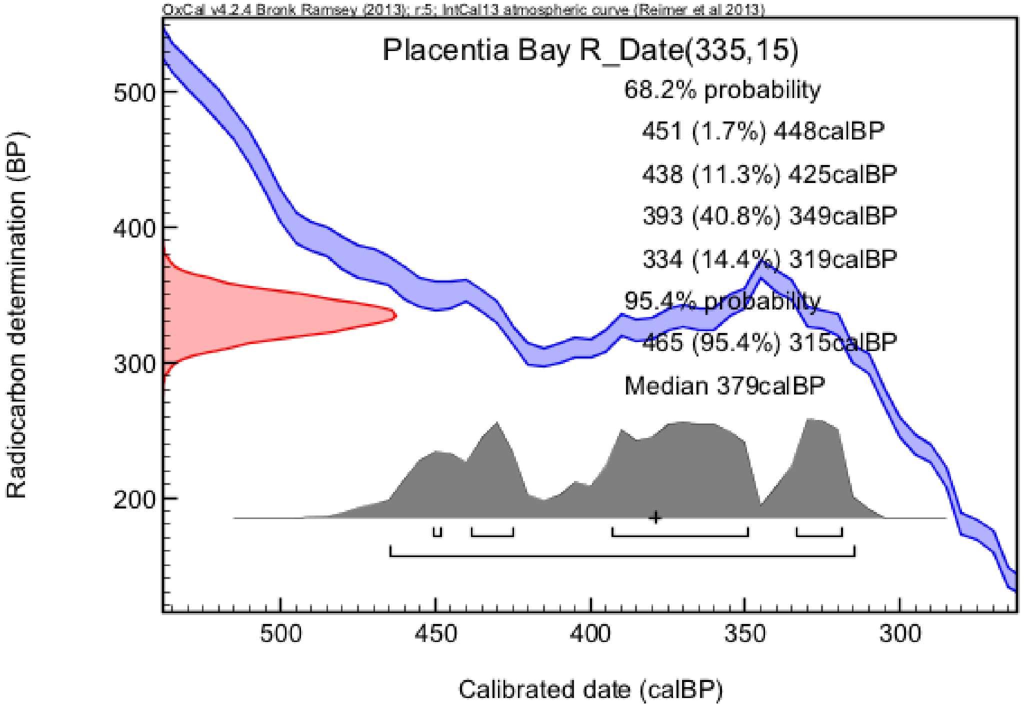

Figure 3.1 Example of calibrated historic radiocarbon date. The uncalibrated radiocarbon age and error are given in brackets at the top of the plot.

3.6 Stable nitrogen isotope analysis

The ratio of ^{15}N to ^{14}N ($\delta^{15}N$) is used to track trophic interactions in ancient and extant ecosystems as the $\delta^{15}N$ values of consumers are generally higher than their diet (Minagawa and Wada 1984). This isotope system has been particularly useful for estimating the role that marine resources may have played in the subsistence practices of past human populations (e.g. Tauber 1981). Marine environments contain more trophic levels than terrestrial environments with the result that marine animals have higher $\delta^{15}N$ values than terrestrial animals (Schoeninger and DeNiro 1984). In turn, these higher isotope values are incorporated into the tissues of marine-adapted humans and act as powerful indicators of marine food consumption (e.g. Coltrain et al. 2004). The following section will review the processes of nitrogen isotopic fractionation in terrestrial and marine environments, and in animal tissues.

3.6.1 Nitrogen isotopes in the environment

N_2, or atmospheric nitrogen forms the largest global reservoir of this element and, in this form, has low reactivity until it is bonded to hydrogen and oxygen by the actions of microbial life to form reactive ammonium and oxide compounds (Hoefs 2009). The range of reported $\delta^{15}N$ values in archaeological studies is generally small, ranging from ~0‰ to 20‰ if both marine and terrestrial species are analysed (e.g. Richards and Hedges 1999), but this variation is only representative of a portion of the isotopic fractionation that can occur in biological systems (Handley and Raven 1992). The biological nitrogen cycle begins when N_2 is converted to reactive nitrogen species, such as ammonium (NH_4) by “nitrogen-fixing” microorganism in the marine and terrestrial environments (Hoefs 2009). Fixation results in little fractionation and produces organic materials with $\delta^{15}N$ values varying from -3‰ to 1‰ (Hoefs 2009). Fixed nitrogen in ammonium can then be volatized to ammonia, nitrified or oxidized, again by microorganisms, to form nitrites or nitrates, all of which produce kinetic and equilibrium isotopic fractionation (Hoefs 2009). A second process, denitrification, reduces the oxidized forms again to ammonium (Hoefs 2009). Nitrification and denitrification have been associated with large (30-60‰) isotope effects (Handley and Raven 1992). The organic nitrogen contained in plants and animals can be reduced back to ammonium through the process of mineralization, and the isotopic fractionation associated with this process is thought to be relatively small compared to other processes involving nitrogen (Högberg 1997).

Unlike the carbon isotope system, $\delta^{15}N$ values cannot be assumed to reliably track the source of nitrogen in the ecosystem (Evans 2001). Soil nitrogen is difficult to measure analytically and is not representative of the nitrogen available to plants at any one time (Högberg 1997). The $\delta^{15}N$ value of soil can change seasonally, and with soil depth (Delwiche and Steyn 1970), temperature (Amundson et al. 2003), salinity, and marine inputs (Ambrose 1991).

The majority of plants utilise inorganic nitrogen for the synthesis of amino acids, however, mycorrhizal plants, such as *Picea* and *Pinus* species common to the Boreal forest, living in symbiosis with fungi are capable of using organic nitrogen as well and will have lower $\delta^{15}N$ values than non-mycorrhizal plants as the fungi will retain the heavier isotope (Craine et al. 2009; Hobbie and Colpaert 2002; Näsholm et al. 1998). For example, Craine et al. (2009) found that ericoid mycorrhizal plants, like wild blueberry (*Vaccinium augustiforum*), can have $\delta^{15}N$ values up to 5.9‰ lower than other C_3 plants.

The amount of fractionation caused by plant uptake of soil nitrogen appears to vary depending on the concentration and supply of available nitrogen, and between different species (Craine et al. 2009; Högberg 1997). For legumes, plants capable of fixing atmospheric nitrogen, only a small fractionation factor has been reported, sometimes involving a slight discrimination against ^{14}N resulting in lower $\delta^{15}N$ values than for non-legume species (Högberg 1997). Further isotopic fractionation can occur within plants as nitrogenous compounds are reduced resulting in differences between different plant tissues (Högberg 1997).

The source of nitrogen available to marine plants is not atmospheric nitrogen, but nitrate, which is enriched in ^{15}N relative to N_2 with values of approximately 6 – 8‰ (Hoefs 2009). Higher $\delta^{15}N$ values are carried through the marine ecosystem with the result that marine animals have $\delta^{15}N$ values that are, on average, 9‰ higher than terrestrial animals (Schoeninger and DeNiro 1984). Isotopes of nitrogen have been measured in modern marine invertebrates, fish, and marine mammals from the north Atlantic, producing $\delta^{15}N$ values that range from ~7‰ for particular organic matter to +15‰ for high trophic level fish and marine mammals (Hobson et al. 2002; Sherwood and Rose 2005).

3.6.2 Nitrogen isotopes in animal tissues

Nitrogen is present in amino acids as NH_3^+ molecule bonded to a carbon-based backbone (Stoker 2010). An organism's amino acid pool is sourced from essential amino acids sourced from diet; non-essential amino acids biosynthesized in the liver or recycled through the process of protein turnover (Stoker 2010). The $\delta^{15}N$ of individual amino acids depends upon their biosynthetic pathway. Amino acids are degraded and recycled by the dual processes of transamination and oxidative deamination (Stoker 2010). Due to isotopic fractionation associated with transamination and deamination of amino acids, synthesized tissues will be enriched in ^{15}N relative to whole dietary protein, resulting in a positive trophic level shift in isotope values (Macko et al. 1986). Measured diet-tissue offsets in δ^{15}N values range from 2 to 6‰ between consumers and their diets which results in stepwise increases in trophic levels (DeNiro and Epstein 1981; Minagawa and Wada 1984; O'Connell et al. 2014). The range in reported offsets presents a clear problem for estimating trophic levels in past ecosystems, and the average increase of +3‰ applied in many palaeodietary reconstructions (e.g. Bocherens and Drucker 2003; Hedges and Reynard 2007) has recently been called into question. A short-term feeding study of humans suggested a $\Delta^{15}N_{diet\text{-}collagen}$ offset of +5.9‰ to +6.3‰ (O'Connell et al. 2014). The authors of the study admitted that their results could have been an overestimation, but even their most conservative estimate of +4.6‰ could have a significant impact on the interpretation of the stable isotope values of archaeological populations. Further variation in δ^{15}N offsets may arise due to diet composition, health status, nutritional status (Fuller et al. 2005; Hobson et al. 1993) ontological age, or the tissue being analysed (Katzenberg and Lovell 1999; Webb et al. 2016).

In general terms, the $\delta^{15}N_{diet\text{-}tissue}$ depends in part on the nitrogen balance of a consumer. During normal tissue synthesis and maintenance, ingested and excreted nitrogen should be roughly equal (Stoker 2010). During periods of growth, the direct routing of dietary protein, as opposed to the recycling of old amino acids, for new tissue synthesis has been shown to result in smaller diet-tissue offsets (Fuller et al. 2004; Webb et al. 2016). A negative nitrogen balance, resulting from nutritional stress or illness has been shown to increase δ^{15}N values, potentially through the reduction of urea formation (Fuller et al. 2005; Hobson et al. 1993; Katzenberg and Lovell 1999). In the case of tissue catabolism, the increase in δ^{15}N is arising from the same mechanism as that acting between consumers and their diets, only in this case, the diet is the consumer's own tissues which results in a trophic level increase (Fuller et al. 2005).

Further variation in the diet-tissue offset may arise from the quality and amount of dietary protein, although these effects are not well understood. A protein rich diet may result in less isotopic discrimination and therefore lower δ^{15}N values (Roth and Hobson 2000), or it may result in more isotopic discrimination and higher δ^{15}N values (Pearson et al. 2003). Robbins et al. (2005), noting that these hypotheses were in direct opposition, conducted a meta-analyses of existing data and concluded that increasing the amount of protein in a diet would have the effect of reducing the δ^{15}N value by causing less isotopic discrimination. The authors concluded by making an important distinction between laboratory animals fed commercial food pellets, and wild animals free feeding, and noted that isotopic discrimination factors between these two groups could not be considered equal as each food type differed in available amino acids and nutrition quality (Robbins et al. 2005).

In summary, nitrogen is found in every amino acid, and can undergo considerable isotopic fractionation through the degradation and assimilation of amino acids sourced from diet, or recycled through the processes of protein turnover and biosynthesis. Nitrogen isotope values can be used as tracers in archaeological studies, allowing the average sources of dietary protein consumed by past populations to be estimated from the δ^{15}N values of bone collagen. The relationship between diet and body proteins, such as bone collagen, is complicated by several factors, including diet quality and health status. Even so, the differences between marine and terrestrial sources of nitrogen isotopes are clearly distinguishable. Nitrogen isotope analysis is an important tool employed by this research that as it allows for relative contributions of marine and terrestrial foods to Amerindian diet to be determined.

3.7 Sampling and analysis

Diagenesis is an everpresent problem in stable isotope analysis of archaeological materials, however, precautions can be taken through the methods used in analyses. Care must be taken in choosing these methods, as the stable isotope values of a bone or tooth sample can be influenced by choice of sample pretreatment and by analytical factors (e.g. Metcalfe et al. 2009; Rand et al. 2015; Snoeck and Pellegrini 2015). The following section will review the processes and effects of diagenesis, how common methods used to isolate collagen and carbonate from archaeological bones and teeth are designed to address issues arising from diagenesis, and finally, how diagenetic stable isotope values are identified and possibly corrected in bioarchaeological stable isotope studies.

3.7.1. Diagenesis and the preservation of biogenic stable isotope values

A primary concern of stable isotope studies of archaeological bones is the effect of diagenesis on the preservation of *in vivo* stable isotope ratios (e.g. Dobberstein et al. 2009). Diagenesis, or the post-depositional alteration of skeletal material, includes all biological, chemical and physical processes that occur after the death of an organism (DeNiro 1985). Diagenetic processes have been shown to affect the stable isotope composition of bones and teeth through the decomposition of the original tissues, and through the addition of chemical compounds from the burial environment (Child 1995;

Collins et al. 2002; Nielsen-Marsh and Hedges 2000; Nielsen-Marsh et al. 2007; Smith et al. 2007; Wang and Cerling 1994). The preservation of bones and teeth depend on the condition of the skeletal element before it was deposited in the post-mortem environment, and on the conditions of the burial environment (Jans et al. 2004). For example, cultural treatments of bones and teeth, such as boiling, cremation and defleshing, have also been shown to alter the way that microbial life engages with bone (Collins et al. 2002; Jans et al. 2004) which in turn, can alter the stable isotope values of the sample (Munro et al. 2008).

Following deposition in the post-mortem environment, collagen and bioapatite follow different pathways of diagenetic alteration. In the burial environment, bioapatite is subject to recrystallization, physical damage, loss of carbonate, and breakage of the phosphate bond by microbial enzymes (Nelson et al. 1986; Schoeninger et al. 2003). Carbonate from the burial environment can be adsorbed onto the surface of enamel and bone bioapatite, and it can also substitute for carbonate in the bioapatite matrix through the process of recrystallization, although this is much less of a problem for enamel than it is for bone (Koch et al. 1997).

Collagen degradation is mediated by environmental factors, such as soil pH and microbial enzymatic activity. These can cause the hydrogen bonds stabilizing collagen to break and the peptide to fragment (Child 1995; Collins et al. 1995; Grupe et al. 2000; Nielsen-Marsh and Hedges 2000). An additional source of alteration and potentially contamination of the *in vivo* stable isotope composition occurs in the formation of cross-linkages with exogenous carbon-bearing compounds, like humic and fulvic acids (van Klinken and Hedges 1995). Humic acid contamination has been shown to be a problem affecting archaeological remains collected from sites in Newfoundland and Labrador (Harris 2014; Rand et al. 2015), the analyses of human remains from Port au Choix-3 and Beothuk mortuary sites address this problem through collagen pretreatment.

3.7.2 Analysis of carbon in bioapatite

The external surface of enamel is one of the first regions of a tooth to be affected by chemical alteration (Schoeninger et al. 2003), therefore, in the preparation of enamel for isotopic analysis, it has been advised that this section be removed by mechanical abrasion (Montgomery 2002, but see Zazzo 2014). Enamel carbonate must be pretreated to remove potentially contaminating compounds, such as secondary carbonates that formed through the process of recrystallization either during life or in the burial environment (Koch et al. 1997). Secondary carbonates are usually removed by dissolution via the application of a mild acetic acid treatment (Nielsen-Marsh and Hedges 2000b). The reaction time for this process varies; some researchers limit the reaction to ten minutes (Lee-Thorp, n.d.), while others may allow up 72 hours. Longer reaction times, and/or stronger acid treatments may bring about isotopic fractionation and have been discouraged (Garvie-Lok et al. 2004; Pellegrini and Snoeck 2015), to the point that some researchers now refuse to apply an acetic acid treatment at all (e.g. Buchan et al. 2015). Many researchers also treat enamel samples with an oxidizing agent to remove organic contaminants (e.g. Bendrey et al. 2015; Britton et al. 2009), although since enamel contains only trace organics, and the main oxidizing agents, sodium hypochlorite and hydrogen peroxide, have both been shown to bring about isotopic fractionation this pretreatment has now been called into question (Grimes and Pellegrini 2013; Pellegrini and Snoeck 2015). After pretreatment, enamel powders are dried at a low temperature

(~30 to 50℃), weighed into sealed glass vials and reacted with pure phosphoric acid on a heater block (Stuart-Williams and De Groot 2009). The temperature of this reaction can vary between 50℃ and 95℃, although poor reproducibility of isotopic results has been observed at higher temperatures (Metcalfe et al. 2009). The reaction of the carbonate with phosphoric acid produces water vapour and carbon dioxide gas. These are separated on a gas chromatograph column and the isotopes of oxygen and carbon in the carbon dioxide are measured with a mass spectrometer.

Due to the poor survival of collagen in palaeontological materials, a great deal of effort has been invested in the analysis of bioapatites as palaeodiet and palaeoclimate proxies, thus prompting the creation of techniques designed to assess the survival of biogenic stable isotope signals in very old, fossilized material. There are several tests available to assess the likelihood that stable isotope ratios from bioapatite have undergone diagenetic alteration. These include Fourier Transform Infrared Spectroscopy (FTIR) of bone and enamel powders, quantification of elemental nitrogen, radiocarbon dating of paired enamel and dentine samples, trace element and rare earth element analysis, bone histology, and cathodeluminescence (Nielsen Marsh and Hedges 2000a; Sponheimer and Lee Thorp 1999; Schoeninger et al. 2003; Trueman et al. 2008; Zazzo 2014) . These checks are crucial for the study of bone bioapatite as this substance, given its small and disorganized crystal structure, is more prone to diagenetic alteration than enamel (Lee-Thorp and Sponheimer 2003). However, the tests used to assess stable isotope ratios from bioapatite have limited utility as they only provide indirect proxies of diagenesis. Changes in bone and enamel crystallinity are correlated to altered stable isotope values, but the causal link is difficult demonstrate, in large part because diagenetic tests, such as FTIR, cannot clearly differentiate loss or reorganisation of endogenous carbonate from incorporation of exogenous carbonate (Sponheimer and Lee Thorp 1999; Zazzo 2014). Regardless, for samples of Holocene age, enamel carbonate seems to preserve *in vivo* isotope ratios if proper pretreatment protocols are carried out (Zazzo 2014).

3.7.3 Analysis of carbon and nitrogen in collagen

Nitrogen and carbon isotope ratios are measured in bone collagen, which once extracted, should be a pure protein and its isotopic ratios should reflect the *in vivo* composition of an organism. However, most collagen extraction methods do not completely isolate the collagen molecule from other non-collagenous bone proteins (Ambrose 1990). Collagen extraction methods begin by dissolving a sample of clean whole or powdered bone in mild hydrochloric acid (HCl), or ethylenediaminetetraacetic acid (EDTA), at either room temperature, or at 4°C (e.g. Chisolm et al. 1983; Longin 1971; Sealy 1986; Tuross et al. 1988). The cooler temperature reduces the rate of the reaction of bioapatite with the acid. If a piece of bone is used, then a spongy bone pseudomorph will remain after the bone mineral has dissolved; if a bone powder is used, then a protein residue will remain. The bone pseudomorph or residue is composed of collagen, non-collagenous proteins, and acid-insoluble contaminants, such as humic substances (Ambrose 1990). One commonly used method (Sealy 1986) lyophilizes and measures all of these substances, usually with no effects on the resulting $\delta^{13}C$ value (Rand et al. 2015; Sealy et al. 2014). More commonly, the collagen is further isolated from non-collagenous material with the application of a base, such as sodium- or potassium hydroxide, to remove base-soluble contaminants (Berklund et al. 1977;

Gurfinkel 1987; van Klinken and Hedges 1995). The sample is then heated at a low pH to gelatinize or solubilize the collagen molecule (Brown et al. 1988; Longin 1971). Filtration then serves to isolate collagen molecules based on size and molecular weight (e.g. Brown et al. 1988). The resulting residue is then lyophilized and the carbon and nitrogen isotopes are measured using an elemental analyser coupled to a mass spectrometer. For well-preserved bones, the choice of extraction method has not been shown to affect the isotope ratios (Pestle et al. 2014; Rand et al. 2015; Sealy et al. 2014). Bone samples that are poorly preserved, or that bear humic acid contamination, benefit from an approach designed to address the particular needs of the sample (Rand et al. 2015).

The condition or preservation of bone collagen and its stable isotope composition are assessed using three quantitative indicators: the percent yield of collagen, the atomic C/N ratio, and the measured weight percent of elemental carbon and nitrogen in a sample. The percent yield of collagen is the least robust of these indicators, especially with the addition of ultrafiltration which used to separate molecules based on their molecular weight. Modern bone is composed of 20-28% Type 1 collagen (Ambrose 1990; van Klinken 1999). After death, the collagen molecules begin to break down, or bond through the development of cross-linkages to contaminants in the burial environment (Collins et al.1995). The extraction processes used in stable isotope facilities are designed to separate the collagen and an assessment of the resulting yield can be the first indication that the collagen is poorly preserved. Ultrafilters can be purchased with a molecular weight cut-off of 30 kilodaltons (kDa) or 10 kDa, but 30 kDa is used most frequently for stable isotope analysis (e.g. Brock et al. 2013; Brown et al. 1988). Molecules with a lower molecular weight, such as humic substances, or fragmented collagen peptides, will pass through the filter, leaving behind larger molecules, such as intact collagen peptides. While this improves the chance that only preserved collagen will be analysed, it also decreases the yield of collagen as only larger, intact peptides will be analysed (Brock et al. 2013). Without ultrafiltration, the percent yield of collagen is a better estimation of the amount of collagen in a bone sample. This measurement has been used to assess the quality of samples prior to analysis as yields falling below 1% do not reliably produce stable isotope values that are demonstrably unaltered by other quantitative indicators (Dobberstein et al. 2009; van Klinken 1999).

More robust indications of collagen diagenesis can be found in the atomic C/N ratio or in the weight percent of carbon and nitrogen in a combusted collagen sample. Carbon and nitrogen atoms are present in collagen in a ratio of ~ 3:1, with an accepted range of 2.9 to 3.6 (DeNiro 1985; Schwarcz and Schoeninger 1991), although a more conservative range of 3.1 to 3.5 has also been advised (van Klinken 1999). The C/N ratio becomes more powerful when used in tandem with the weight percent of carbon and nitrogen. Alone, the C/N ratio speaks to the number of carbon atoms to nitrogen atoms, which is problematic as analytical or diagenetic issues can alter the isotopic composition of collagen, while still maintaining a 3:1 ratio of carbon to nitrogen atoms (Schoeninger et al. 1989). The weight percent of carbon or nitrogen in modern bone ranges from 15% to 47% and 5% to 17%, respectively (Ambrose 1990). As this is a very broad range, this indicator must be used with the C/N ratio in order for it to be meaningful. Additionally, measured carbon and nitrogen concentrations can vary based on the daily tuning of a mass spectrometer, therefore the measured concentrations of the run’s standards must also be considered when assessing the concentrations in a sample of archaeological bone (V. Grimes, personal communication 2015).

3.8 Chapter summary

Past dietary practices are recorded in the chemical composition of human bones and teeth, but the interpretation of these data must take several factors into consideration. The isotopic composition of human bone is a function of diet, but also of protein turnover within the bone, protein routing, and diagenesis. As bone collagen is synthesized in large part from dietary protein, isotopic measurement of this tissue can be used to distinguish the major sources of protein consumed by past people. Further insight can be gained by analysing the carbon found in tooth enamel carbonate, which is routed from whole diet, and should indicate the sources of dietary energy, in addition to dietary protein. As the questions pertaining to Amerindian subsistence centre on the relative contributions of coastal and terrestrial resources, a stable isotope-based approach is ideally suited for investigating Amerindian foodways in Newfoundland. This method can be used to estimate the relative contributions of marine and terrestrial protein to Maritime Archaic and Beothuk diet, and may be useful for quantifying the role of particular prey classes, such as seabirds or seal. An added benefit gained from these data is in their use for calibrating radiocarbon dates from human bone.

CHAPTER 4: EVIDENCE FOR AMERINDIAN SUBSISTENCE

Food is studied for its connection to landscape, its role in negotiating identity and social difference, and social organization (Appadurai 1981; Curet and Pestle 2010; Smith 2006). The cultural meanings ascribed by precontact people to food have received less attention than those of modern or historic populations, which are considerably more accessible (Twiss 2012). The study of prehistoric and precontact foodways generally emphasizes the nutritional aspects of food and the role of food in sustaining life (Speth and Spielmann 1983), leaving more nuanced approaches to historical and ethnoarchaeologists (Janik 2003). Stable isotope analysis offers evidence complimentary to more traditional archaeological research. It is possible to examine subsistence practices at multiple scales of analysis by characterizing the dietary variation associated with different biosocial categories, such as sex and age.

Amerindian subsistence and foodways in Newfoundland have been understood through four key lines of evidence: the abundance, seasonality and spatial distribution of modern animal and plant species; the distribution of Amerindian sites over the landscape in relation to key resources (e.g. Kristensen 2011); the species represented in zooarchaeological assemblages (e.g. Cridland 1998); and ethnohistoric accounts (e.g. Marshall 1996). These are also key considerations for the interpretation of stable isotope data from human skeletal remains and for the development of a nuanced palaeodietary reconstruction in which multiple lines of evidence are integrated. The chapter opens with a description of the modern environment, and the species that inhabit the island and surrounding waters. A knowledge of the types of animals that were available to Amerindian hunter-gatherers is critical for interpreting the composition of zooarchaeological assemblages (Reitz and Wing 1999), and the underlying function of Amerindian site location. Zooarchaeological assemblages that have been attributed to Maritime Archaic and later Amerindians will be discussed next, followed by a review of site distribution studies. Amerindian material culture and the limited ethnohistoric record are also reviewed as evidence of subsistence. The review section of this chapter closes with a brief discussion of the previous stable isotope studies that have been conducted in the province. The chapter concludes by summarizing the evidence for Amerindian subsistence and relating it to the objectives of this thesis.

4.1 The modern environment

The island of Newfoundland is the easternmost point in continental North America. The east coast of the island is bound by the Atlantic Ocean, and the west coast by the Gulf of St. Lawrence. The Northern Peninsula, the most northerly point on the island, is separated from Labrador by the ~90km wide Strait of Belle Isle. The island still bears the scars of the last glaciation, with deep fjords scouring the coastlines, numerous ponds and lakes, and a marked dearth of topsoils (Roberts 1983). Despite its inclusion in the Boreal zone, the winter temperatures are fairly mild and summers moderated by the maritime influence (Banfield 1983). The insular climate is strongly mediated by the Labrador Current which encircles the island, bringing cold temperatures from the Arctic and minimizing the warming influence of the Gulf Stream (MacPherson 1981). Between the period of 1941 and 1970, Newfoundland received on average 1500mm of precipitation per year and had a mean annual air temperature ranging from 1 to 3°C in the north to 5°C along the south coast (Banfield 1983). A north-south gradient in surface air temperature, amount of precipitation and number of days above 5℃ is apparent over the island, with additional variation occuring between the coasts and interior of the province (Banfield 1983). The gradations correspond to Banfield’s climate zones and there is also considerable overlap between climate variables and vegetative cover (Damman 1983).

The use of the modern distribution of animal and plant species to evidence past subsistence practices rests on the assumption that there has been continuity in the taxa present on the island, however, human interference, and fluctuations in environmental conditions may have acted to bring about a change in the diversity of species and their distribution. Over the course of the historic period, several species, such as the great auk (*Pinguinis impennis*) and Newfoundland wolf (*Canis lupus Boeothicus*), have been extirpated or hunted to extinction, and several others, such as the moose (*Alces alces*), coyote (*Canis latrans*) and snowshoe hare (*Lepus americanus*), have been introduced. The following section reviews the species present in the modern environment.

4.1.1 Terrestrial resources

The Boreal Forest meets its southernmost extent on the island of Newfoundland. The island is characterized by stands of pine, spruce, and birch. Port au Choix-3 is located within Damman’s Northern Boreal ecoregion where the growing season is short and the vegetation predominantly comprised of tuckamoor (Damman 1983). The smaller Recent Indian and Beothuk mortuary sites are scattered among the many islands of the Bay of Exploits and Notre Dame Bay and fall within the North Shore ecoregion (Damman 1983). The likely social catchment areas for these sites include the Exploits River, and Red Indian and Gander Lake, all of which are included within the Central Newfoundland Ecoregion. The Central Newfoundland region is forested with balsam fir, birch and alder

(Damman 1983). The North Shore region is characterized by stands of white pine near the coast and alder in wet areas (Damman 1983).

The island's location in the North Atlantic and its glacial history have impacted the diversity of terrestrial species. Newfoundland has only 14 species of terrestrial mammals, a fact that has been extensively commented on in Newfoundland archaeology (e.g. Tuck and Pastore 1985; Renouf 1999). Three of these species, the meadow vole and two species of bat, are unlikely to have figured in Amerindian subsistence. The Newfoundland wolf occurs rarely in faunal assemblages (e.g. Hartery and Rast 2003; Wells 2005), and the arctic fox (*Vulpes lagopus*) and polar bear (*Ursus maritimus*) are both seasonal visitors, traveling to the island on sea ice during the winter. Lynx (*Lynx lynx*) are elusive predators and the author has not discovered their presence yet in any faunal bone assemblages from the island. The species of economic importance, based on zooarchaeological assemblages, include the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus obscurus*), black bear (*Ursus americanus*), red fox (*Vulpes vulpes*), and the woodland caribou (*Rangifer tarandus*) (Cridland 1998; Cumbaa 1984; Gilbert 2002; Reader 1998). These will be discussed briefly below with respect to their geographic and temporal distribution on the island.

The Newfoundland caribou (*Rangifer tarandus*) can be distinguished from the barren ground caribou of Labrador and Northern Quebec by the lack of variation in habitat selection and migratory behaviour between males and females, and to a lesser extent by its relatively sedentary behaviour (Mahoney and Schaefer 2002; Mahoney and Virgl 2003). Spiess (1993) cautions against using the barren ground/woodland dichotomy as an explanatory device for past hunting strategies. Four primary herds were recognized in the mid-20th century, but further research has since identified 13 subpopulations that appear to roughly correspond to the management zones established by the provincial government, and are distributed across the island (Bergerud 1971). Herd movements appear to follow a rough north-south track with winter ranges influenced by topographic factors and summer/calving grounds influenced by the instinct to avoid predation (Bergerud 1974; Mahoney and Schaefer 2002). Caribou could have been hunted year round, but were likely preferred in autumn as they began their migration to their winter forage grounds as this would have corresponded to when they were in the best physical condition (Speth and Spielmann 1983; Tuck and Pastore 1985). Caribou migratory movements and the distribution of historic Beothuk sites along the island's river systems have shown to be linked. Beothuk sites located along the south sides of the Exploits River have been interpreted as fall ambush sites, while those along the north side of the river may have been spring hunting sites (Holly 2008: 180).

Beaver and muskrat inhabit the freshwater systems of Newfoundland. The Newfoundland beaver population suffered from over-hunting during the 20th century, limiting estimates of population size in the past. Beaver colonies are distributed throughout the island's many freshwater systems, but reach greater density on the Avalon, Bonavista, and Burin Peninsulas (Bergerud and Miller 1977). They are also found south of Notre Dame Bay and Bay of Exploits, and in the region of St. Anthony on the Northern Peninsula (Bergerud and Miller 1977). Few colonies are reported on the west coast, and Bergerud and Miller (1977) found that beaver were absent from most of the south coast and from the Long Range Mountains. The muskrat population is distributed throughout the marshy regions of Newfoundland (Rigby and Threlfall 1981;

Soper and Payne 1997). Muskrat typically construct lodges from cattails, but the limited distribution of this plant species in Newfoundland has resulted in a shift to burrowing behaviour in Newfoundland muskrat (Soper and Payne 1997). This type of behaviour may have limited the availability of the species in the winter. Beaver would have been available year round and could have been hunted in their lodges, albeit with some difficulty, during the winter (Tuck and Pastore 1985).

The red fox and black bear appear to have played some role in subsistence, either by supplying meat or skins. The modern distribution and population density of the black bear population appears to be strongly influenced by the distribution of garbage dump sites in the province, however, black bears also tend to be found around the island's barren grounds in the summer where berries are plentiful (Payne 1978) and along salmon rivers (Dodds 1983). The red fox is distributed across the island, in all habitats, and has been observed feeding on small rodents and birds, and on seabird eggs (Dodds 1983; Sklepovych and Montevecchi 1996).

4.1.2 Marine resources

Many species of whale, shark, fish and invertebrates thrive in the productive, cold waters around Newfoundland. Whales are represented by the blue, fin, pilot, beluga, humpback, bowhead, and orca whales; shark species include the blue, mako and Greenland sharks; and fish species that currently hold a position of economic importance include the Atlantic cod, mackerel, herring, and a variety of groundfish (Canada Department of Fisheries and Oceans [DFO] 2016). Although the Atlantic cod (*Gadus gadus*) was the species of primary economic importance during the historic period, it maintains a discrete presence in the faunal assemblages attributed to hunter-gatherers, suggesting that cod, and other species of fish, were only fished opportunistically (Tuck and Pastore 1985).

Six species of seal can be found off the coast of Newfoundland, although two of these (ringed and bearded) are only rare visitors from the Arctic (DFO 2016). There are three harp seal whelping grounds, one located in the Gulf of St. Lawrence, one south of Mecatina, on the Quebec Lower North Shore, and the other located to the northeast of Newfoundland, along the southern coast of Labrador (DFO 2016). The seals from the Gulf and Mecatina grounds migrate through the Strait of Belle Isle and north along the shore of Labrador to the Arctic Ocean in the early spring. The seals return in early winter and at this point, they divide into two herds: the Gulf Herd continues on to the Gulf of St. Lawrence, while the Front Herd passes by northeastern Newfoundland (Sergeant 1965). The harp seal shares its whelping grounds in the Atlantic and Gulf of St. Lawrence with the hooded seal, a large migratory species that occupies Arctic waters for most of the year. Grey seals can be found in the Gulf of St. Lawrence and around Newfoundland where they prey on adult cod (DFO 2016). Harbour seals, a gregarious and non-migratory species, are found in close to Newfoundland’s shores and would have been available year round (DFO 2016).

The accessibility of whelping harp seal populations may have been limited at several points in the past by relatively brief periods of environmental change. Levac (2003) found evidence of a period of environmental warming, occurring between 1500 and 1000 years ago that may have brought warmer sea surface temperatures, and reduced sea ice cover to the Strait of Belle Isle. Renouf and Bell (2008) realized the implications that this may have had on the lifeways of the Dorset Palaeoeskimo and noted a relationship between the timing of the sea surface warming, the apparent efforts of the Dorset to diversify their resource base, and the subsequent abandonment of the large site of Phillip's Garden (Hodgetts et al. 2003; Renouf and Bell 2008). However, Levac's work makes it apparent that considerable uncertainty is associated with the analyses used to convert fossil data to palaeotemperatures, a fact that appears to have been overlooked in subsequent discussions of these data (e.g. Renouf and Bell 2008). Dinoflagellate sequences from Bonavista and Placentia Bays also indicate brief periods of climate amelioration, however these occurred before and after the time period indicated by the west coast cores, emphasizing the influence of local climatic factors on sea surface conditions (Solignac et al. 2011). Therefore, while the evidence presented by Renouf and Bell (2008) is compelling, further temporally and regionally specific palaeoecological research is required to clarify the cause and degree of warming that occurred.

Migratory and resident seabird populations are ubiquitous along the rocky coasts of Newfoundland, forming colonies on the small, barren islands that dot the outer coastal areas of the northeast and Avalon Peninsula. The island lies beneath the North Atlantic flyway and is visited by 74 migratory species each summer, including the dovekie, shearwater and storm petrel (Mednis 1981). Forty-one resident species inhabit the island, including the common loon, kittiwake, common and thick-billed murre, and black guillemot (Mednis 1981; Threlfall 1983). The great auk was hunted to extinction by 1844, but prior to that date inhabited several islands in the North Atlantic including Funk Island, to the northeast of Newfoundland, which is thought to have been the largest breeding colony in the world (Bengtson 1984). The great auks of Funk Island had a larger body size than other contemporaneous populations in Scandinavia, and produced large eggs, likely making them an appealing source of protein to past populations (Bengtson 1984; Burness and Montevecchi 1992).

4.1.3 Estuarine and Freshwater resources

Shellfish, particularly blue mussel (*Mytilus edulis*), butter clam (*Saxidomus gigantea*), and sea urchins, are present in the shallow marine waters and protected bays of Newfoundland and their remains have been recovered from Dorset and historic Amerindian sites, but their role in hunter-gatherer subsistence has not been explored in great depth (e.g. Cumbaa 1984; Tuck and Pastore 1985). Anadromous and freshwater fish species receive greater mention in the archaeological and historic literature of the province. Newfoundland has 18 species of freshwater fish (Newfoundland Department of Environment and Conservation 2016). The Atlantic salmon (*Salmo salar*) is the species of primary economic importance. It spends most of its life at sea, migrating north to the Labrador Sea, or west to the Bay of Fundy, returning to spawn in Newfoundland rivers between May and November, but typically within a narrower range in the summer (DFO 2016). Major salmon rivers include the Exploits, Gander and Campbellton Rivers on the northeastern shore, the Torrent River south of Port au Choix, and the Humber River on the southwestern coast (DFO 2016). Otters can be found in the island’s estuarine and freshwater regions where they feed on sculpin, cunners and other shallow water fish species (Cote et al. 2008; Dodds 1983).

4.2 Zooarchaeological assemblages

Zooarchaeological assemblages act as archives of human-animal interactions that can inform on the main prey species exploited by past hunter-gathers and the intensification of hunting strategies, as just two of many possible examples. The study of zooarchaeology in Newfoundland has been limited by the impact of environmental conditions and past cultural activities. Zooarchaeological assemblages are subject to taphonomic bias that can influence the species represented in the assemblage, and thus the interpretations drawn from the assemblage. Bias can be introduced into an assemblage in one or more ways with the final species and element counts being the result of cultural treatment of animal remains, survival in the burial environment, and archaeological sampling methods (Reitz and Wing 1999). For example, away from the alkaline bedrock of the west coast of Newfoundland, soils are acidic and not conducive to bone preservation (e.g. Carignan 1975; Reader 1998). This decreases the likelihood that the small bones of fish and birds will be preserved, and places limitations on the faunal identifications that can be made. Few Maritime Archaic sites have been found with bone preservation sufficient to reconstruct dietary practices at the site (Spiess 1992). Likewise, with several notable exceptions (e.g. Boyd's Cove and Inspector Island), cultural activities at Recent Indian sites, such as crushing bone to extract grease and marrow, have hampered species identification and the determination of traditional zooarchaeological indices, such as the minimum number of individuals (MNI), and number of identified specimens (NISP) (e.g. Simpson 1984). While Palaeoeskimo assemblages have been well studied, due to the excellent preservation at sites like Phillip's Garden and Peat Garden North, few formal studies have been made of Recent Indian assemblages (Cridland 1998; Cumbaa 1984; Stewart 1973). Nevertheless, zooarchaeological collections, such as those described below, have been critical for understanding Amerindian site distribution, culturally specific patterns of landscape use, and the influence of cross-cultural interactions (e.g. LeBlanc 1973).

4.2.1 Maritime Archaic Zooarchaeological Assemblages

Maritime Archaic faunal assemblages have been recovered from mortuary and workshop sites in Newfoundland and Labrador, but the nature of these assemblages has limited the data that can be obtained so that studies of Maritime Archaic subsistence rely more on modern animal distribution and the location of sites on the landscape to understand palaeodiet during this time period (e.g. Renouf and Bell 2006). Faunal bone assemblages from habitation sites in Newfoundland and Labrador are small, calcined and highly fragmentary, but the limited analysis that has been done to date indicates that seal, walrus, seabirds and caribou were hunted (Spiess 1992, 1993). These findings receive further support from the species composition of mortuary assemblages. The bones of birds and fish, and the tusk of a walrus were recovered from L'Anse Amour burial mound in Labrador (Tuck and McGhee 1975). While not necessarily representative of the animals that were eaten by Maritime Archaic people, the diversity of species placed as grave offerings with the deceased at Port au Choix-3 does offer an indication of the types of animals that could be obtained by people, either through hunting, gathering and fishing, opportunistic scavenging, or trading (Spiess 1992). Animal remains from the site were classed as tools, or as non-utilitarian objects. Bones in the tool class included worked antler, bone and teeth of caribou, beaver incisors, and worked whale bone (Tuck 1976a). Non-utilitarian objects included skeletal elements that were likely added as decoration to clothing. For example, 200 auk bills were recovered from the burial of NP 35A that may have been sewn onto a cloak (Tuck 1976a). Bird remains were numerous, with over 30 species represented, including diving birds, ducks, and birds of prey (Spiess 1992). The differential distribution of auk, gull, and merganser skeletal elements across different burial clusters has suggested to some that these species were symbolic of participation or inclusion in different corporate (Tuck 1976), or status (Jelsma 2000) groups.

In summary, the faunal remains provide evidence that the Maritime Archaic people hunted a variety of seabirds and mammals, terrestrial furbearers, caribou, and fish. Taken together, the faunal collections from mortuary and habitation contexts indicate a predominantly coastal adapatation, but one that was supplemented with terrestrial mammals. As other authors have noted, the bones of walrus and whales suggest that the Maritime Archaic people were capable of hunting large, dangerous marine mammals, although it is also possible, albeit less likely given the material culture associated with this population (section 4.4), that these animals were obtained by scavenging the carcasses of marine mammals on shore.

4.2.2 Recent Indian Zooarchaeological Assemblages

In the study of Recent Indian zooarchaeological assemblages, much has been made from only a few relatively large collections, although it is worth noting that even the small scattered faunal finds, when combined with other lines of evidence, have yielded useful information regarding food procurement and the risk management strategies employed by island people. The preservation of faunal remains from Early Recent Indian sites has generally been poor, except where bone fragments have been protected from the acidity of the soil by virtue of being calcined (e.g. Holly and Erwin 2009; Reader 1998; Spiess 1992; 1993). Two sites in the interior of the island, Deer Lake Beach and Birchy Lake 9, have provided limited evidence for subsistence. A large bone mash feature was recovered from Birchy Lake 9 that probably represented grease-rendering activities related to the presence of a nearby caribou migration route (Holly and Erwin 2009). Heavily calcined and fragmented beaver and caribou bones were recovered from two broadly contemporaneous house pits at Deer Lake Beach (Reader 1998). The NISP of each species differed between dwellings which Reader (1998) attributed to separate economic activities occurring in each house, or to variability in the intensity of caribou versus beaver harvest over time. The difference in NISP may also be attributable to the greater durability of calcined beaver bone relative to the bones of other species (Knight 1985).

Faunal remains from Recent Indian and Beothuk sites are frequently calcined and very fragmentary (Holly et al. 2015; Simpson 1984). At Stock Cove West, the Little Passage faunal assemblage is largely calcined, while only ~4% of the Dorset faunal assemblage from nearby Stock Cove shows evidence of being burned (Holly et al. 2015; Wolff et al. 2010). The presence of bone mash features at Deer Lake Beach, Birchy Lake 9, and Boyd's Cove are replicated in the archaeological record of the Recent Indian tradition of Labrador and Quebec (Pastore 1985). These bone features, or *shaputuan* as they are known ethnohistorically, are thought to be a regional expression of the mokoshan, an annual rite practiced by the Innu in historic times that was created to honour the caribou and its prominent role as a provider (Holly 1998; Pastore 1985).

The diverse range of taxa represented in Little Passage zooarchaeological assemblages suggests that the Little Passage hunting economy rested upon a broad, seasonal resource base. For example, in the Little Passage assemblage from Inspector Island, Cridland (1998) identified seal (harbour and harp), sculpin, smelt, cod, caribou, Canada goose, and soft-shell clam. The assemblage from Russell's Point predominantly featured beaver, with some caribou and seal (Gilbert 2002). The calcined bones of beaver, caribou, marten and seabirds were recovered from the site of Port au Port, on the west coast (Simpson 1984). Caribou, seal, fox and birds representative of the alcidae and anatidae families were recovered from the late Little Passage site of Stock Cove West (Holly et al. 2015). From these sites, there is some indication of seasonal occupation, with Inspector Island being occupied in the late winter to early summer, and Russell's Point occupied periodically from spring to fall (Cridland 1998; Gilbert 2002). Certain species, particular caribou, beaver and fish, appear to have been targeted at different times of the year, consistent with later ethnohistoric accounts of the Beothuk seasonal round. What comes across more strongly than the seasonal element of Little Passage subsistence is the flexibility of their adaptation. This will be further treated below in the discussion of site distribution, but from the composition of the faunal assemblages discussed above, it is clear that Little Passage people were willing and able to hunt and gather a variety of species.

Faunal assemblages from three Beothuk sites have contributed significantly to the way Beothuk subsistence is understood, and when taken together can be seen to chronicle the change in Beothuk subsistence over the historic period. Early Beothuk lifeways appear to have been largely indistinguishable from late Little Passage lifeways. Indeed, distinguishing between early Beothuk sites and Little Passage sites is quite difficult, therefore, Beothuk subsistence as a separate phenomenon is not easily described until the mid-historic period. Boyd's Cove is located in the Bay of Exploits and is the site of 11 Beothuk housepits, likely occupied between the 17th and 18th centuries (Pastore 1984). Pastore (1984) also found traces of a Little Passage component beneath the housepits, however, the faunal collection has been attributed to the later Beothuk occupation. Mammalian taxa were predominantly represented in the assemblage, with bones of seal, otter, beaver, and caribou identified (Cumbaa 1984). Also worth noting were the remains of seabirds, marine and anadromous fish species, and shellfish. The site provides evidence for the presence of the Beothuk on the coast during the spring to early summer and, like early Little Passage sites, demonstrates the diversity of the Beothuk resource base in the area (Cumbaa 1984). The presence of multiple small, fur-bearing animals in the faunal bone assemblage may evidence of an informal trade between the Beothuk and Europeans, although, as Pastore (1987) notes, the trade of animal skins does not preclude the consumption of the animal afterwards.

The study of the Beothuk extinction has focused on the archaeological sites located in the interior as this region formed the last stronghold of the Beothuk. In particular, the site of Wigwam Brook has been used to evidence Beothuk subsistence as Europeans encroached upon Beothuk territory (LeBlanc 1973; Rowley-Conwy 1990). Caribou remains predominate in the large faunal assemblage, composing ~98% of the identified faunal bone with a calculated MNI of 97 (Stewart 1973). Seasonal indicators support a fall to winter occupation, however, LeBlanc (1973) argued that Wigwam Brook was occupied year round. These results were provocative from an analytical standpoint (Rowley-Conwy 1990), but seemingly supported by the large quantity of caribou bone, altered food disposal practices, and the substantial dwellings that, so far, have not been duplicated at any other location on the island, or at any other time in Amerindian history in the region (Holly 2005; LeBlanc 1973; Reader 1998). The reduction of residential mobility implied by the faunal assemblage at Wigwam Brook and the permanence of the habitation structures acts as a reminder of limitations of zooarchaeological data. While the majority of the caribou hunted at Wigwam Brook appear to have been killed in the autumn, Stewart (1973) raises the important point that the site could have been occupied year round if the Beothuk had stored the meat. Evidence for food storage will be discussed below, in subsections 4.5 and 4.6.

The data from Recent Indian, and historic Beothuk faunal assemblages reveal a degree of diachronic variability, even when poor bone preservation and taphonomic biases are taken into consideration. The change in subsistence patterns over time forms an interesting comparison with the earlier Maritime Archaic people on the island of Newfoundland, for whom, there appears to be temporal continuity in subsistence practices. At this point it is difficult to assess if the continuity is a real phenomenon, or if it results from low data resolution. Stable isotope analysis of the human skeletons from Port au Choix-3 will address this by providing dietary data tied to a tight site chronology. Patterns can then be sought in correlations between dietary variation and time.

4.3 Site distribution

In light of the paucity of faunal remains preserved on the island, the location of Amerindian sites remains one of the key sources of information pertaining to past subsistence and settlement systems. Studies focusing on site distribution envision the landscape as a series of discrete zones characterized by the geographic location and access to particular sets of resources (e.g. Holly 2002; Pastore 1986; Rast 1999; Renouf and Bell 2006; Schwarz 1994). Pastore (1986) and Schwarz (1994) drew attention to culturally specific patterns in the distribution of Palaeoeskimo and Recent Indian sites in relation to major resource areas of the island. Rast's (1999) survey of sites and material culture from the south coast provided further support and expanded the dataset to include observations of Maritime Archaic settlement patterns. Renouf and Bell (2006) synthesized Maritime Archaic site distribution data and demonstrated a clear coastal orientation, that Lacroix (2015) further explored through computer modelling and material culture analysis. Holly (2002) demonstrated diachronic variation in the positioning of Early and Late Recent Indian sites, and Renouf (1999) and Renouf et al. (2000) focused on the potential of Palaeoeskimo-Amerindian interactions in geographic/ecological zones where, based on site distribution and radiocarbon dates, cultural overlap was likely to have occurred. This shift in focus, from environmental determinants of settlement patterns to social determinants are increasingly demonstrating the complexity of Newfoundland’s social landscape over the past 2000 years and are allowing provocative new questions to be asked of the archaeological record.

4.3.1 Maritime Archaic site location

Maritime Archaic settlement patterns in Newfoundland are reasonably well understood, but there is a recognized bias introduced by sea level. This has resulted in the loss of sites to the ocean, particularly along the southern shore of the island, and loss of sites to deep peat deposits and thickly forested areas along the northwestern coast (Bell et al. 2005; Renouf and Bell 2006). In addition to this, as surveys of the interior are increasingly demonstrating, inland sites are probably underrepresented, not because they do not exist, but because archaeological research has been predominantly focused on the coastlines (Renouf and Bell 2006).

During the period of Maritime Archaic occupation on the island, the coastal landscape underwent dramatic change due to isostatic rebound along the Northern

Peninsula. Approximately 10,000 years ago, the northernmost reaches of the Northern Peninsula existed as a series of islands (Bell et al. 2005). These would have been the regions first settled by the Maritime Archaic people. Over the next 5000 years, the low lying land gradually rebounded, and by approximately 4500 B.P., when the Maritime Archaic people were interring their dead at Port au Choix-3, the burial ground was located on a small island, separated by from the mainland by a small ‘tickle’ of water (Bell et al. 2005; Renouf and Bell 2011). Similar to the findings of Fitzhugh (1984) for the Nulliak region in northern Labrador, the oldest Archaic sites in Newfoundland are probably located at quite a distance from the modern shoreline, likely under the cover of peat and tuckamore (Bell et al. 2005). The locations of over 120 sites found to date largely reflect the coastal orientation suggested by the faunal remains and the distribution of modern species. Renouf and Bell (2006) tallied the sites with diagnostic Maritime Archaic artifacts and noted their location in relation to outer and inner coastal zones, river mouths, sources of freshwater and areas of high marine productivity, among other variables. Greater than 80% of sites were located in proximity to the coast (Renouf and Bell 2006). Within the coastal zone, sites were concentrated in nearshore regions adjacent to areas of high marine productivity, such as along the north shore and in the Burgeo region where the distribution of seals and sea birds overlapped (Rast 1999; Renouf and Bell 2006). They also noted that some sites were distributed near river mouths that would have allowed access to the interior, and the potential for movement between coasts, a theme later picked up by Lacroix (2015). It now appears that the interior may hold more clues to Maritime Archaic lifeways than originally considered, but the nature of the use of the interior by this group of people is still a question that requires considerable research (Renouf and Bell 2006).

4.3.2 Recent Indian site location

In terms of resource access, similar patterns have been noted for later Amerindian sites as for Maritime Archaic sites, but where this research has diverged is in noting diachronic variability in Recent Indian settlement patterns that may have resulted as a response to climate change, or cross-cultural interactions. Early Recent Indian sites have been best understood in relation to the location of Palaeoeskimo sites. Schwarz (1994) first identified that, although warm season Recent Indian sites tended to occur in similar coastal regions as Palaeoeskimo sites, cold season sites were found in the interior and near-interior regions. This was in contrast to cold season Palaeoeskimo sites which appeared to be situated in the outer coastal areas to access the late winter seal migration (Pastore 1986). As mentioned earlier in this chapter, there is some evidence that the Strait of Belle Isle may have been affected by a period of environmental warming that persisted for several centuries, and Renouf and Bell (2008) have posited that this negatively impacted Dorset lifeways and prompted the abandonment of Phillip’s Garden, eventually leading to the collapse or retreat of the Palaeoeskimo from the entire island. Holly (2002) observed that Early Recent Indian sites were located primarily along the north shore of the island, in those regions where both seal and sea birds could be accessed. Following the disappearance of the Dorset, Recent Indian sites spread from the north shore to include the nearshore areas of the island, places deemed ideal for allowing the greatest number of resources to be monitored (Holly 2008; Rowley-Conwy 1990). This change has been explained in relation to both the physical and social landscapes. By their ability and willingness to diversify their resource base, the Recent Indians may have been better adapted than the Dorset to cope with environmental risk introduced by climate change and they capitalized on the vacated territory left by the Dorset (Holly and Erwin 2009).

After the disappearance of the Dorset, the Recent Indians appear to have adopted the familiar settlement pattern found at the Beaches, Inspector Island, Russell’s Point and Stock Cove West sites. Little Passage sites are located in those areas where many resources can be monitored and accessed, and as such, sites are ephemeral and generally small (Holly 2002; 2008). Recent Indian sites are distributed along the coasts, extending the length of the Northern Peninsula, west coast, and spotted along the southern shore. In contrast, later Beothuk sites are concentrated around the Bay of Exploits and Notre Dame Bay, and extend down the Exploits River to Red Indian Lake. Kristensen (2011) emphasized the position of coastal sites relative to bird colonies and hypothesized based on site distribution that seabirds played a large role in later Amerindian subsistence. With this in mind, the absence of late historic Beothuk sites along the coast (Pastore 1981) is now taken to indicate the alteration of subsistence practices in response to the growing European presence (Tuck 1976b; Holly 2008). Rowley-Conwy (1990) argued that the evidence from the interior sites of Indian Point and Wigwam Brook supported a year round occupation of the interior, but that the Beothuk were able to access the coast, albeit in a far diminished capacity from their precontact ancestors. Holly (2008) has taken a more nuanced approach, proposing that while the Beothuk were forced to give up the most strategic regions of the landscape (the inner coast), they still made use of coastal resources, just on a smaller scale.

In summary, the distribution of Amerindian sites around the island has been very telling of past subsistence strategies. Sites are most frequently located where a broad range of food resources can be monitored, usually in the inner coastal or near-shore regions. However, with sites located in these productive areas, it become difficult to discern the degree to which marine versus terrestrial resources were relied upon. This question has relevance when attempting to discern the relative effects of external social pressures and environmental variation on the lifeways of hunter gatherers.

4.4 Material Culture

The function of the material culture, and tool kits in particular, of Amerindian people in Newfoundland has been understood through the use of ethnographic analogy, comparisons with other archaeological collections, and on the basis of accepted views of the functions of different tool classes (Tuck 1988). This section reviews some aspects of Amerindian material culture that have been used by past researchers to elucidate Maritime Archaic and Beothuk subsistence on the island of Newfoundland.

4.4.1 Maritime Archaic material culture

The utilitarian objects recovered from Port au Choix-3 have been informative not only for the variety of recovered stone tool forms, but also for the presence of organic tools manufactured from antler, bone and teeth. Unlike the animal bones recovered from the site, the tools can generally be considered representative of the variety of objects used by the Maritime Archaic people as many of them, regardless of tool class, bear use wear (Tuck 1988). Tuck divided lithic procurement tools into two classes: points and bayonets. Most of the points from Locus II were large with broad stems (Tuck 1976a). The ground slate bayonets are consistent with sea mammal hunting tools, while the points could be divided into those that would have been appropriate for hunting birds, and those that are analogous to leister points used by other coastal hunter-gatherers to harvest fish (Tuck 1988). Many of the antler and bone tools would have functioned to prepare hides for clothing (Tuck 1976a). Non-utilitarian objects from the burial ground speak to human-animal interactions, and the world view of the Maritime Archaic, but not necessarily to the role of different animals in subsistence. For example, bird effigies feature prominently, and Tuck has hypothesized that the stone orca effigy may have functioned as a type of totem to channel the hunting proficiency of the killer whale into human seal hunters (Tuck 1976a; 1988).

4.5.2 Recent Indian and Beothuk material culture

Recent Indian and Beothuk hunting technology included spear and harpoon points (Fig. 4.1) for hunting caribou and marine mammals, respectively. Small projectile points for tipping arrows are associated with the transition from the Early to Late Recent Indian tradition and are carried into the Beothuk period (Erwin et al. 2005). This technological transition appears to coincide with the alteration in settlement pattern observed between the Beaches and Little Passage complexes and suggests a diversification of the resource base over time (Erwin et al. 2005).

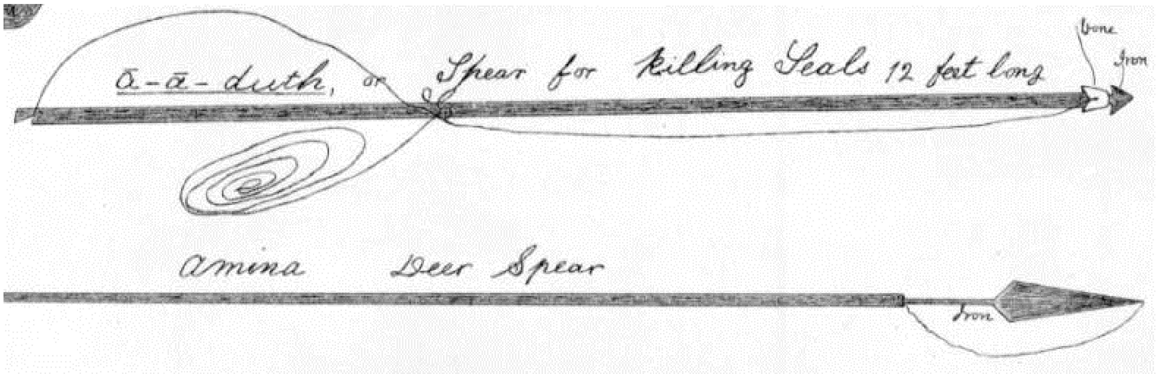

Figure 4.1 Beothuk caribou spear and sealing harpoon. Drawing by Shawnadithit, ca. 1823. Original in Howley (1915). http://collections.mun.ca/cdm/ref/collection/cns_images/id/71

Recently, a connection has been drawn between the bone pendants found at many Beothuk burial sites and the role of seabirds in Beothuk cosmology and potentially, subsistence (Kristensen 2011; Kristensen and Holly 2013). Kristensen and Holly (2013) pointed to similarities in the shape of several classes of bone pendant to the morphology of bird feet, and tail feathers in flight as supporting evidence for the critical role played by seabirds in both subsistence and in Beothuk worldview. Other Beothuk grave offerings provide evidence for subsistence and lifeways. For example, the hide wrapping preserved with the mummified child (NP 240) recovered from Big Island has been used to evidence the period of scarcity afflicting the Beothuk in their years immediately preceding their cultural extinction. The wrapping was fashioned from several pieces of hide modified from a woman's legging. Assuming that the burial dated to the Terminal Beothuk occupation, Whitehead (1987) suggested that the reuse of an article of clothing was evidence that the Beothuk were afflicted by a time of scarcity. Whitehead proposed two hypotheses to explain the use of spruce root to sew the legging. Spruce root may have been chosen to sew items of clothing for its red colour, a shade with known cosmological significance to the Beothuk (Howley 1915; Whitehead 1987). Alternatively, and this appears to have been the hypothesis favoured by Whitehead, the use of spruce root instead of sinew may have indicated that the Beothuk were unable to procure a sufficient number of caribou to meet their subsistence needs (Whitehead 1987). Whitehead's interpretation of the Big Island mortuary assemblage was not supported by a radiocarbon date from the site, but a a date of 549 ± 62 B.P. was later obtained from a sample of soft tissue (Jerkic et al. 1995) leading subsequent authors to interpret the site as precontact (e.g. Holly and Kristensen 2013). However, it seems quite likely that the radiocarbon date and isotope data obtained from the sample may not be accurate. The mummified remains of the child were heavily treated at some point in the past with an unknown consolidant. Based on the $\delta^{13}C$ value (-17‰), carbon contained in the consolidant likely contaminated the radiocarbon determination. The date and isotope data obtained over the course of this thesis differ significantly (see Chapter 6). Rather than dating to the pre-European contact period, as proposed by Jerkic et al. (1995), or the 19th century, as proposed by Whitehead (1987), the mummified child appears to date to the late 17th to 18th century. This date and the marine diet of the child suggest that Whitehead's initial statement regarding the colour of the spruce root may carry more weight in explaining the materials used to make the burial shroud.

4.5 Ethnohistoric evidence

With the exception of early accounts by John Guy and Henry Crout, the scant ethnohistoric literature pertaining to the Beothuk is heavily weighted towards the late 18th and early 19th centuries and accounts made with the purpose of shedding light on the lifeways of an imperiled culture (Howley 1915). During, and subsequent to his 1768 journey down the Exploits River, Lieutenant John Cartwright recorded his observations and collected other accounts of Beothuk subsistence, many of which focused on the remains of Beothuk housepits and storage structures that Cartwright encountered in the summer of 1768 (Marshall 1996). Cartwright's expedition to Red Indian Lake did not bear fruit with respect to making contact with the Beothuk, as neither he, nor any member of his party, encountered a Beothuk person, presumably because the Beothuk were visiting the coast for the summer (Marshall 1996). Without a Beothuk informant, Cartwright attempted to interpret the campsites that he saw along the river and lake's edge and came to the conclusion that the habitations were the main settlement of the Beothuk (Marshall 1996). He presumed that one-half to two-thirds of the population would assemble each fall where they would subsist on caribou throughout the winter (Marshall 1996). Cartwright's observations are valuable, especially in light of the damage to the archaeological record incurred through damming and flooding of the rivers and lakes of the interior (e.g. Holly and Erwin 2009; Sproull Thomson 1982), but caution must be used when extrapolating from these accounts as the way of life being described was likely altered by European settlement along the coast at this time. Furthermore, Cartwright's conclusions were drawn without the benefit of a Beothuk informant, and the importance that Cartwright places on the caribou hunt and the settlements of the interior may not have been consistent with Beothuk lifeways, and furthermore, may not have been consistent with the pre-European contact past (Damm 2005).

Working primarily from ethnohistoric accounts, Marshall (1996) posited the existence of two region specific Beothuk subsistence patterns. She described the first as a generalized adaptation with base camps located on the coast and smaller resource exploitation sites located near key resources. Citing Schwarz' model for Little Passage subsistence, Marshall (1996) pinpointed the sites of Boyd´s Cove and the Beaches as possible base camps. Beothuk campsites in Placentia and Trinity Bays, recorded by Henry Crout and John Guy, were further consistent with exploitation camps (Marshall 1996). A second economic model focused on caribou hunting along the Exploits River and Red Indian Lake, supplemented by summer forays up the river to the Bay of Exploits. In this model, the central base camp was located in the interior, and in the summer, the group would disperse throughout the islands of Notre Dame Bay and the Bay of Exploits (Marshall 1996). Despite the support Marshall's model finds in the ethnohistoric record of the late 18th and early 19th century, evidence for two subsistence economies that divide along regional lines has not yet been recovered from the archaeological record (Holly 2008). The archaeological evidence for an interior-based subsistence economy suggests instead that the Beothuk only developed this adaptation in the historic period as a response to external social pressures from European migrant fishermen and settlers (Holly 2008; Reader 1998).

Marshall (1996: 298) provides a list of all of the animal species that may have been hunted by the Beothuk and their ancestors, the Little Passage culture. It is a list that reads like a catalogue of all available prey species in Newfoundland, excepting bats and voles. It is tempting to dismiss this list as an overgeneralization, but it is supported by the archaeological record. As has been discussed previously in this chapter the Beothuk of the early historic period, and their immediate ancestors, appear to have subsisted by strategically exploiting both marine and terrestrial food sources. However, this type of generalist approach is a sum of its parts, and as accounts from the late 18th and early 19th century show, the reduction in the use of coastal hunting territories had a profound impact on Beothuk lifeways (Howley 1915). Shawnadithit, speaking to William Cormack in the early 19th century, recounted the struggles of her tribe to survive in the final years before her capture.

> "At the time when she and two other females surrendered, the tribe had been reduced to so small a number that they were unable to keep up the deer fences; and, being driven from the shore, and from the fish and the oysters, and the nests of waterfowl, their means of existence were completely cut off." [Cormack in Marshall 1996: 210].

Newfoundland's ethnohistory was largely created with an interest in preserving Beothuk culture, but even so, the use of ethnohistoric data to interpret Beothuk lifeways, and the subsistence patterns of those who preceded them, cannot be done uncritically. Beothuk life was undoubtedly altered by the presence of Europeans on the coast by the time John Cartwright made his first trek down the Exploits River. This line of evidence will be useful for interpreting the stable isotope data from human remains that date to the historic period, but is less informative for understanding earlier subsistence patterns.

4.6 Stable isotope studies in Newfoundland

Archaeological human and animal populations in Newfoundland and Labrador are increasingly becoming the focus of stable isotope and bioarchaeological studies (e.g. Britton 2007; Guiry and Grimes 2013; Guiry et al. 2012; Harris 2014; Harris and Grimes 2016; Munkittrick 2016; Pike 2014). Three published stable isotope studies have been conducted on indigenous people in Newfoundland, and a fourth has been made of Moorehead occupation skeletal material from Maine, U.S.A. (e.g. Bourque and Krueger

1994; Jelsma 2006; Kuch et al. 2007; Raghavan et al. 2014). These will be reviewed briefly below, as they stand as the only direct evidence of Amerindian and Palaeoeskimo diet.

4.6.1 Maritime Archaic

In the late 1990s, PhD candidate Johan Jelsma of the University of Groningen, conducted a study of the material culture remains from Port au Choix-3, and compared his results to bioarchaeological data from a subset of the burials. Jelsma conducted $\delta^{13}C$ and $\delta^{15}N$ analysis of 29 individuals from Locus II with the aim of shedding light on the meaning of the three burial clusters in the locus. The results (Fig. 4.2) indicated that the $\delta^{15}N$ values differed significantly between burial clusters A and B (Jelsma 2000). Significant differences were also noted between individuals buried with slate bayonets versus those buried with spear points, and in relation to burial direction and grave cover (Jelsma 2000). The lower $\delta^{15}N$ values of several males were attributed to the consumption of terrestrial resources, while females, young and older males consumed seal and fish. It should be noted that the bones of local fauna were not also sampled, therefore Jelsma's dietary reconstruction is based on an estimate of where prey species would fall in isotopic space. Jelsma interpreted the isotopic differences as deriving from dietary practices rooted in status distinctions. As beaver was considered a high status food by some Amerindian groups on the mainland, it may also have been viewed as such by the Maritime Archaic, while marine mammals and fish, relatively easy to hunt, would been considered lower status foods (Jelsma 2000). Despite the presence of several individuals with lower $\delta^{13}C$ and $\delta^{15}N$ values that are indicative of moderate consumption of terrestrial protein, the isotope values of the rest of the skeletal sample were overwhelmingly marine in origin and supported Tuck’s (1971, 1976a) suggestion that the tradition had a coastal orientation.

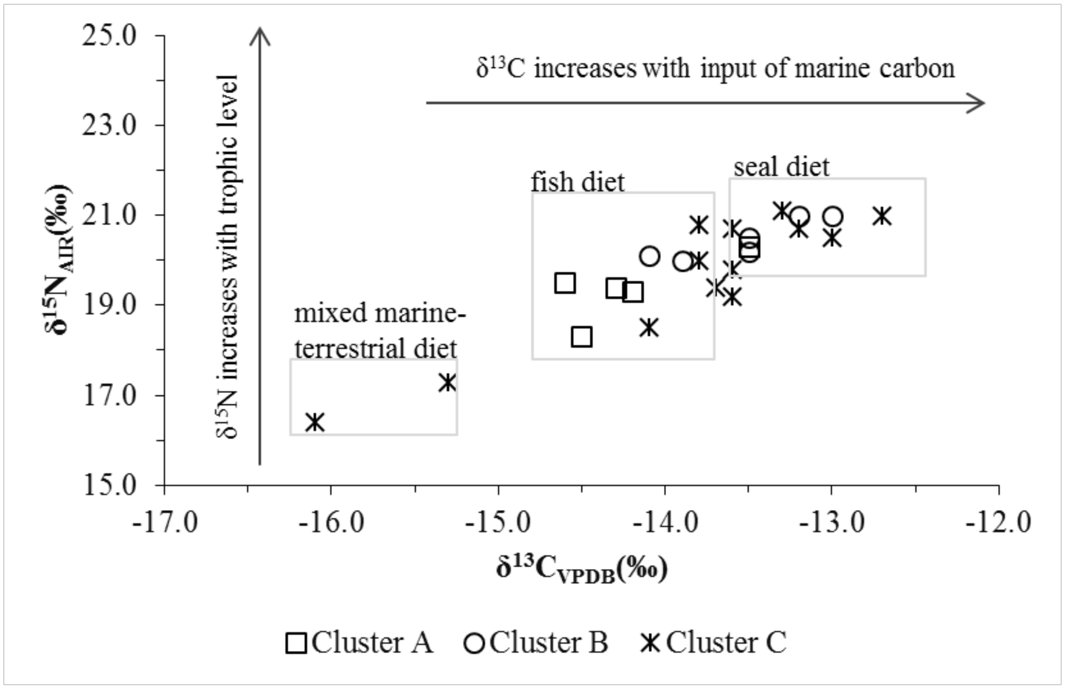

Figure 4.2 Port au Choix-3 Locus II δ^{13}C and δ^{15}N results (n = 29) presented by burial cluster, as analysed by Jelsma (2000, 2006).

Although not in Newfoundland, the isotopic study of a small Moorehead (the regional variant of the late Archaic in Maine) cemetery deserves a brief mention here. Ten individuals from the Nevin site, dating from approximately 5000-4500 B.P. were sampled for δ^{13}C and δ^{15}N analysis (Bourque and Krueger 1994). The authors argued that the data (not published) indicated regular consumption of marine fish, such as swordfish and cod, consistent with the archaeological record of that time period (Bourque and Krueger 1994). The authors tentatively proposed that the two individuals who appeared to have consumed more terrestrial protein were immigrants, or that this was evidence for food preference (Bourque and Krueger 1994). The results of these studies generally support the coastal orientation that Tuck (1971) attributed to the Maritime Archaic tradition throughout the Atlantic region, but together, indicate the possibility for greater dietary diversity within each regional population that may be linked to biosocial categories, status, or natal origin (Bourque and Krueger 1994; Jelsma 2000).

4.7.2 Palaeoeskimo

One stable isotope study has been conducted on Palaeoeskimo human remains from Newfoundland, and is mentioned here due to its value as a comparative dataset, and for the strong relationship between the stable isotope results and the zooarchaeological record associated with Dorset Palaeoeskimo lifeways in Newfoundland. Raghavan et al. (2014) conducted δ^{13}C and δ^{15}N analysis on the remains of eight individuals recovered from four sites on the Northern Peninsula: Englee, Phillip’s Garden, Gargamelle Rockshelter, and Eastern Point.

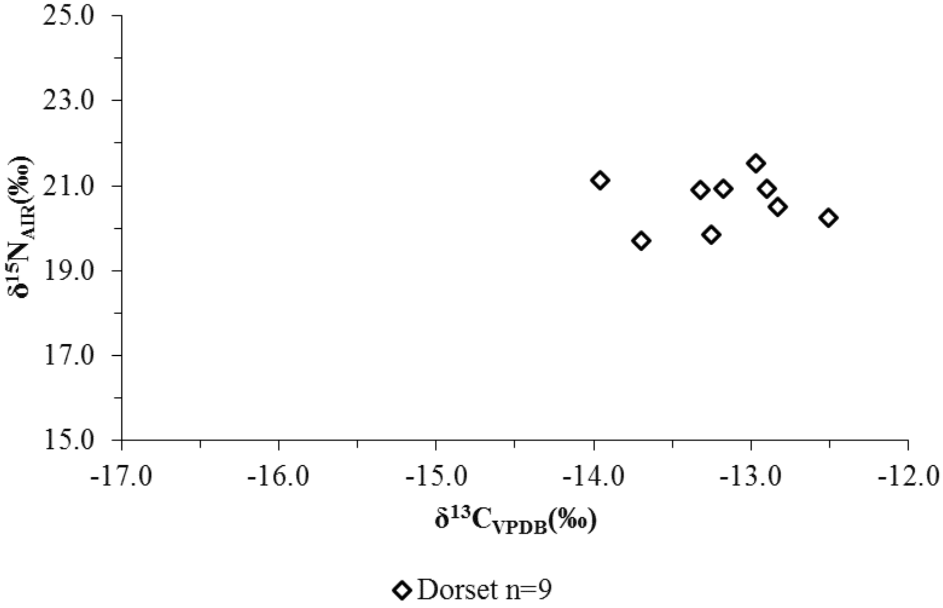

Figure 4.3 The δ^{13}C and δ^{15}N values of Dorset Palaeoeskimo (Raghavan et al. 2014).

The results (Fig. 4.3) indicate that each individual consumed high trophic level marine protein, probably consistent with harp seal and some seabirds (Raghavan et al. 2014). The stable isotope data were produced for the purpose of calibrating the radiocarbon determinations on human bone, and thus were not interpreted from an archaeological perspective. It is clear that, relative to the Maritime Archaic people, the Dorset Palaeoeskimo sample exhibited less variance. This could be due to the small sample size, but it seems more likely given the composition of Dorset faunal assemblages from the Northern Peninsula (e.g. Hartery and Rast 2001; Hodgetts et al. 2003; Wells 2005), and from the Avalon Peninsula (Wolff et al. 2010), that the variance in the stable isotope data may accurately reflect that in the greater population.

4.7.3 Beothuk

Prior to the beginning of this project, two attempts were made to reconstruct Recent Indian/Beothuk diet using a stable isotope-based approach. The first, conducted by Jerkic et al. (1995) has already been mentioned. The results of this study should be viewed with caution given the choice of soft tissue as an analyte and uncertainty regarding sample pretreatment and analysis. Therefore, this study will not be discussed further.

Kuch et al. (2007) conducted a multi-isotope study and ancient DNA analysis of the skeletal remains of two Beothuk, Demasduit and Nonosabasut, curated in Scotland. This study was an important stepping stone for the realization of the current SSHRC-funded project. A molar from each individual was taken for isotopic analysis. The authors conducted $\delta^{13}C$ and $\delta^{15}N$ analysis on dentinal collagen, and $\delta^{13}C$ and $\delta^{18}O$ analysis on the enamel carbonate. A discussion of the oxygen isotope results is not relevant here. As with the research conducted by Raghavan et al. (2014), the focus of the Kuch et al. study was the ancient DNA analysis, therefore the presentation of stable isotope methodology, results and interpretation was not a priority. It is unclear which molars were sampled, and thus what period of life the isotopic signal represented. An earlier study by Black et al. (2005) on the morphology of the Beothuk skulls makes reference to two missing teeth, a first molar from Demasduit and a third molar from Nonosabasut, sampled for a genetic study. It is assumed here that this was a reference to the work of Kuch and colleagues, which would have been ongoing at the time of the publication of the Black et al. paper. If these were the teeth sampled by the DNA researchers, then it is likely that the stable isotope data obtained from Demasduit would reflect early childhood diet, including the period before she was weaned, while the data from Nonosabasut would represent later childhood and early adolescence (Ubelaker 1979).

Table 4.1 Results of stable isotope analyses conducted on the teeth of two Beothuk individuals, Nonosabasut and Demasduit. Data from Kuch et al. (2007)

	$\delta^{13}C_{coll}$(‰)	**$\delta^{15}N_{coll}$(‰)**	**$\delta^{13}C_{carb}$(‰)**
Nonosabasut	-15.8	13.2	-12.6
Demasduit	-15.2	13.1	-12.4

The results (Table 4.1) do not indicate a significant contribution from marine protein, especially when the isotope values are compared to those of the Dorset and Maritime Archaic people (Fig. 4.4), but the $\delta^{13}C_{collagen}$ results do suggest that Nonosabasut and Demasduit were consuming some marine or anadromous species (Kuch et al. 2007). The $\delta^{13}C_{carb}$ results, reflecting the total dietary carbon intake, are similar to those expected for terrestrial C_3 consumers indicating that the dietary carbohydrates, fats and some of the protein eaten by Nonosabasut and Demasduit were sourced from the terrestrial environment (Kellner and Schoeninger 2007).The results from this study are significant with respect to the contributing factors to the Beothuk extinction, namely that the Beothuk became less focused on coastal resources during the latter part of the historic period. The results indicate that during the early 19th century, at least two Beothuk individuals were consuming a predominantly terrestrial diet, which is consistent with the ethnohistoric records of the period (e.g. Howley 1915). However, in the absence of isotope data from other individuals, it is not clear how great a deviation from pre-European contact diet this represents, and this is one area where the analyses presented in this thesis stand to make a contribution.

The pilot study conducted by Grimes et al. (2011) stands to shed further light on this issue. These data were first presented at the 2011 United Kingdom Archaeological Science, but have never been published as it was the intention of the lead author that they be incorporated with the current SSHRC study of Beothuk and Maritime Archaic, thus they will be presented and discussed further in the results and discussion chapters of this thesis.

The results of these studies are notable for the differences in subsistence that correspond to culture, supporting the hypothesis that culture had a greater influence in shaping adaptation to the island environment than would be assumed, giving the supposed marginality of the landscape (Schwarz 1994). A comparison of the isotope data from each culture further reveals the importance that a comparative faunal dataset be developed. For example, the two Beothuk samples have significantly lower $\delta^{13}C$ and $\delta^{15}N$ values that the two Maritime Archaic individuals with mixed marine-terrestrial diet, and yet both have been described in similar ways (e.g. Jelsma 2000; Kuch et al. 2007). This changes how mixed diets are understood isotopically and reduces the explanatory power of the concept.This demonstrates the limitations faced by studies that attempt to reconstruct human diet without an anchoring comparative dataset. The fauna analysed in this study will be useful for determining where individual human diets fall in isotopic space in relation to key prey species, such as seal, seabirds, and caribou or beaver.

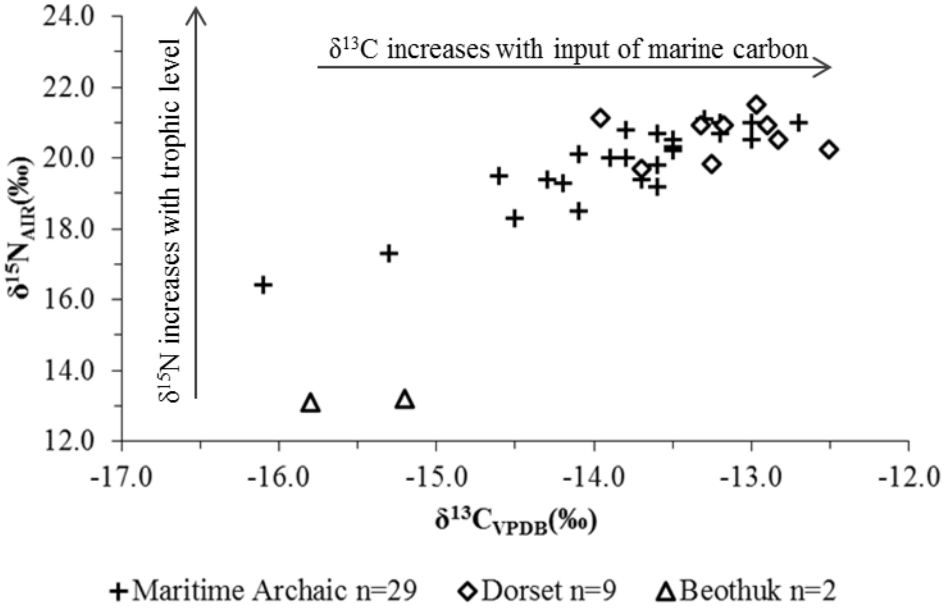

Figure 4.4 The δ^{13}C and δ^{15}N results of three studies conducted on the bone collagen of Maritime Archaic (Jelsma 2000), Dorset (Raghavan et al. 2014) and Beothuk (Kuch et al. 2007) people.

4.7 Chapter summary

This chapter presented the archaeological and ethnohistorical evidence for Amerindian subsistence in Newfoundland. Maritime Archaic subsistence appears to have had a coastal orientation. This is evidenced by specialized hunting implements, zooarchaeological assemblages, figurative animal representations, the location of sites in areas of high marine productivity, or in geographic regions that allow transit between coasts, and stable isotope analysis of human remains. There is also evidence for periodic use of the interior and consumption of terrestrial animals. Sites have been found along the rivers of the interior, tools have been manufactured from caribou bone and beaver incisors, and intra-population variation in stable isotope values indicates limited consumption of terrestrial animals that may correspond to status, sex, or to a yet to be determined factor. The composition of faunal assemblages, location of sites, and technology appears invariable over the Maritime Archaic period in Newfoundland, suggesting subsistence practices may have been relatively uniform, despite evidence for environmental change in Newfoundland and the arrival of another culture in Labrador. It is anticipated that the results of this research will speak to these points. Stable carbon and nitrogen isotope analysis of humans and representative prey species will address the relative contribution of marine and terrestrial foods to Maritime Archaic diet, and allow the roles of interior and coastal sites to be further explored. By sampling each member of the burial population of Port au Choix-3, the variation within the cemetery that was implied by earlier research (e.g. Jelsma 2000; Lacroix 2015) can be further evaluated. This research will build on previous studies of material culture and site distribution in order to move away from the critique of overgeneralization and provide a more nuanced view of Maritime Archaic subsistence practices on the island.

The overall impression of later Amerindian subsistence is that it is characterized by a generalist adaptation. This is evidenced by diverse taxa represented in faunal assemblages, specialized hunting techonology to harvest marine and terrestrial animals, and sites located in regions where multiple resources could be monitored and accessed. There may be regional variation in the contribution of marine and terrestrial resources to

Beothuk diet, at least during the early historic period. Diachronic variation in subsistence is apparent when the distribution of early and late Recent Indian sites are compared, in the absence of later Beothuk sites on the coast, and from the stable isotope analysis of two nineteenth-century Beothuk individuals. This variation seems to be attributable to the presence of other cultures on the landscape. Through the paired application of stable isotope analysis and radiocarbon dating of human skeletal remains, this project has an opportunity to examine the impact that European settlement may have had on Beothuk subsistence.

CHAPTER 5: MATERIALS AND METHODS

This chapter provides the details of the human and faunal skeletal materials sampled, and the methods utilised in this research. Details of the human samples are presented first, including the methodology used to estimate sex and age for the Recent Indian/Beothuk skeletons, and the sampling protocol. Next, the archaeological context for each faunal collection used in the development of an isotopic baseline for the island will be provided. The chapter then focuses on the methods used to sample, prepare and measure stable isotopes of carbon and nitrogen in human and faunal bones and teeth, and briefly reviews the methodology employed by the Keck Carbon Cycle AMS Laboratory and the details of radiocarbon date calibration. Next, the sampling, pretreatment and analytical methods used to measure isotopes of carbon in human tooth enamel are detailed. The chapter closes by presenting the statistical program and tests used to analyse the data.

5.1 Human Remains

5.1.1 Identification numbers and MNI

The Maritime Archaic skeletal remains are curated by the Department of Archaeology, at Memorial University of Newfoundland(MUN) on behalf of The Rooms Inc., as are 17 of the Recent Indian/Beothuk skeletons. These skeletons had previously been assigned an internal identification number with the prefix ‘NP’. The Port au Choix-3 graves received a NP number, and the burials within each grave were labelled alphabetically, e.g. NP 60A, NP 60B. Each skeleton had previously been inventoried and placed in perforated plastic or brown paper bags. An additional 11 Recent Indian skeletons are curated by the Canadian Museum of History and were given museum identification numbers with the prefix *XIII-*. It is cautiously assumed here that the separation of the skeletons by lab/museum number accurately represent the minimum number of individuals.

5.1.2 Sex and age estimation

The human skeletal remains from Port au Choix-3 have been analysed by different researchers over the period of their curation. Anderson (1976), Kennedy (1980), and Jelsma (2000) separately determined sex and age for the skeletons. Here, Anderson's sex and age estimations are used, as these were duplicated by Kennedy (1980), and Marshall (1990). Adults were classified as young (20 to 34 years), middle (35 to 50 years), or old adult (50+ years). Subadults were classified as newborn, infant (0 to 2 years), early childhood (2 to 6 years), late childhood (6 to 12 years) or adolescent (12 to 21 years) (after Anderson 1976).

There is little published literature pertaining to the Beothuk skeletal remains, however, the Department of Archaeology at MUN maintains an osteological database of all of the skeletal remains curated in the osteological laboratory. This database contains sex, age and archaeological information for several of the Recent/Indian Beothuk skeletons. Osteological methods to estimate sex, age, stature, and health assume that a complete, or largely complete skeleton is available for analysis. Unfortunately, the Recent Indian/Beothuk skeletal series curated at MUN is fragmented, and in some cases, comingled, with the result that a complete biological profile could be reconstructed only for one individual (NP 152).

Estimation of ancestry using morphology-based methods is contentious, especially with fragmentary, incomplete skeletal material (Hefner 2009). This research relies heavily on the archaeological context (see Chapter 2 for a review), the radiocarbon dates and isotope data obtained from each individual to assess ancestry. The assumption regarding the isotope data, based on previous and ongoing research into the subsistence practices of Europeans on the island, is that Amerindian populations would have consumed more marine protein than European settlers, at least during the early period represented by the migratory fishery (e.g. Harris 2015; Munkittrick 2016; Pike 2014).

5.1.3 Human bone and tooth samples

A list of sampled tissues from each human skeleton can be found in Table A.1.a. and Table A.1.b. Two bone samples were taken from each Maritime Archaic skeleton. One of these was for carbon and nitrogen isotope analysis and one for radiocarbon dating. These were largely selected from either ribs or long bones, and preferably the same bone for both analyses, although this was not always possible. To limit the visibility of the destructive analyses, effort was made to take bone samples from bones that had already been damaged either in the burial environment, or over time through handling and curation. Two bone samples, and one tooth was selected from each Recent Indian individual with preserved teeth for $\delta^{13}C$ analysis of enamel carbonate, $\delta^{13}C$ and $\delta^{15}N$ analysis of bone collagen, and radiocarbon dating. Second molars and premolars were preferentially selected as these teeth should represent the post-weaning isotope signal. Each sample was assigned an internal laboratory (marc) number and all teeth were photographed prior to being sampled. Many of the Maritime Archaic and Recent Indian samples had been treated with an unknown consolidant at some point during their post-excavation history. The consolidant was soluble in acetone therefore bone samples from treated skeletons were soaked overnight in a small amount of acetone, rinsed thoroughly with DI H_2O and allowed to dry prior to collagen extraction. Teeth were first wiped with acetone and allowed to dry prior to sampling for carbon isotope analysis.

5.2 Faunal bone assemblages

Faunal bone specimens were taken from two Palaeoeskimo and six Recent Indian/Beothuk zooarchaeological assemblages (Fig. 2.1) to provide a carbon and nitrogen isotopic baseline for the island, a critical step for interpreting the human data and calibrating the radiocarbon dates. The pertinent details for each site are reported below. The faunal collections were housed at the Rooms Provincial Museum, or in the Department of Archaeology at MUN. Due to financial constraints and feasibility, the assemblages, such as that of Wigwam Brook (DfAw-1), curated at the national museum in Gatineau, QC, were not sampled. Effort was made to sample equal numbers of species from marine, terrestrial and estuarine environments. This should enable the construction of a baseline that is more representative of the natural isotopic variation within these environments. Stable isotopes of carbon and nitrogen were measured in 101 faunal bone collagen samples according to the methods outlined in section 5.4 of this chapter.

This research aimed to provide regional and temporally specific isotope datasets, however, the Dorset period is primarily represented by assemblages from the west coast of the island, while the Recent Indian and Beothuk periods are represented by sites in the interior and north coast. This poses a problem for distinguishing temporal shifts in the isotopic baseline from differences that relate to the ecology of the geographic region sampled. Data from the specimens sampled from each site will therefore be averaged by species, and the entire dataset will be used to develop endpoints for radiocarbon calibration and palaeodietary modelling (after Raghavan et al. 2014). As the two

Amerindian traditions studied in this research were both thought to be mobile, it may be that any subtle differences in regional or temporal baselines will be masked by the averaging effects of protein routing during collagen synthesis.

5.2.1. Beaches (DeAk-1)

The multi-component Beaches site has been visited by researchers for over 100 years, beginning with T.G.B Lloyd in the late 19th century (Lloyd 1875), and most recently by MUN graduate student A. Johnson-Henkes in 2015. Devereux (1969) visited the site in the 1960s, excavated a portion of the site and recovered faunal remains from a Beothuk midden. Carignan's excavation in the early 1970s yielded poorly preserved faunal remains that were not easily assigned to a particular cultural group (Carignan 1975). The site was revisited in the late 1980s and throughout the 1990s, producing a larger faunal assemblage from a more secure context. Jennifer Cridland, a graduate student in archaeology from MUN, conducted the faunal analysis of the skeletal material recovered during the 1989 and 1990 excavations. Further analysis of the 1992 and 1995 material was conducted by undergraduate students Cynthia O'Driscoll and Michael Slaney, of MUN, under the aegis of The Beaches Archaeological-Paleoethnobotanical Project, and their results are reported in Deal and McLean (1997).

The 15 faunal specimens sampled for this study were recovered from Beothuk House Pit 6, and Feature 4, a midden associated with Beaches, Little Passage and Beothuk activity, during the excavations of 1989, 1990, 1992, and 1995 (Deal and McLean 1997). Beothuk and European materials were recovered from Housepit 6, and a radiocarbon date of 390 ± 70 B.P. indicate that the faunal remains from this area of the site date to the historic period (Deal and McLean 1997). Feature 4 is a large midden feature that produced a radiocarbon date of 585 ± 80 B.P. (Beta-34272) and two diagnostic Little Passage triangular bifaces (Cridland 1998). The faunal specimens were brown in colour, giving the indication of potential humic contamination, and somewhat weathered, but the overall condition of the samples indicated that some collagen was likely preserved.

5.2.2 Boyd's Cove (DiAp-3)

The multicomponent site of Boyd's Cove was located by Dr. Ralph Pastore of MUN during his 1981 survey of eastern Notre Dame Bay and subsequently excavated over the following five years (Pastore 1983, 1984, 1985). The site has provided evidence for Beaches and Little Passage occupation, and a substantial Beothuk component, dating to the early historic period (Pastore 1984; 1985). The site provided firm evidence in support of the continuum connecting the Beaches, Little Passage and Beothuk cultures and provided a coastal counterpoint to the precontact and historic sites found in the interior of the island, ultimately helping to create a more complete picture of Beothuk subsistence in the early historic period (Cumbaa 1984; Pastore 1984). The faunal analysis was conducted by Dr. Stephen L. Cumbaa, then of the Zooarchaeological Identification Centre, National Museums of Canada. The 23 faunal specimens sampled for this research were recovered by Pastore during the excavation of Beothuk Houses 1 and 5, and the House 1 midden in the field season of 1982 (Cumbaa 1984). House 1 is believed to have been the earliest Beothuk house at the site and it produced more mollusc shell (*Mya arenaria*) than bone (Cumbaa 1984). The House 1 midden and House 5 follow in chronological order and feature mixed assemblages of mammal, bird and fish species (Cumbaa 1984). Cumbaa (1984) was able to identify 13% of the House 1 assemblage, 22% of the House 1 midden, and ~30% of the House 5 assemblage to the taxonomic level of family or better. The faunal specimens were friable, and some had the appearance of being burned.

5.2.3 Crow Head Cave (EeBi-04)

Crow Head Cave is a Middle Dorset mortuary site that was first discovered in the mid-20th century, but not professionally excavated until the mid-1980s, by Dr. Stuart Brown of MUN. The site had been extensively disturbed, but still produced human skeletal remains, a beautiful assemblage of Dorset tools, and a large assemblage of faunal remains. The provenience of the artifacts and ecofacts in the site was destroyed by looting and the setting of an explosive charge at the cave entrance, preventing a comprehensive analysis of the assemblage (Brown 1988). The faunal remains collected by excavators were very well preserved and represented a wide range of species. Cumbaa (1988) identified harp seal, arctic and red fox, domestic dog, mussel and clam shell, 16 bird species, 4 species of marine fish, pine marten, lynx, beaver, vole, polar bear, hare, and a single caribou element. The presence of domestic dogs was odd, given their scarcity in Dorset assemblages (Maxwell 1985), but radiocarbon determinations on the dogs returned dates consistent with the Maritime Archaic occupation of the region (Harris and Grimes 2016). Five other radiocarbon determinations on human, fox and ptarmigan bone produced dates consistent with Groswater and Dorset occupations (Table 5.1). Initially, Brown attributed the faunal remains from the cave to be the work of predatory animals, but when a later survey of nearby caves failed to produce similar assemblages, and after the abundance of species from Crow Head Cave was quantified, it is clear that at least some of the species, such as harp and grey seal, in the cave were present due to human involvement, while others like the voles, and small birds may have been preyed up by another animal (Brown 1988). For the purpose of characterizing the isotopic variation in the palaeoenvironment, the means by which the faunal remains came to be in the cave is important to consider as it cannot be expected that all of the remains date to the same time period. Sixty-eight faunal specimens were sampled from the Crow Head Cave assemblage. These generally appeared very well preserved, almost fresh, with the exception of several seal and cod bones which had a dry and flaky, but not friable texture.

Table 5.1 ^{14}C dates from human and faunal bone from Crow Head Cave (EeBi-4) corrected for the marine reservoir effect where necessary (section 5.4.3). Samples calibrated with OxCal v. 4.2 (Bronk Ramsey 2009) against IntCal13 and Marine13 (Reimer et al. 2013).

Species	**Lab No.**	**^{14}C Age B.P.**	**Error ± B.P.**	**δ^{13}C(‰)**	**2σ range cal B.P.**	**2σ range cal B.C./A.D.**
Human	UCIAMS-129849	1955	25	-12.8	1509-1175	442-775
Human	UCIAMS-129847	1965	20	-12.5	1507-1170	445-780
Human	UCIAMS-129850	1950	25	-13.5	1504-1163	447-788
Human	UCIAMS-129848	1960	25	-12.6	1537-1238	413-712
Arctic fox	UCIAMS 159457	2065	25	-13.3	1672-1320	279-631
Ptarmigan	UCIAMS 159458	2435	25	-19.8	2698-2356	-749- -407

5.2.4 Indian Point (DeBd-1)

The site of Indian Point is located on the northeastern shore of Red Indian Lake, in the interior of the island (Sproull Thomson 1981). The site was first investigated by Mi’kmaq people, who related the results of their exploration to anthropologist Frank Speck (Sproull Thomson 1981). Speck visited the site, but it was Helen Devereux (1970) who formally excavated the site and distinguished a precontact and historic component. Jane Sproull Thomson (1981) later revisited the site and conducted further mapping and excavation. The site has been extensively disturbed by logging and damming activities around Red Indian Lake, and the site continues to be monitored. It is not clear during which excavation the three bone samples were collected. The presence of moss growing on the caribou mandible indicates that it, at least, was likely a surface find.

5.2.5 Parke's Beach (DgBm-1)

Parke's Beach is a multicomponent site located on the west coast of Newfoundland, in the Bay of Islands. During the 1997 field season, David Reader excavated a Groswater Palaeoeskimo habitation, and a nearby Beothuk housepit and midden (Reader 1997). Iron implements recovered from the site and the dynamics of European settlement in the area led Reader to propose that the Beothuk occupation likely dated to before the mid-18th century (Reader 1997). The faunal specimens sampled in this study were recovered from the Beothuk midden, Feature 13 (Reader 1997). The midden feature produced clam shell, and calcined and uncalcined bone representing predominantly avifauna (Reader 1997), but a formal faunal analysis was never carried out. Elements of caribou, seal and beaver were identified during sampling of the Rooms faunal collections for this project.

5.2.6 Peat Garden North (EgBf-18)

The multicomponent site of Peat Garden North is located on the Dog Peninsula which forms the eastern border of St. Margeret's Bay and was excavated over several years by Reader in 1997, and Hartery and Rast in 2000 and 2001 (Hartery and Rast 2003). EgBf-18 is the Dorset Palaeoeskimo component of the site, and the source of the faunal material sampled in this study. Radiocarbon dated charcoal ranged from 1570 ± 60 B.P. (Beta-113160) to 677 ± 45 B.P. (BGS-2321) (Hartery and Rast 2003; Reader 1998). The latter date was obtained from several small flecks of charcoal and falls outside of the Middle Dorset chronological range. Hartery and Rast (2003) obtained two more dates on land mammal collagen, 1030 ± 290 B.P. (TO-9555) and 1490 ± 50 B.P. (TO-10468), that were consistent with Dorset chronology, and thus the excavated features and faunal remains are assumed to all be Middle Dorset in age and cultural affiliation. A large collection of faunal bone and shell has been recovered from the site. Murray identified the material collected by Reader in 1997, and Hartery analysed the bones from the 2000 and 2001 excavations (Hartery and Rast 2003). Over half of the identified faunal material represents bird, with smaller amounts of seal, fish and terrestrial mammals, a deviation from the classic faunal assemblage typically recovered from Dorset Palaeoeskimo sites (Hartery and Rast 2003). The 18 bone samples taken for analysis exhibited some brown staining consistent with humic acid contamination, but otherwise had the appearance of well-preserved bone.

5.2.7 Port au Port (DdBq-1)

The Port au Port site was first excavated by Carignan (1975) and later revisited by Simpson (1984). The site is located on the isthmus connecting the Port au Port Peninsula to the mainland, on the west coast of the island. The site features three cultural components: a Beothuk component comprising Area I, a Dorset Palaeoeskimo component in Area II, and Little Passage complex material in Area III. A small Beaches complex assemblage was also found in Area III (Simpson 1984). A single radiocarbon assay returned a date of 790 ± 70 B.P. (Beta-7777) (Simpson 1984). The faunal specimens sampled in this study were recovered from Area III. The faunal analysis was conducted by David Black, then a graduate student at McMaster University and Simpson drew heavily on his report for the interpretation of the remains. The faunal remains from Area III were largely calcined and fragmented, limiting taxonomic identification to just 70 specimens, consisting primarily of caribou and beaver, with a minor representation of avian and other mammalian taxa (Simpson 1984). Four specimens were sampled for this study.

5.2.8 Wigwam Brook (DfAw-1)

The site of Wigwam Brook is located west of Grand Falls-Windsor, along the Exploits River. Wigwam Brook was discovered by Don Locke, of Grand Falls-Windsor, tested by Devereux, and excavated by Raymond LeBlanc in 1972 (LeBlanc 1973). LeBlanc's excavations uncovered the remains of three housepit features and a large amount of faunal material. The faunal material from LeBlanc's excavations is not currently curated by the Rooms Provincial Museum, therefore it is assumed that the small amount of material from the site sampled for this study was recovered during later monitoring of the site. Four faunal specimens were sampled.

5.3 Carbon and nitrogen isotope analysis of bone collagen

The following section details the preparation of bone samples for stable carbon and nitrogen isotope analysis.

5.3.1 Sample Preparation

All sample preparation and pretreatment was conducted at the Memorial Applied Archaeological Science (MAAS) Laboratory under the supervision of Dr. Vaughan Grimes. Bone chunks weighing between 150 – 200mg were cut from bones using a hand held dremmel tool. These were cleaned using mechanical, or air abrasion. Cleaning via mechanical abrasion utilised stainless steel burrs to abrade all exposed surfaces of the bone pieces and remove dirt and trabecular bone. The burrs were ultrasonicated in DI H_2O (18.3MΩ) between each sample. However, after the laboratory acquired a functioning air abrasion system, bone samples were cleaned more quickly by blasting the bone surfaces with aluminum oxide powder. The majority of the faunal samples were cleaned in this fashion, and approximately half of the human bone samples. Each bone sample was weighed and the initial mass recorded for later calculation of the percent yield of bone collagen.

5.3.2 Collagen extraction

Collagen was extracted at the MAAS laboratory following the Longin (1971) method as modified by Richards and Hedges (1999) with the addition of a filtration and alkali wash step. Bone chunks were placed in 15ml screwtop glass vials and demineralized in 0.5M HCl at 4°C. The acid was refreshed every other day until the bone chunk was spongy and translucent. The sample was then rinsed with DI H_2O, and refrigerated in DI H_2O until all other samples were demineralized. Samples that appeared brown in colour following demineralization were ultrasonicated in 0.05M NaOH in an ice bath. The NaOH was changed every ten minutes until the solution remained clear (Dr. Paul Szpak personal communication, 2015). The samples were then promptly removed and rinsed with 0.1M HCl to neutralize the NaOH. Samples were rinsed with DI H_2O and allowed to soak overnight to ensure the complete removal of NaOH prior to gelatinization. All demineralized samples were rinsed again with DI H_2O prior to gelatinization, then placed in a dilute HCl solution at a pH of 3 and gelatinized at 70°C for

48 hours. Samples that had appeared well preserved upon initial inspection were filtered (60-90μm, E-zee filters, Elkay Laboratory Products, UK), frozen for 24 hours at -60℃, and lyophilized for 48 hours. Samples that appeared poorly preserved or to have been treated with a consolidant were filtered with E-zee filters, and then ultrafiltered (30KDa, Pall Corp., New York) prior to freezing and lyophilisation. Six samples produced unacceptable collagen quality indicators. These were re-extracted, treated with NaOH and ultrafiltered. All reagents were made from stock solution and diluted to the required molarity or percent with DI H_2O.

5.3.3 Analysis by EA-IRMS

Isotopes of carbon and nitrogen were measured in the Stable Isotope Laboratory of the CREAIT network of MUN. Under the supervision of Alison Pye, 1 mg of dried collagen was weighed into a tin capsule (7 by 7mm ultralight, Elemental Microanalysis, UK), tightly folded, and loaded into an autosampler. Samples were flash combusted at 1800℃ in a Carlo Erba NA 1500 Series elemental analyser. The resulting gases were passed through a reduction reactor held at 650℃ to reduce NO_2 gas to N_2 and remove excess O_2. The gases were then separated on a 3m stainless steel Poropak QS 50/80 chromatographic column. The gases were then carried on a stream of helium to a Thermo Electron ConFloIII interface and then directly to a Thermo Scientific Delta V Plus isotope ratio mass spectrometer. Four pulses of reference gases were injected after each sample and samples were interspersed with reference materials. 10% of the collagen samples were analysed in duplicate.

A calibration curve to normalise the $\delta^{13}C$ and $\delta^{15}N$ values was developed using reference materials. Each analytical run began with five primer samples (MUN-Sulfanilamide), three blank capsules, followed by carbon and nitrogen isotope and elemental calibration standards. Precision on the protein standard B2155 over nine runs (n = 31) ranged from 0.02‰ to 0.45‰ (mean 0.14 ± 0.13‰) for $\delta^{13}C$ and from 0.08‰ to 0.24‰ (mean 0.15 ± 0.07‰) for $\delta^{15}N$. A list of the reference materials, their accepted isotopic and elemental values, and the values measured in all nine runs can be found in Table A.4.b of Appendix 4.

5.3.4 Assessment of collagen preservation

Collagen quality was assessed using the criteria detailed in van Klinken (1999) and Ambrose (1990). Collagen was deemed to be of acceptable quality if the atomic C/N ratio fell between 3.1 and 3.5, if weight %C and %N fell between 15% and 47%, and 5% and 17%, respectively. Collagen yield was calculated using the equation:

$$\%\text{yield} = \frac{\text{Final mass}}{\text{Initial mass}} \times 100$$

5.4 Radiocarbon dating

Bone samples were taken from 46 human skeletons and submitted for radiocarbon dating at the W. M. Keck Carbon Cycle AMS Facility of the University of California Irvine. The following section reports on the methods used to sample, analyse and calibrate the resulting radiocarbon determinations.

5.4.1 Sample preparation and analysis

Samples of bone were collected as reported above (section 5.3.1), weighed and wrapped in aluminum foil for transfer to the W. M. Keck Carbon Cycle AMS Facility

(KCCAMS). Samples were prepared and analysed at the KCCAMS Facility under the supervision of Dr. John Southon. The following information was source from the UCI KCCAMS Facility laboratory protocols (2009, 2011a, 2011b). Collagen was extracted using a standard acid-base-acid protocol, gelatinized, and ultrafiltered. The bone samples were cut into small chunks and demineralized at room temperature in 0.5M HCl for 24 to 36 hours. Samples that appeared to have humic contamination were soaked in 0.1M NaOH for one hour, rinsed with 0.1M HCl and DI H_2O, and gelatinized at 60°C for eight to 10 hours. Following gelatinization, cooled samples were ultrafiltered (Centriprep YM-30, 30kDa), frozen and lyophilized. Collagen yield was determined using the equation in subsection 5.4.4. Collagen samples were reduced to graphite over an iron oxide catalyst prior to ^{14}C measurement using a 500 kV compact AMS unit (National Electrostatics Corp.) equipped with an NEC 40-sample MC-SNICS (Multi Cathode-Source of Negative Ions by Cesium Sputtering).

5.4.2 Marine correction

As both populations were marine-adapted to variable extents and consumed carbon from both atmospheric and marine radiocarbon reservoirs, it was necessary to combine the atmospheric (IntCal13) and marine (Marine13) calibration curves during the data calibration. The percentage of marine carbon incorporated into human bone collagen was calculated using linear interpolation. The marine and terrestrial endpoints were determined by taking an average of the $\delta^{13}C$ values of all marine (-14.2‰) and terrestrial (-19.8‰) animals sampled in this study and adding +1‰ to account for isotopic fractionation between prey and consumer bone collagen (after Raghavan et al. 2014). After correction for fractionation, the marine and terrestrial endpoints were -13.2‰ and

-18.8‰, respectively. Then, using the equation from section 3.5.2 (p. 71), the percent marine carbon was calculated for each radiocarbon sample by inputting the $\delta^{13}C$ measurement provided by the TERRA facility.

5.4.3 Radiocarbon calibration

The radiocarbon dates were calibrated using the web-based program OxCal version 4.2 (Bronk Ramsey 2009). The dates were calibrated against the northern hemisphere atmospheric curve, Intcal13 (Reimer et al. 2013) and the marine calibration curve, Marine13 (Reimer et al. 2013). The percentage of each was determined by inputting the percentage of marine carbon with an uncertainty of 10% to account for isotopic variability within the marine and terrestrial environment. The ΔR was selected using the online 14CHRONO Marine Reservoir Database. In the eastern Arctic and Subarctic, the ΔR varies significantly between the Canadian Arctic Archipelago (335 ± 85 years), the southeast of Baffin Island (150 ± 60 years), the Hudson Strait (65 ± 60 years), and Ungava Bay (145 ± 95 years) (Coulthard et al. 2010). Raghavan and colleagues (2014) applied a ΔR correction of 140 ± 50 years to ^{14}C dates from the bone collagen of Palaeoeskimo seal hunters. This ΔR is an average of offsets from the Ungava Bay – Labrador Sea region and was applied to the dates obtained from Amerindian bone collagen in this study. This ΔR may not be representative of the variation around the province, especially in the region of the Bay of Exploits due to the influx of freshwater from the Exploits River, however, there are currently no ΔR measurements for this region (McNeely et al. 2006).

5.5 Carbon isotope analysis of enamel carbonate

Eleven enamel samples were taken from Recent Indian and Beothuk individuals to determine whole dietary carbon. The following section details the chemical pretreatment applied to the enamel powders, and the analysis of carbon isotopes via mass spectrometry.

5.6.1 Sample preparation and pretreatment

Core enamel samples were removed from 11 premolars and second molars, mechanically separated from adhering dentine using an acid-cleaned tungsten carbide burr, and the enamel was ultrasonicated in DI H_2O. Dried enamel samples of approximately 10 to 15mg were ground in an agate mortar and pestle and weighed into clean 2ml microcentrifuge tubes. The enamel powder was pre-treated following the methodology detailed in Lee Thorp (n.d.), without the acetic acid step. To remove organic contaminants, 1.7% sodium hypochlorite was added to each tube and agitated for approximately 20 minutes at room temperature. The samples were then centrifuged at 10,500 rpm for 10 minutes. The supernatant was carefully pipetted out of each tube, leaving each sample suspended in approximately 250μL of solution to conserve the original sample size. Each sample was rinsed five times with deionized water and centrifuged after each rinse to remove any lingering sodium hypochlorite. Following the final rinse, the samples were covered with perforated parafilm and dried for 48 hours at 30°C.

5.5.2 Analysis via GasBenchII

Approximately 3-7mg of each carbonate sample were weighed into acid-cleaned, screw-top 15ml glass vials at the CREAIT network TERRA facility under the supervision of Alison Pye. Carbon and oxygen stable isotope ratios were measured using a Thermo Electron GasBench II coupled via ConFlo III to a Thermo Scientific Delta V Plus mass spectrometer. The samples were placed on a heated block and flushed with helium at 50℃. Heated phosphoric acid (99%) was manually injected into each sample and the resultant carbon dioxide and water vapour were carried on a stream of helium gas through hygroscopic Nafion tubing, separated on a GC column and the CO_2 was carried to the isotope ratio mass spectrometer. The $\delta^{13}C$ values were referenced to the V-PDB scale using the IAEA primary standard NBS-19 ($\delta^{13}C_{VPDB}$ = 1.95‰), and an in house standard MUN-CO-2 ($\delta^{13}C_{VPDB}$ = -40.11 ± 0.15‰). A third in house standard, CBM ($\delta^{13}C_{VPDB}$ = -0.75 ± 0.06‰) was used for quality control. Precision on CBM (n = 5) was 0.08‰ for carbon and 0.05‰ for oxygen.

5.6 Statistical Analysis

5.6.1 Descriptive statistics

The isotope data was analysed using IBM SPSS Statistics v.21. All isotope data sets were first evaluated using exploratory, descriptive statistics. These consisted of checks for normality, skewness, and outlier tests, in addition to calculation of the mean, median, standard deviation and variance. Outlier analysis was conducted using Tukey’s boxplot method and the interquartile range (IQR), which identifies minor and major outliers. Minor outliers are those data points that are greater than 1.5 × IQR, and major outliers are greater than 3 × IQR. The Shapiro-Wilk test, which uses the W statistic, was used to determine whether or not a dataset was normally distributed.

5.6.2 Comparative and inferential statistics

Two methods were used to explore diachronic variation in the diets of those buried at Port au Choix-3. First, the isotope values from Loci I, V, and Harp's Burial were combined and compared using a Mann Whitney U test (for carbon) and T-test (for nitrogen). Second, as Pearson's correlation is sensitive to outliers, Spearman's Rho was used to determine if dietary change correlated with time by comparing the median calibrated radiocarbon dates from each locus with the corresponding isotope values. Further intra-population variation within the Port au Choix-3 sample relating to sex was investigated using Welch's *T* tests for both carbon and nitrogen. The isotope data were not normally distributed, thus violating one of the assumptions of *T* test, however, when the size of each sample is similar and inequality of variance is demonstrated, the *T* test has been shown to outperform non-parametric equivalents (Zimmerman 1987). Finally, differences between Port au Choix-3 burial clusters were investigated using the non-parametric Kruskal Wallis test. The Recent Indian/Beothuk sample was deemed to be too small to analyze statistically, however, the correlation between δ^{13}Ccoll and δ^{13}Ccarb was investigated using the Pearson correlation test.

5.6.3 Cluster analysis

The Port au Choix-3 humans and the faunal δ^{13}C and δ^{15}N values were analysed using hierarchical agglomerative cluster analysis and k-means cluster analysis to determine if isotopically distinct groups existed that may have dietary relevance. The faunal data were first analysed by hierarchical cluster analysis using two common measures of cluster distance: Ward's method of minimum variance, and between-groups-linkage (BGL). Both methods were used with squared Euclidean distance as a measure of similarity. Ward’s method fuses clusters based on the error sum-of-squares criterion, while BGL utilises the average distance between pairs of data points (Everitt 2011). BGL is relatively insensitive to cluster size and the presence of outliers, while Ward’s method, used more commonly in isotope studies (e.g. Davenport and Bax 2005), is sensitive to cluster size and outliers and tends to form spherical clusters (Everitt 2011). The resulting clusters were then assessed through visual analysis of vertical dendrograms and scree plots of coefficients (Kurle and Worthy 2002; Yim et al. 2015). The data were then reanalysed, after Froehle et al. (2012) using k-means cluster analysis to determine if the same cases were assigned to clusters by each type of analysis.

The Port au Choix-3 samples were similarly analysed, however, the hierarchical clustering methods did not produce clusters that were interpretable from a dietary perspective. The data were then reanalysed using K-means clustering, with two to 12 clusters. The validity of the number of clusters was estimated using the ‘elbow method’. The elbow method plots the number of clusters against the sum of squared errors (SSE) within each group in a scree plot (e.g. Valentine et al. 2015). The elbow in the plot marks the number of clusters with a low SSE, while retaining a meaningful number of clusters.

CHAPTER 6: RESULTS

This chapter presents the results of the biochemical analyses conducted on human and faunal skeletal remains from Newfoundland. The roles played by different prey animals in Beothuk and Maritime Archaic subsistence were estimated by comparing the human data to a set of stable isotope measurements made on the bone collagen of fauna from Newfoundland archeological sites. This had a further effect of allowing more accurate radiocarbon calibrations of human bone collagen dates to be made, as it enabled the contribution of carbon from the marine radiocarbon reservoir to human tissues to be quantified.

As expected, the analysis of terrestrial and marine animal bone collagen revealed distinct differences in the isotopic values of these species that corresponded to the different habitats and feeding ecology of these species. Small differences were observed in the $\delta^{13}C$ and $\delta^{15}N$ values of the seals, fish and seabirds, but the breadth of these differences may not enable the species to be distinguished isotopically. It was also possible to distinguish animals that fed in the benthic marine environment from those who inhabited pelagic environments.

Radiocarbon dates were obtained from the collagen of 17 individuals from Port au Choix-3. These produced a range of dates from 2876 cal B.C. to 1740 cal B.C. Harp’s burial, and Loci I and V produced the oldest dates, and Locus II the youngest, contrary to previous research (Tuck 1976a). Stable carbon and nitrogen isotope analysis was conducted on the bone collagen of 70 individuals. The results differed significantly from those of previous isotope research on this burial population. No statistically significant differences in the $\delta^{13}C$ or $\delta^{15}N$ values were found between burial clusters, nor were diachronic trends apparent in the consumption of marine food over the total history of the cemetery (based on human radiocarbon dates). A slight positive correlation was observed between the radiocarbon age and corresponding δ^{13}C value of the individuals of Locus II, suggesting some temporal variation in the consumption of marine taxa. While the range of isotopic values measured in the population indicated that the average person consumed predominantly marine protein, the variation around the average value suggested the presence of multiple subsistence strategies, all featuring marine protein, but to variable extents. Statistically significant differences were observed in the δ^{13}C values of adult males and females. However, the δ^{13}C values of newborns and infants suggest that the adult females buried at Port au Choix-3 may not be representative of all of the females in the greater population.

As the archaeological context of the Recent Indian mortuary sites was disturbed, every human skeleton was radiocarbon dated. The radiocarbon dates ranged from 585 cal A.D. to 1847 cal A.D. Twenty-six of the 27 skeletons dated to the historic period. The δ^{13}C and δ^{15}N values of the single pre-European contact skeleton were lower than those of the Maritime Archaic people and indicated a diet composed of both marine and terrestrial protein. Many of the 17th and 18th century skeletons produced similar results and provided evidence for the generalized marine adaptation diet suggested by the archaeological record (e.g. Holly 2014). The lowest δ^{13}C and δ^{15}N values were measured in the Beothuk skeletons that dated to the 19th century. The results indicated that the individuals recovered from the sites of Ladle Point and Charles' Arm consumed more terrestrial protein than any of the other individuals measured in this study. Thanks to archaeological and ethnohistoric research, it is now generally accepted that the Beothuk visited the coast with less frequency during the 19th century than during the previous centuries, altering their subsistence practices so that they relied more heavily on terrestrial resources (Holly 2008; Marshall 1996). The results of this study provide biological support for this, while still providing evidence for some limited consumption of marine foods.

The detailed results are presented as summary statistics, with the range presented first followed by the mean and standard deviation. When the data are plotted as mean values, the results are presented to two standard deviations if $n \geq 3$. Tables of the complete stable isotope datasets can be found in Appendix 2. The complete faunal dataset can be found in Table A.2.a. The Port au Choix-3 $\delta^{13}C$ and $\delta^{15}N$ results are presented in Table A.2.b. The results of bone collagen and enamel carbonate analysis of Recent Indian and Beothuk individuals are presented in Table A.2.c. The radiocarbon dates are presented in Appendix 3. The details of the statistical analyses, and complete summary statistics can be found in Appendix 4. The stable isotope results of the standards run concurrently with the collagen and enamel samples can be found in Appendix 5.

6.1 Collagen preservation

This section reports on the preservation of the faunal and human bone collagen analysed in this study. As a reminder, well preserved collagen should have a C:N ratio between 2.9 and 3.6, the concentration of carbon should fall between 15% and 47%, and the concentration of nitrogen between 5% and 17% (Ambrose 1990; van Klinken 1999).

6.1.1 Faunal bone samples

The preservation of faunal bone collagen was variable across and within sites with conditions at Boyd’s Cove (DiAp-3) producing the poorest preservation and Crow Head

Cave (EeBi-4) the best. Three samples (marc 3163, 3164, 3170) yielded no collagen, and one sample (marc 3181) produced a C:N value of 4.8 and concentrations of carbon and nitrogen of 9.3% and 2.2%, respectively. One sample from the Beaches site (DeAk-1) did not yield a measurable amount of collagen, and a second sample (marc 3190) analysed in duplicate produced divergent C:N values (3.4 and 3.7), carbon concentrations (35.2% and 38.7%) and δ^{13}C values (-18.0‰ and -19.8‰), while %N and δ^{15}N values remained within analytical error. A caribou molar (marc 3214) from Indian Point (DeBd-1) analysed in duplicate produced very different collagen quality indicators, and stable isotope values, however the C:N ratios from both analyses were consistent at 3.3. The first analysis of this sample produced carbon and nitrogen concentrations of 84.2% and 30.2%, respectively, while the second analysis produced values of 44.6% and 16.0%, respectively. The first δ^{13}C and δ^{15}N values were -16.7‰ and 8.9‰, respectively, and from the second analysis, -18.3‰ and 3.3‰, respectively. The divergent values result from analytical error, as the gelatinization and filtration steps should function to homogenise the collagen sample, thereby reducing the possibility of obtaining such variable data.

The mean differences between isotope values from five duplicate analyses of faunal collagen were 0.8 ± 0.8‰ for carbon, and 1.9 ± 2.3‰ for nitrogen. These values are in excess of the analytical error for each run. The values were calculated with the inclusion of two samples with poor preservation quality indicators. If these samples are excluded, the δ^{13}C duplicates range from 0.0‰ to 0.7‰ with a mean and standard deviation of 0.3 ± 0.4‰, which is acceptable, as it is consistent with analytical error. After the samples with anomalous preservation were excluded, the δ^{15}N values of duplicates range from 0.3‰ to 2.8‰ with a mean of 1.2 ± 1.4‰. The mean difference exceeds analytical error and is clearly due to the inclusion of sample of seal bone (marc 3205) from Parke's Beach, which has $\delta^{15}N$ values that differ by 2.8‰. The preservation indicators of this sample are acceptable (C:N = 3.3, 3.3; %C = 37.5, 38.2; %N = 13.2, 13.4). The samples were run on different days, therefore it seems likely that the difference could be due to an analytical issue. Samples with divergent duplicate results were excluded from further analysis as it is not clear which, if either, value is accurate.

6.1.2 Port au Choix-3 human bone samples

Despite the age of the burial ground, the preservation of the skeletal remains from Port au Choix-3 was generally good. Collagen yields ranged from 0.7% to 25%. Since ultrafilters were employed for some of the samples, collagen yields are not a useful indicator of preservation. For example, NP 14B (marc 3254) had a collagen yield of 1.6%, but the %C (41.4%), %N (14.2%) and the C:N ratio (3.4) were within the bounds of the acceptable range stated by van Klinken (1999), DeNiro (1985), and Ambrose (1990). The concentration of carbon ranged from 38.1% to 47.4% (mean 44.2 ± 2.1%) and the concentration of nitrogen ranged from 11.4% to 16.9% (mean 15.3 ± 1.1%). The two samples with the lowest concentration of carbon and nitrogen also happened to have C:N ratios that exceeded 3.6. The C:N ratios ranged from 3.2 to 4.2 (mean 3.4 ± 0.2). Seven samples had C:N ratios exceeding 3.6.

Of the 85 individuals sampled, six samples were re-extracted and processed with sodium hydroxide and ultrafiltration following poor collagen yields and C:N ratios. A comparison of the original and re-extracted samples can be found in Table A.2.b. In the case of re-extracted samples, the original sample had a lower $\delta^{13}C$ value than the re-extracted sample. This suggests that the addition of a sodium hydroxide treatment and ultrafiltration had the effect of removing base-soluble contaminants that were probably humic in origin. Furthermore, the sodium hydroxide seems to have had a greater effect, as five of the original samples were also ultrafiltered. The four duplicate analyses of the human samples were more consistent than those of the faunal samples. The greatest difference observed occurred between $\delta^{13}C$ values of marc 2739 which differed by 0.9‰. The three other duplicates differed by at most 0.2‰ for carbon and 0.2‰ for nitrogen.

6.1.3 Recent Indian and Beothuk human bone samples

The Recent Indian samples were reasonably well preserved. Collagen yields ranged from 6.7% to 24.2% (mean 11.6 ± 5.4%). Carbon and nitrogen concentrations ranged from 43.4% to 47.6% (mean 45.9 ± 1.2%) and 15.7% to 17.5% (mean 16.6 ± .5%), respectively. C:N ratios ranged from 3.2 to 3.3 (mean 3.2 ± 0.04). The final run of Recent Indian samples consisted of the samples from the Canadian Museum of History. These consistently had higher elemental nitrogen concentrations, ranging from16.1% to 17.5%. These fall at the upper end of the range (5% to 17.3%) reported by Ambrose (1990) for modern bone samples, and exceed the range (11% to 16%) reported by van Klinken (1999) for archaeological samples. van Klinken (1999) argued that high elemental concentrations were indications of the addition of organic carbon and nitrogen in the burial environment or during the extraction process. A comparison of the data obtained from processing at the MAAS lab and data from the UCIAMS lab on the same samples indicates that whatever caused the difference in the elemental concentration data did not simultaneously affect the stable isotope values.

6.2 Newfoundland isotope ecology

The stable isotope values of human bone collagen and bioapatite are in themselves informative, especially if prior archaeological data about the diet of the population under study is available. Previous isotopic studies of Newfoundland's indigenous populations have interpreted human stable isotope values by drawing on published faunal datasets from other parts of the world (e.g. Kuch et al. 2007), and on ethnographic evidence from living populations (e.g. Jelsma 2000). Such approaches identify the consumption of marine food versus terrestrial food through comparison with observed patterns among other archaeological and modern datasets, however, in order to create a more accurate palaeodietary reconstruction, it is important to compare the human data to an isotopic baseline that has been developed from local archaeological fauna (Schwarcz and Schoeninger 1991). This is the approach taken by this thesis. The following section reports the results of δ^{13}C and δ^{15}N analysis conducted on the bone collagen of archaeological animals from Newfoundland. To reconstruct human diet, the human data (section 6.4 and 6.6) were situated relative to the faunal data in isotopic space using hierarchical and k-means cluster analyses, and the expected trophic level offsets for δ^{15}N (+3 to 5‰) and δ^{13}C (+1‰) values (McCutchan et al. 2003).

6.2.1 Terrestrial environment

Animals from the terrestrial environment produced the most variable stable isotope values. The δ^{13}C values ranged from -9.9‰ to -22.9‰ (mean -19.1 ± 3.2‰), and the δ^{15}N values from 0.5‰ to 19.8‰ (mean 6.3 ± 5.8‰). This variability is due to the inclusion of animals with allochthonous sources of carbon and nitrogen. For example, the two polar bear specimens have high δ^{13}C and δ^{15}N values indicating that their source of dietary protein was obtained from marine animals. This consistent with data and observations of modern polar bears (e.g. Cherry et al. 2011). The other two animals with high δ^{13}C and δ^{15}N values relative to other terrestrial species are the fox from the Beaches (marc 3195), one of the pine martens (marc 3167) from Boyd's Cove, and two beaver specimens, one from Boyd's Cove (marc 3175) and the other from Beaches (3187). Red and Arctic foxes have been observed hunting seabirds and consuming their eggs, both in Newfoundland and at higher latitudes (Angerbjorn et al. 1993; Sklepkovych and Montevecchi 1996) and thus the stable isotope values from the Beaches fox come as no surprise.

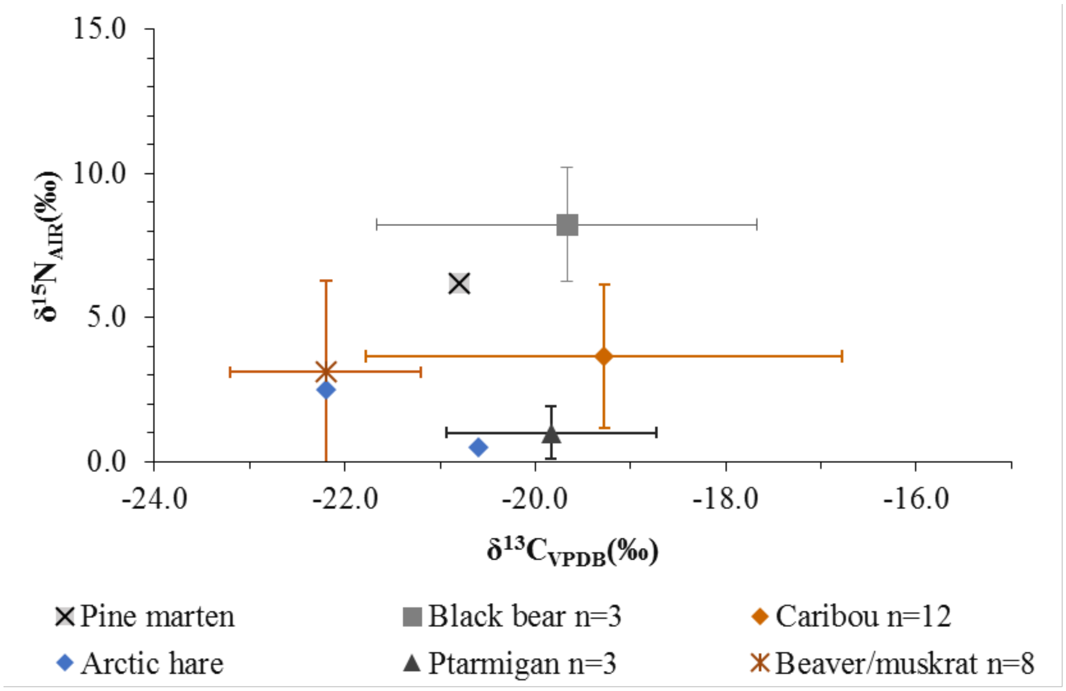

Figure 6.1 The δ^{13}C and δ^{15}N values of terrestrial species.

The pine marten and beaver specimen data are harder to interpret. In the case of the pine marten and beaver from Boyd's Cove, it is possible that the bones were misidentified and may in fact belong to an otter, or small seal, in which case the carbon and nitrogen isotope values would be consistent with the feeding behaviours of those species (Cote et al. 2008; Lawson et al. 2000). The bone sample from the Beaches beaver was taken from what is clearly a beaver mandible. Given the isotopic variability attributed to analytical issues in subsection 6.1.1, it is possible that this sample was influenced by similar problems during analysis and was removed from further analysis.When the samples containing marine carbon and nitrogen are removed, the terrestrial samples (Fig. 6.1), have δ^{13}C values ranging from -22.9‰ to -17.8‰ (mean -19.9 ± 1.5‰), and δ^{15}N values ranging from 0.5‰ to 10.3‰ (mean 4.3 ± 2.6‰). This range of values is consistent with measurements taken from similar species in Newfoundland (Guiry et al. 2012), Labrador (Britton 2007; Harris 2014), and Greenland (Nelson et al. 2012). It is perhaps notable that caribou and beaver have quite different δ^{13}C values. This difference is unlikely to be measurable in human bone collagen, unless an individual demonstrated a preference for one species over the other. The general trend among the terrestrial animals indicates that if the Beothuk or Maritime Archaic were consuming a diet composed predominantly of terrestrial protein, this would be registered within their bone collagen as δ^{13}C values lower than -17‰, assuming a +0.5 to 1‰ trophic shift (Bocherens and Drucker 2003; McCutchan et al. 2003). It is unlikely, however, based on the species composition of archaeological faunal assemblages and site distribution that this would be the case.

6.2.2 Marine environment

Seal, seabirds, and cod were included together as animals representing the marine environment (Fig. 6.2). Stable carbon isotope values ranged from -17.9‰ to -12.5‰ (mean -15.5 ± 1.3‰), and nitrogen isotope values from 11.5‰ to 19.8‰ (mean 15.4 ±

1.7‰). The seal group included animals identified through zooarchaeological methods as harp, harbour and grey seal, as well as those animals that could only be identified as *Phocidae*. The $\delta^{13}C$ values of the seals ranged from -12.5‰ to -15.7‰ (mean -14.5 ± 0.9‰), and the $\delta^{15}N$ values ranged from 13.4‰ to 19.8‰ (mean 16.0 ± 1.4‰). The broad range of measured isotope values may be attributable to inter-specific, or age-specific food preferences. Nelson et al. (2012) found an equally broad range of $\delta^{13}C$ and $\delta^{15}N$ values in a sample of 67 harp, harbour, ringed and bearded seals recovered from Inuit and Norse sites in Greenland. The $\delta^{13}C$ values of the Greenland seals ranged from -12.1‰ to -16.1‰, and the $\delta^{15}N$ values ranged from 9.9‰ to 18.0‰. In a sample of 59 modern harp seal, caught off the coast of Newfoundland, Lawson and Hobson (2000) found statistically significant differences between the $\delta^{15}N$ values of subadults and adults. These comparative datasets suggest the range of values observed in the archaeological seals is to be expected.

The seabird group numbered 23 and included dovekies, gulls, murres, common puffins, great auks, and guillemots. The seabird $\delta^{13}C$ values ranged from -14.3‰ to -17.9‰ (mean -16.4 ± .8‰), and the $\delta^{15}N$ values ranged from 11.5‰ to 18.0‰ (mean 14.9 ± 1.8‰). The range in $\delta^{15}N$ values can be traced to trophic level. Murres were found to have the highest $\delta^{15}N$ values, followed by dovekies, great auks, and puffins. These findings are consistent with published ecological literature and relate to the feeding behaviours of different seabird species (Hobson et al. 2002). Dovekies and puffins consume copepods and zooplankton, while murres are piscivorous (fish eaters) (Hobson and Montevecchi 1991). This thesis reports the lowest $\delta^{15}N$ value (11.8‰) recorded for the extinct great auk (Hobson and Montevecchi 1991). The $\delta^{15}N$ values for this species now range from 11.8‰ to 19.7‰, with the breadth of values likely attributable to age-specific feeding behaviours (Hobson and Montevecchi 1991).

Three codfish are included with the marine group, and each specimen was recovered from the Crow Head Cave faunal assemblage. The δ^{13}C values ranged from -13.9‰ to -16.1‰ (mean -14.8 ± 1.2‰), and the δ^{15}N values ranged from 14.2‰ to 16.7‰ (mean 15.3 ± 1.3‰). These values are consistent with those of archaeological specimens recovered from historic Newfoundland fishing sites (Guiry et al. 2012).

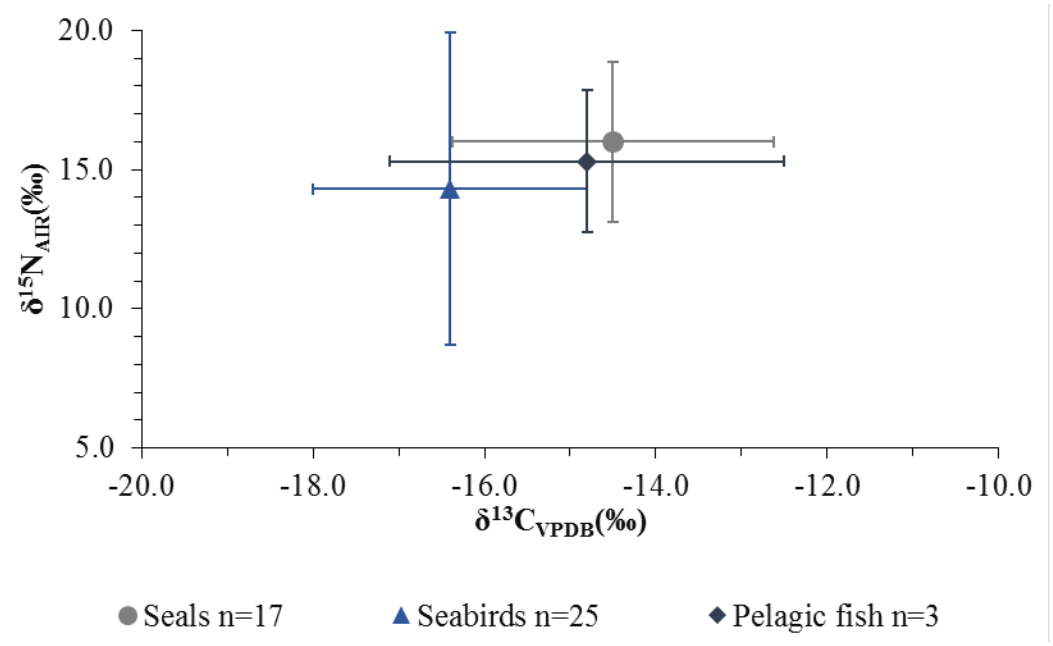

Figure 6.2 The δ^{13}C and δ^{15}N values of seals, seabirds, and pelagic fish.

There is considerable overlap in the δ^{13}C and δ^{15}N values of the seals, seabirds and codfish, however, as expected, all can be distinguished from terrestrial fauna. The average seal δ^{13}C and δ^{15}N values are higher than seabirds which should enable the identification of humans who consume predominantly seal, but the role of seabirds in human diet may be more difficult to identify if working solely from the stable isotope values in human and animal bone collagen. Based on the isotope values of the animals, a human diet composed of large amounts of seabird may be indistinguishable from a mixed marine-terrestrial diet.

6.2.3 Estuarine and nearshore environments

Animals inhabiting the estuarine and nearshore environments had $\delta^{13}C$ values ranging from -16.7‰ to -8.4‰ (mean -11.7 ± 2.7‰) and $\delta^{15}N$ values ranging from 6.6‰ to 18.7‰ (mean 13.8 ± 3.3‰) (Fig.6.3). This group is characterized by higher $\delta^{13}C$ values relative to the marine group. The group includes otters, shallow water fish, such as sculpin, and birds that can inhabit a range of marshy or shallow water environments, such as Canada geese and cormorants.

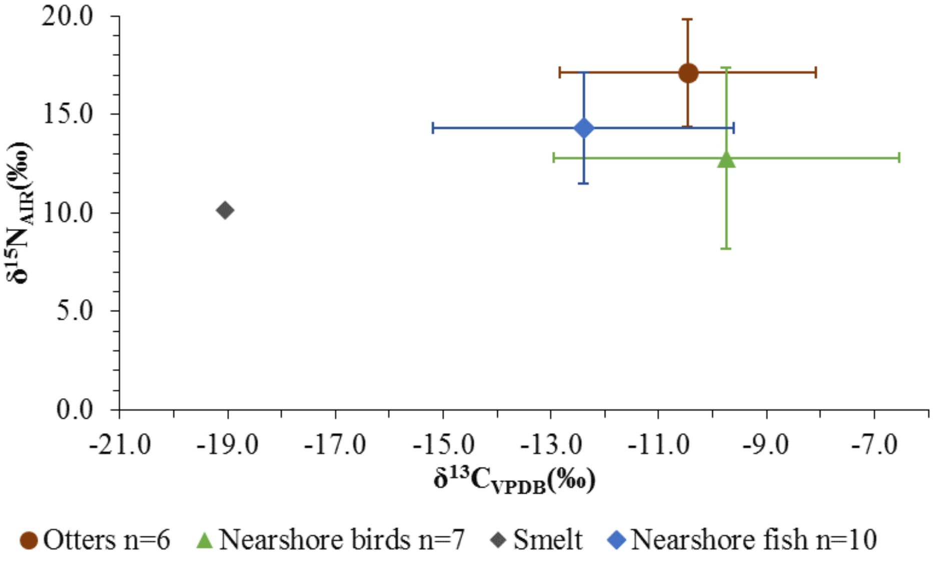

Figure 6.3 $\delta^{13}C$ and $\delta^{15}N$ values of species inhabiting nearshore and estuarine environments.

A study of otters in Bonavista and Placentia Bays reported that otters preyed on sculpin, cunners, flounder and occasionally cod, and selected larger individuals within those taxa (Cote et al. 2008). This study found a mean $\delta^{13}C$ value of -10.5 ± 1.2‰ from otter bone collagen, which is higher than the mean $\delta^{13}C$ of -12.4 ± 1.7‰ of the shallow water fish. This is a slightly higher than the average trophic shift in carbon values, but is likely consistent with a predator-prey isotopic relationship (McCutchan et al. 2003). It is difficult to interpret the isotope values of the nearshore birds as this group includes migratory species that may have incorporated nitrogen and carbon into their collagen from the entirety of their migratory range (Hobson 1999). Duplicate measurement of the single smelt specimen from Boyd's Cove produced a low $\delta^{13}C$ value of -19.1‰ and $\delta^{15}N$ value of 10.2‰. These values appear to be consistent with those of freshwater fish reported elsewhere (Schoeninger and DeNiro 1984).

6.2.4 Cluster analysis

The aquatic faunal isotope data were analysed using hierarchical and K-means cluster analysis. The clusters produced using between-groups linkage and Ward's method of minimum variance were compared to those produced using K-means clustering. Ward's Method assigned cases to two clusters. K-means analysis with two clusters assigned 68 of 72 cases to the same clusters as Ward's Method. Between-group linkage assigned cases to three clusters. K-means analysis with three pre-assigned clusters assigned 57 cases to the same three clusters as the between-groups linkage method. Due to the better agreement of the cases assigned by Ward's method and k-means using two clusters, two clusters of aquatic fauna, shown with terrestrial fauna in Figure 6.4, were used in subsequent analyses and interpretation of the human collagen data. The samples included in marine clusters 1 and 2 can be found in Appendix 5. Marine cluster 1 includes all of the otters from Boyd's Cove and Beaches, most of the shallow water fish, scoters, eider ducks from Crow Head Cave, and Boyd's Cove, and the tuna from Peat Garden North. The δ^{13}C centroid is -10.7‰, and the δ^{15}N centroid is 14.8‰. The inclusion of the tuna from Peat Garden North is based purely on the isotopic values of the specimen and in this case, does not reflect the habitat of the animal. Marine cluster 2 includes all of the seals from every site, the dovekies and murres from Crow Head Cave and Boyd's Cove. The δ^{13}C centroid is -15.5‰, and the δ^{15}N centroid is 15.5‰. With the exception of the tuna, clustering the data effectively divided the samples between nearshore species (Marine cluster 1) and offshore species (Marine cluster 2) which should enable hypotheses relating to site distribution and diet to be tested through palaeodietary modeling.

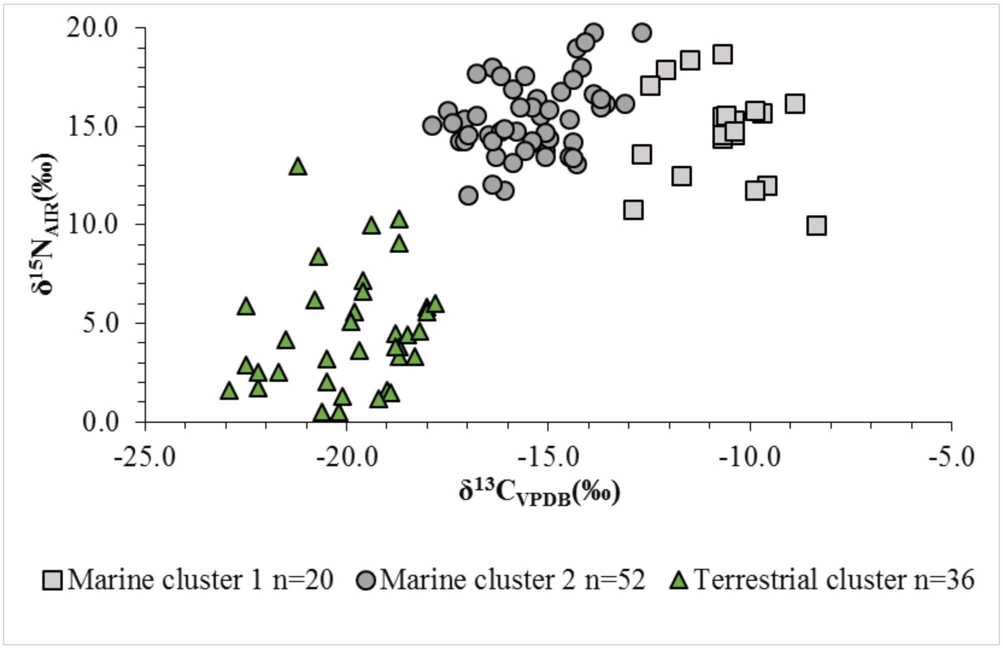

Figure 6.4 Results of cluster analysis of marine data. Terrestrial cluster is composed of all terrestrial animals.

6.3 Human radiocarbon dates from Port au Choix-3

The radiocarbon dates are first presented uncalibrated, by locus, followed by the estimated percent marine carbon contribution, and calibrated date ranges (see also Table 6.1). Seventeen new radiocarbon dates were obtained from Locus II. When these are added to the nine previously obtained by Jelsma, the uncalibrated dates range from 3985 ± 15 B.P. to 4335 ± 20 B.P. Seven radiocarbon dates were obtained from Locus I and these ranged from 4355 ± 20 B.P. to 4460 ± 20 B.P. Four radiocarbon dates were obtained from Locus V, including a date from NP 171, the infant that potentially suffered from histiocytosis X (Kennedy 1989). The dates ranged from 4345 ± 15 B.P. to 4485 ± 30 B.P. NP 171 dated to 4450 ± 15 B.P., potentially making this the oldest known case of histiocytosis X in North America (Colombo et al. 2015). Finally, one date was obtained from the set of burials designated “Harp’s Burials”. NP 277 was dated to 4365 ± 25 B.P. Tuck had originally estimated that Locus I was younger than Locus II, but the dates obtained directly from human skeletons have revealed that Loci I, V, and Harp’s burials all predate Locus II, the largest of the burial loci at Port au Choix-3.

In Locus II, the percentage of marine carbon calculated using linear interpolation ranged from 50% for NP 35A to greater than 100% for NP 49A, with a mean percent marine carbon of 83 ± 13%. This means that the radiocarbon ages reflect the contribution of older marine-derived carbon that was incorporated into human bone collagen via the consumption of marine protein, such as by eating seal or fish. When the percent of marine carbon was incorporated into the calibration, the calibrated median dates ranged from 4348 - 3905 cal B.P. (mean 4080 ± 116 cal B.P.), or from 2399 - 1956 cal B.C. (mean 2131 ± 116 cal B.C.).

Table 6.1 Raw and calibrated ^{14}C dates from Port au Choix-3 (human bone only).

Lab No.	**NP No.**	**Locus**	**^{14}C age (±yrs B.P.)**	**cal B.P. (2σ)**	**cal. B.C (2σ)**
UCIAMS 159453	277	Harp’s burial	4365 (25)	4825 - 4450	2876 - 2501
UCIAMS 159455	286	V	4485 (30)	4800 - 4398	2851- 2449
UCIAMS 125916	164	V	4405 (20)	4789 - 4395	2840 - 2446
UCIAMS	60I	I	4435 (20)	4778 - 4283	2829 - 2334
UCIAMS 125918	60A	I	4430 (20	4775 - 4284	2829 – 2335
UCIAMS	60C	I	4460 (20)	4775 - 4272	2826 – 2323
UCIAMS 154053	162C	V	4420 (15)	4699 - 4266	2750 - 2317
UCIAMS 154062	171	V	4450 (15)	4778 - 4292	2840 – 2446
UCIAMS 154070	162A	V	4345 (15)	4612 - 4235	2663 – 2286
UCIAMS 125920	61B	I	4355 (20)	4628 - 4231	2679 – 2282
UCIAMS 125917	60D	I	4420 (20)	4645 - 4210	2696 – 2261
UCIAMS 125921	61A	I	4365 (20)	4611 - 4211	2662 - 2262
UCIAMS 125922	60B	I	4360 (20)	4605 - 4205	2656 - 2256
UCIAMS 167195	285	V	4385 (20)	4553 - 4141	2604 - 2192
UCIAMS 167193	46A	II	4335 (20)	4526 - 4145	2577 - 2196
GrA-6527*	35A	II	4110 (50)	4510 - 4091	2561 - 2142
GrA-6478*	1B	II	4220 (50)	4504 - 4065	2555 - 2116
UCIAMS 159449	31	II	4050 (25)	4400 - 4000	2451 - 2051
GrA-6479*	12	II	4160 (50)	4409 - 3963	2460 - 2014
UCIAMS 159447	50B	II	4175 (25)	4378 - 3960	2429 - 2011
UCIAMS 167194	44B	II	4110 (15)	4348 - 3954	2399-2005
UCIAMS 159441	10A	II	4135 (25)	4343 - 3929	2394 - 1974

Continued

Table 6.1 continued

UCIAMS 167190	3	II	4085 (15)	4285 - 3909	2336 - 1960
UCIAMS 159440	8A	II	4105 (25)	4293 - 3890	2344 - 1941
GrA-6501*	30C	II	4130 (50)	4340 - 3864	2391 - 1915
GrA-6495*	36A	II	4150 (50)	4339 - 3855	2390 - 1906
GrA-6496*	40A	II	4000 (50)	4291 - 3857	2342 - 1908
GrA-6526*	25	II	4150 (50)	4340 - 3864	2355 - 1868
UCIAMS 159448	50C	II	4170 (25)	4222 - 3884	2273 - 1935
UCIAMS 159445	49A	II	4165 (25)	4216 - 3879	2267 - 1930
UCIAMS 167196	6	II	4105 (25)	4233 - 3838	2284 - 1889
UCIAMS 159446	50A	II	4125 (25)	4238 - 3833	2289 - 1884
UCIAMS 167192	14A	II	4060 (15)	4211 - 3827	2262 - 1878
UCIAMS 159442	37A	II	4065 (25)	4213 - 3805	2264 - 1856
UCIAMS 159443	37B	II	4035 (30)	4174 - 3768	2225 - 1819
	47B	II	3995 (15)	4149 - 3802	2200 - 1853
UCIAMS 159444	47A	II	4045 (25)	4121 - 3705	2172 - 1756
GrA-6525*	18A	II	4000 (50)	4140 - 3689	2191 - 1740
UCIAMS 167189	9	II	3985 (15)	4085 - 3712	2136 - 1763

*Denotes data from Jelsma (2000: 191).

The percentage of marine carbon calculated from the Locus I samples ranged from 80% to 95% (mean 88 ± 5%). The calibrated median dates ranged 4490 - 4406 cal B.P. (mean 4450 ± 36 cal B.P.), or from 2541 - 2457 cal B.C. (mean 2501 ± 36 cal B.P.). The percentage of marine derived carbon in Locus V samples ranged from 75% to 98% (mean 88 ± 8%). The calibrated median dates ranged from 4571 - 4357 cal B.P. (mean 4479 ± 77 cal B.P.), or from 2622 - 2408 cal B.C. (mean 2530±77 cal B.C.). NP 277, one of Harp’s Burial, had one of the lowest calculated percentage marine carbon values of 52%, and the oldest calibrated median radiocarbon date of 4649 cal B.P. (4825 - 4450 cal B.P., 2σ), or 2700 cal B.C. (2851 - 2449 cal B.C., 2σ). The infant with bone lesions consistent with histiocytosis X was dated to 4497 cal B.P. (4778 - 4292 cal BP, 2σ), or 2548 cal B.C. (2840 - 2446 cal B.C., 2σ).The KCCAMS lab was unable to extract viable collagen from the bone sample submitted from Locus IV.

If the two-sigma confidence limits are considered, the burial ground may have been in use from 4825 - 3689 cal B.P. (2876 - 1740 cal B.C.) or just over 1000 years. If the median calibrated dates alone are considered, a shorter range of ~750 years is suggested. It is unfortunate that the bone sample from Locus IV could not be placed within the chronology as well. As the radiocarbon dates indicate contemporaneity between Loci I, V, and Harp’s Burial, these burials will be considered together in further discussion of Maritime Archaic diet.

6.4 Maritime Archaic diet

6.4.1 Diet and burial loci

The mean stable isotope data from each locus are plotted in Figure 6.5. The $\delta^{13}C$ values from the 10 individuals from Locus I ranged from -14.4‰ to -13.4‰ (mean -13.9 ± 0.2‰). The $\delta^{15}N$ values ranged from 19.3‰ to 21.4‰ (mean 20.1 ± 0.6‰). This indicates the consumption of high trophic level marine protein over terrestrial protein. Given the high $\delta^{13}C$ and $\delta^{15}N$ values measured in seal collagen relative to other marine species, seals were probably acquired and eaten more frequently than seabirds or fish by the people interred in Locus I, assuming a +3 to 5, assuming a +3 to 5‰ trophic shift (McCutchan et al. 2003).

The $\delta^{13}C$ values from 80 Locus II individuals ranged from -16.8‰ to -12.7‰, with a mean of -14.3 ± 0.8‰. The data were not normally distributed ($W = .956$, $df = 81$, $p < .05$) with six outliers identified by a Tukey's boxplot (Table 6.2).

Table 6.2 Locus II individuals with $\delta^{13}C$ and $\delta^{15}N$ values exceeding 1.5* the interquartile range. $\delta^{13}C$ is expressed relative to VPDB and $\delta^{15}N$ relative to AIR. Bolded isotope values are outliers. Includes data from Jelsma (2000: 286)

NP	Cluster	Sex	Age	$\delta^{13}C$(‰)	$\delta^{15}N$(‰)
5	A	Male	Young adult	-15.2	**17.5**
22D	B	Male	Old adult	**-15.9**	19.5
26	B	?	Infant	**-16.8**	19.6
31	C	Male	Middle adult	**-15.9**	**16.6**
33	C	?	Infant	-14.0	**24.2**
35B	C	?	Infant	**-15.9**	20.3
35A	C	Male	Adult	**-16.6**	**16.9**
40A	C	Male	Middle adult	-15.5	**17.5**
46D	C	?	Infant	**-15.7**	22.5
49A	C	Female	Adult	**-12.7**	21.0

The $\delta^{15}N$ values from Locus II range from 16.6‰ to 24.2‰ with a mean of 20.6 ± 1.5‰. The broader range of $\delta^{13}C$ and $\delta^{15}N$ values in Locus II indicates a greater diversity of diets than in Locus I. The 7.6‰ range in $\delta^{15}N$ can in part be explained by the presence of nursing infants in the locus. There are 23 infants or children below the age of six in Locus II and 15 of these have $\delta^{15}N$ values greater than one standard deviation above the adult female mean (20.4 ± .6‰) calculated from all of the females in the burial ground, indicating the strong possibility that these children were still breastfeeding, or had only recently begun the weaning process prior to death (Jay et al. 2008). The nitrogen isotope data from Locus II were normally distributed ($W = 0.980$, $df= 81$, $p > .05$). Five outliers were identified (Table 6.2) and, with the exception of the infant, whose sex is indeterminate, the individuals with outlying $\delta^{15}N$ values are all male.

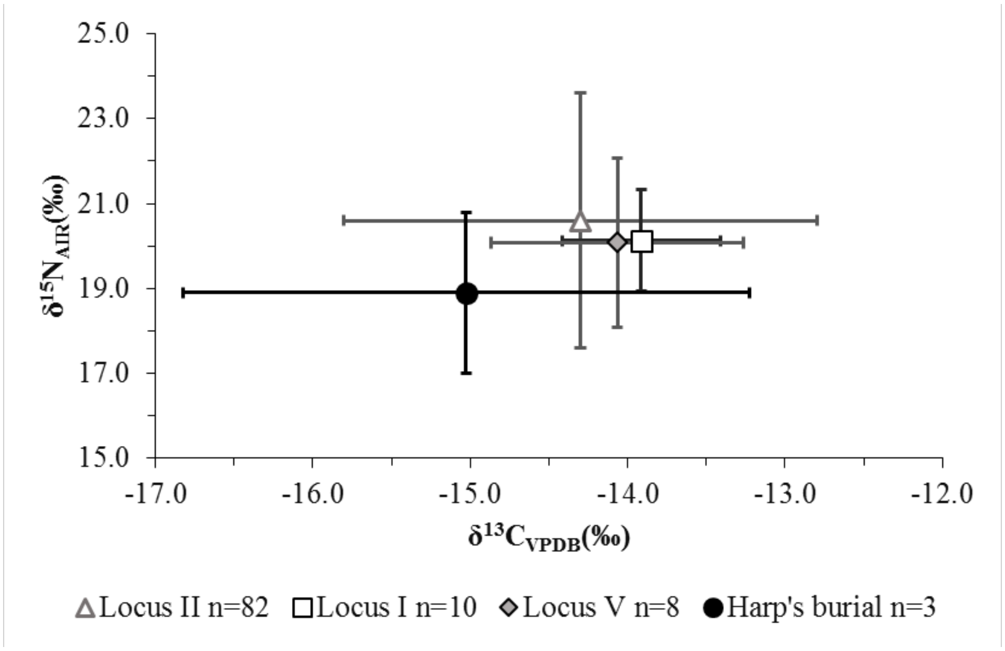

Figure 6.5 Mean δ^{13}C and δ^{15}N values from each Port au Choix-3 burial loci and Harp's burials. Values are presented to two standard deviations.

The δ^{13}C values of 8 individuals from Locus V ranged from -14.7‰ to -13.4‰ (mean -14.1 ± 0.4‰), and the δ^{15}N values ranged from 18.9‰ to 22.1‰ (mean 20.1 ± 1.0‰). The three individuals known as Harp's Burials had slightly lower δ^{13}C values, with a range of -16.0‰ to -14.2‰ (mean -15.0 ± 0.9‰). The δ^{15}N values ranged from 18.0 to 19.0‰ (mean 18.9 ± 1.0‰).

Jelsma (2000) proposed a diachronic shift in diet towards a greater consumption of marine food over the period of time represented by Locus II. For the purpose of investigating possible occurrences of dietary change over time, Loci I, V, and Harp's burials were combined and compared with Locus II. When combined, the carbon isotope values were not normally distributed ($W = 0.837$; $df = 21$; $p < .05$) and one major outlier was identified, NP 277. The nitrogen isotope values were normally distributed (W = 0.923; df = 21; $p > .05$), and two minor outliers were identified, NP 277 and NP 171.

The δ^{13}C values (Z = -0.900; df = 100; $p > .05$), and δ^{15}N values (T = -1.763; df = 100; $p > .05$) did not differ significantly between burial loci. Although there is a marked difference in sample size between the loci, the relative consistency in the diets of each group is supported by a comparison of radiocarbon dates and δ^{13}C and δ^{15}N values (Fig. 6.6, Fig. 6.7).

A statistically insignificant positive correlation (r = .15; $p > .05$) was observed between the radiocarbon dates and dietary isotope values indicating relative isotopic consistency over the approximately 700 to 1000 years that the cemetery was in use. A slight statistically significant positive correlation (R = 0.42; $p < .05$) was observed between the median calibrated radiocarbon dates of the adults in Locus II and the corresponding δ^{13}C values. A significant correlation of radiocarbon dates and δ^{15}N value was not observed, contrary to Jelsma's (2000) initial findings. At most, a slight variation in consumption of marine resources may be suggested by these results, but the overlap in the radiocarbon dates, and the contemporaneous presence of consumers of both marine and terrestrial protein argues against a diachronic trend. Therefore in further analyses of patterning in the cemetery with respect to sex or age will consider all burial loci together.

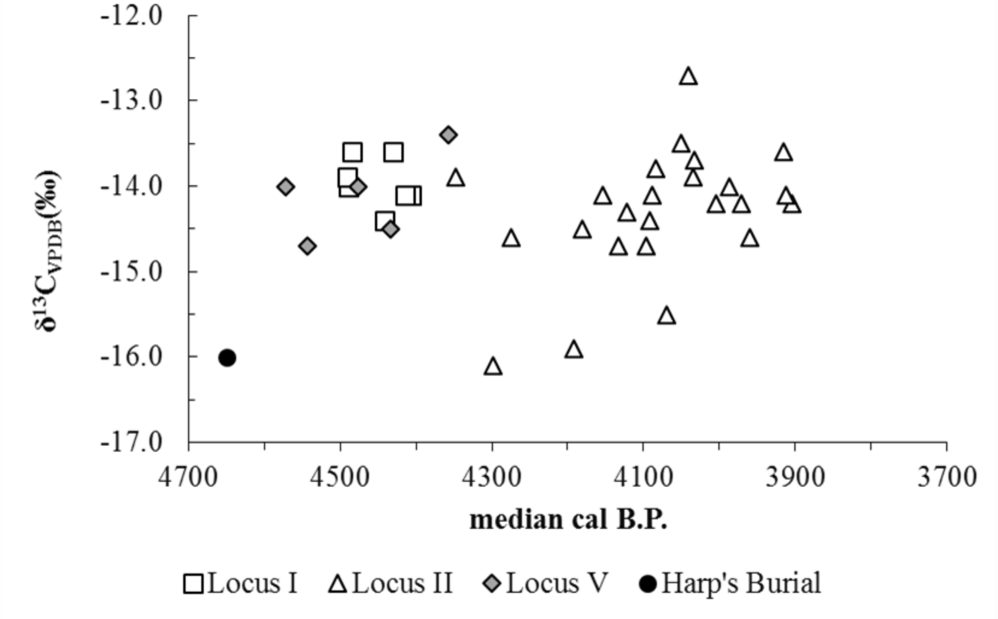

Figure 6.6 Median calibrated radiocarbon dates from the adults in each burial locus plotted against the δ^{13}C values. Includes data from Jelsma (2000: 191, 286).

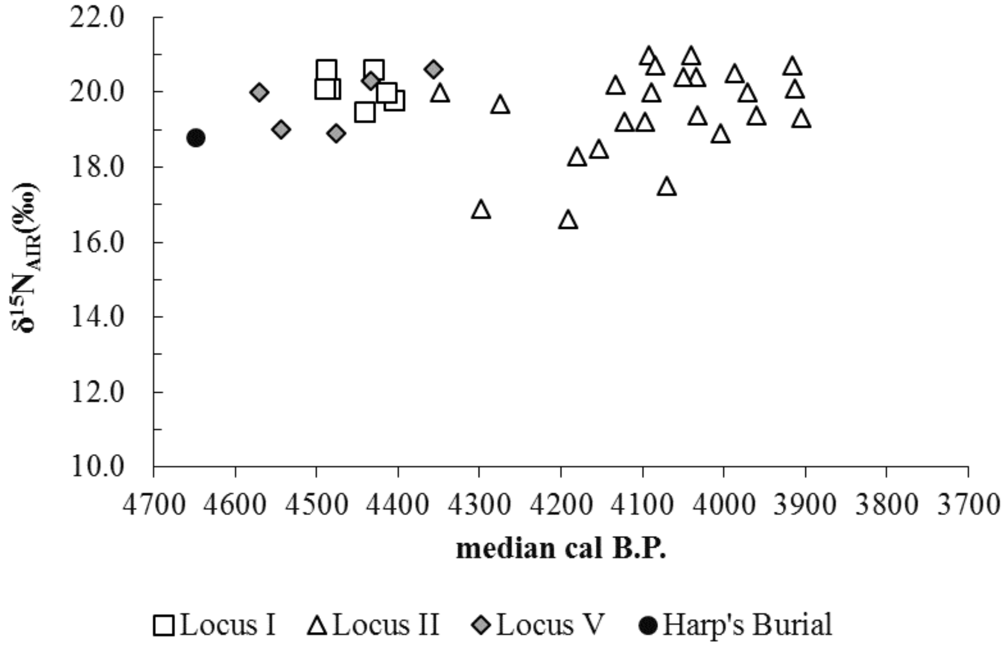

Figure 6.7 Median calibrated radiocarbon dates from adults in each burial locus plotted against the δ^{15}N values. Includes data from Jelsma (2000: 191, 286).

The isotopic evidence does not support significant contributions of terrestrial food to the diets of any of the Maritime Archaic people measured in this study. This is not to say that animals like beaver or caribou were not being consumed (based on the archaeological evidence, they were definitely hunted), but that these animals did not play a significant role in the subsistence of Maritime Archaic people. This is especially apparent when the isotope values of Maritime Archaic people are compared to those of the Beothuk (see section 6.6). The Maritime Archaic people with the lowest δ^{15}N values still fall a trophic level above those of the 19th century Beothuk. It is possible, based on the higher δ^{15}N values relative to the terrestrial fauna, that the Maritime Archaic people with the lowest δ^{13}C values were consuming freshwater or anadromous fish (Schoeninger and DeNiro 1984). It was only possible to sample one anadromous fish specimen in this study, but several recent studies have found δ^{13}C and δ^{15}N values in the tissues of adult salmonids taken from Newfoundland rivers that are lower than those measured in marine fish (Dixon et al. 2012).

6.4.2 Diet and biological sex

The δ^{13}C and δ^{15}N values of adult males, females and adults of indeterminate sex are plotted in Figure 6.8. The male and female δ^{13}C values range from -16.1‰ to -13.3‰ (mean -14.4 ± 0.8‰) and from -14.7‰ to -12.7‰ (mean -13.9 ± 0.5‰), respectively. The male carbon data were not normally distributed ($W = 0.890$; $df = 25$; $p < .05$) and two outliers were identified with values of -15.9‰ and -16.1‰. The carbon isotope data of the adult females were normally distributed ($W = 0.936$; $df = 24$, $p > .05$) and no outliers were identified. Female δ^{13}C values were significantly higher than males ($T = -2.41$, $df = 43$; $p < .05$). The δ^{15}N values of males and females ranged from 16.6‰ to 21.1‰ (mean

19.6 ± 1.3‰), and from 18.8‰ to 22.2‰ (mean 20.2 ± 0.8‰), respectively. As with carbon, the male nitrogen isotope data were not normally distributed ($W = 0.869$; $df = 25$; $p < .05$), however, no outliers were noted in the dataset. Female nitrogen isotope data were normally distributed ($W = 0.966$, $df = 24$, $p > .05$) with no outliers. Females again had higher δ^{15}N values than males, but the difference was not significant ($T = -2.0$; $df = 42$; $p > .05$). The statistical significance of these results does not change if Jelsma's sex estimations are used instead of those of Anderson.

Even though there is considerable overlap in male and female δ^{13}C values, indicating similar reliance on particular food types, there is some divergence with six males having lower values and five females with higher values. Isotopic differences in male and female bone collagen are known from other archaeological populations and have been found to relate to differential access to particular foods resulting from differences in gender roles and/or differences in male and female social status (e.g. Ambrose et al. 2003, Pike 2014). Although Jelsma (2000: 118) did not find statistically significant difference in male and female isotope values, he attributed dietary differences between burial clusters to differential access to terrestrial foods, a difference he believed to be rooted in status. Terrestrial foods, particularly beaver, were deemed to be of higher status than marine foods, like seal (Jelsma 2000:147). This argument was based, in part, on the presence of relatively few individuals with isotope values indicating the consumption of terrestrial protein. The results of this study reveal greater variation within males than was originally found by the previous study. The relationship of social status to diet will be explored further in Chapter 7.

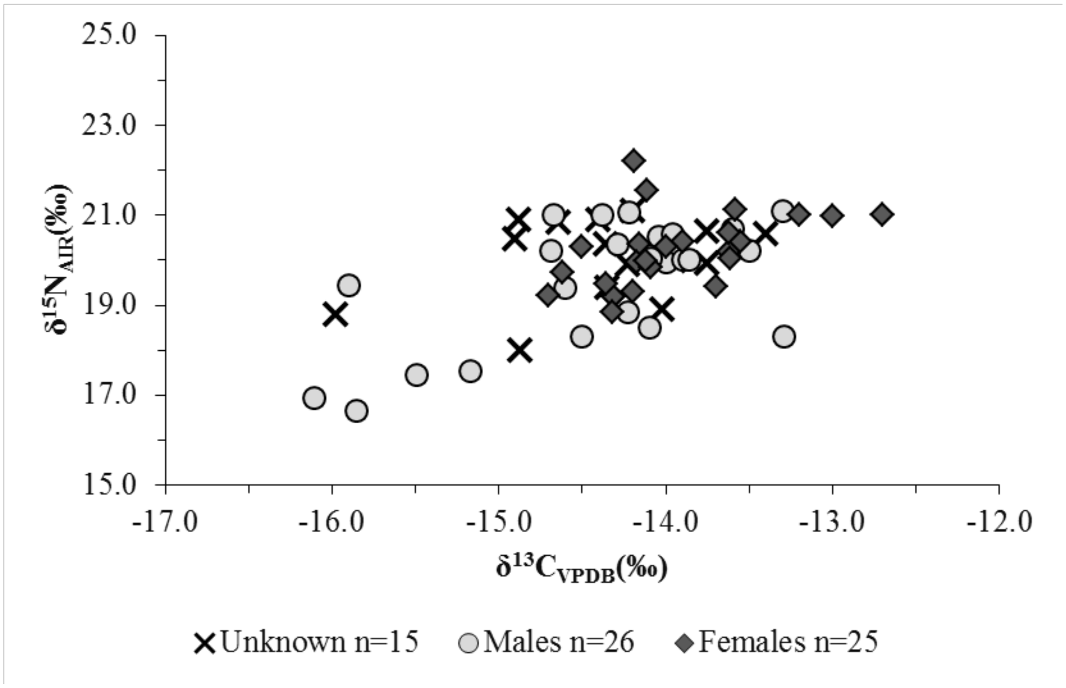

Figure 6.8 δ^{13}C and δ^{15}N values of adult males, females, and adults of indeterminate sex from Port au Choix-3. Includes data from Jelsma (2000:286).

6.4.3 Diet and biological age

The δ^{13}C and δ^{15}N values of subadults are plotted in Figure 6.9. The δ^{13}C values of newborns (n = 9) ranged from -13.0‰ to -16.8‰ (mean -14.7 ± 1.1‰), and the δ^{15}N values ranged from 19.6‰ to 23.6‰ (mean 21.5 ± 1.5‰). Relative to newborns in other archaeological populations, this is a fairly broad range and most likely indicates isotopic differences in maternal diet, as prior to birth, fetuses are obtaining all of their nutrition from the diets of their mothers (Richards et al. 2002). The δ^{13}C values of infants (n = 12) ranged from -13.5‰ to -15.7‰ (mean -14.2 ± 0.4‰), and the δ^{15}N values ranged 20.3‰ to 24.2‰ (mean 22.2 ± 1.2‰). The high δ^{15}N values are to be expected for this age group as they reflec the consumption of breastmilk which raises infants a trophic level above their mothers (Fuller et al. 2006; Schurr 1998). The single individual between the ages of two and six had a δ^{13}C value of -13.0‰ and δ^{15}N value of 22.4‰. The δ^{15}N value may indicate that the child was still breastfeeding at the time of death, or had recently begun the weaning process (Fuller et al. 2006; Schurr 1998). However, δ^{15}N values in excess of 21‰ are also known among the adults in this population (section 6.4.2), therefore the isotope values of this child must be interpreted cautiously.The 11 individuals in late childhood, or between the ages of six and 12, had δ^{13}C values ranging from -13.3‰ to -14.8‰ (mean -13.9 ± 0.4‰), and δ^{15}N values ranging 18.4‰ to 22.5‰ (mean 20.8 ± 1.2‰). Again, the higher δ^{15}N values may be interpreted as an indicator of breastfeeding practices. It is possible that some children were breastfed past infancy in this population, but there is not sufficient evidence to state this with certainty. The nine adolescents, between the ages of 12 and 21 years, had δ^{13}C values ranging from -13.0‰ to -15.4‰ (mean -14.3 ± 0.7‰), and δ^{15}N values ranging from 18.9‰ to 21.0‰ (mean 20.3 ± 0.8‰). Both the δ^{13}C and δ^{15}N values of this group are consistent with those of the adults in the population.

One thing that is worth noting about the isotopic results of the newborns and infants is the range in δ^{13}C and δ^{15}N values relative to those measured in the bone collagen of adult females. Newborn δ^{13}C values cover a 3.8‰ spread with the average value falling 0.9‰ below the average female value. Newborn δ^{15}N values average 1.5‰ higher than the adult females. Newborns should have isotope values that are similar, though not identifical, to their mothers (DeLuca et al. 2012), as the mother’s diet provides the same elements to mother and child. In the Port au Choix-3 population, however, only one newborn (NP 22A) has δ^{13}C and δ^{15}N values that are consistent with the adult females. There are several possible explanations for this discrepancy.The high δ^{15}N values could be due to the poor temporal resolution of ageing techniques for this age group. The individuals identified as newborns may actually be young infants whose bone collagen had begun to reflect the isotopic input of breastmilk. However, breastfeeding studies of human populations have found an approximate 1‰ increase in the $\delta^{13}C$ values of breastfeeding infants over their mothers, dubbed the 'carnivore effect' (Richards et al. 2002).Alternatively, the high $\delta^{15}N$ values of thenewborns could reflect nutritional stress or illness that affected the mothers (Pearson et al. 2010), or metabolic factors in the newborns (Beaumont et al. 2015). High $\delta^{15}N$ values have been measured in nutritionally stressed or fasting wild animals that were in a state of negative nitrogen balance (Hobson et al. 1993; Polischuk et al. 2001). In studies of modern human populations, elevated $\delta^{15}N$ values (relative to a control sample) have been found among patients suffering from anorexia nervosa (Mekota 2006; 2009) and long term wasting illnesses (Katzenberg and Lovell 1999).The most likely explanation, however, is that the isotope values measured in the adult females from the burial ground does not reflect the full range of variation in the female population, a hypothesis supported by the $\delta^{13}C$ values of the newborns and infants. While the infants may have been fed a food with a lower $\delta^{13}C$ value that breastmilk, this does not explain the $\delta^{13}C$ values of the newborns. Jelsma (2000) and Wright (2006) have already alluded to the possibility that only selected individuals were interred in the Port au Choix-3 burial ground, although they disagree to an extent about why this may be.

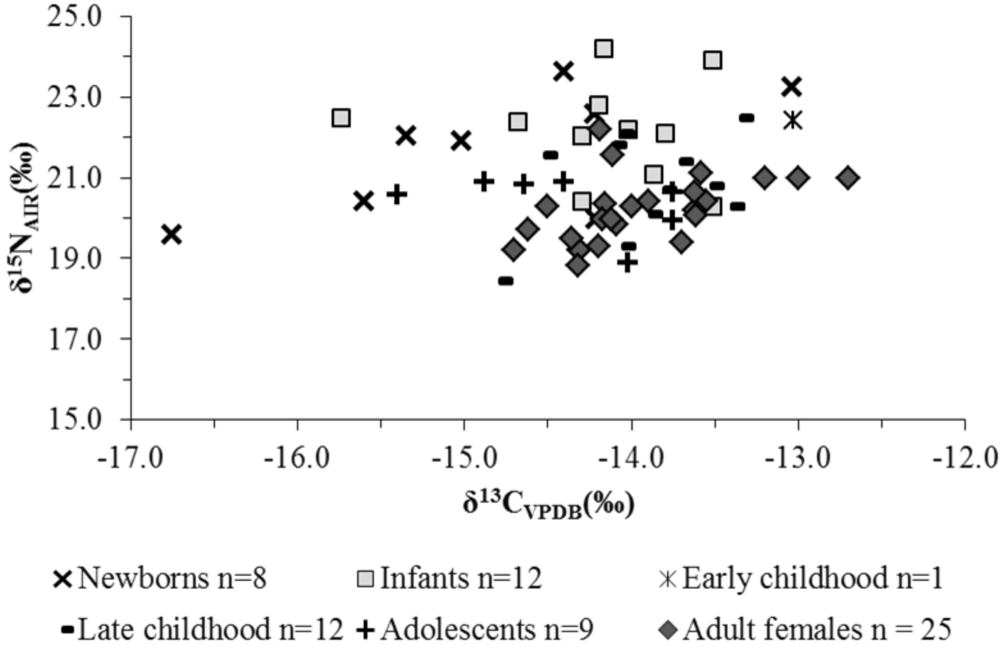

Figure 6.9 The δ^{13}C and δ^{15}N values of newborns, infants, young and older children, adolescents, and adult females. Includes data from Jelsma (2000: 286).

6.4.4 Diet and burial cluster

A difference between the findings of this study and Jelsma's earlier work is the lack of statistically significant difference in the of δ^{15}N values of clusters A and B (F = 0.361; df = 2; $p > .05$). No statistically significant differences were observed in the δ^{13}C values of the clusters ($X^2 = 0.168$; df = 2; $p > .05$), although clusters B and C both featured individuals with lower, outlying δ^{13}C values. One of the individuals, NP 35A, had the lowest δ^{13}C value in Jelsma's study, however, similar low values were measured in Cluster B in this study. The δ^{13}C and δ^{15}N values of the adults from each burial cluster are plotted in Figure 6.10.

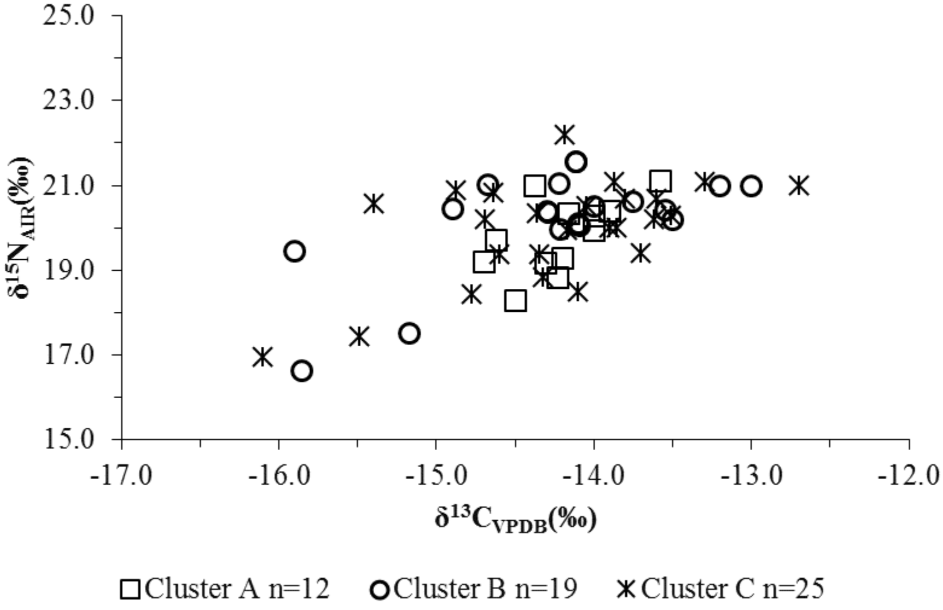

Figure 6.10 δ^{13}C and δ^{15}N values of the adults in each burial cluster in Locus II, Port au Choix-3. Includes data from Jelsma (2000: 286).

6.5 Port au Choix-3 cluster analysis

To clarify the isotope results of the δ^{13}C and δ^{15}N analysis of adult bone collagen and to look for patterns in the data that may relate to different dietary practices, the isotope data were analysed using statistical clustering methods. Using Ward’s method of minimum variance, two clusters were identified in the adult carbon and nitrogen isotope data. These separated primarily by trophic level as indicated by the δ^{15}N, but offered no information regardingthe source of dietary carbon. These results were not particularly meaningful from a dietary perspective, as both diet clusters overlapped considerably. The K-means cluster analysis also produced suboptimal clusters, however, the clusters could be interpreted as isotopically distinct diets. A scree plot (Fig. 6.11), indicated marked decreases in SSE at three clusters, and again at five clusters, but no clear elbow was observed, indicating that this method of cluster validation was not ideal for the dataset. Figures 6.12 and 6.13 plot the clustered isotope data as three and five clusters, respectively, as determined from the K-means analysis and SSE plot. It should be noted here that the plotted data has not been manipulated by the formal cluster analysis. The plots merely indicate possible patterns in the data that may correspond to isotopically distinct diets.

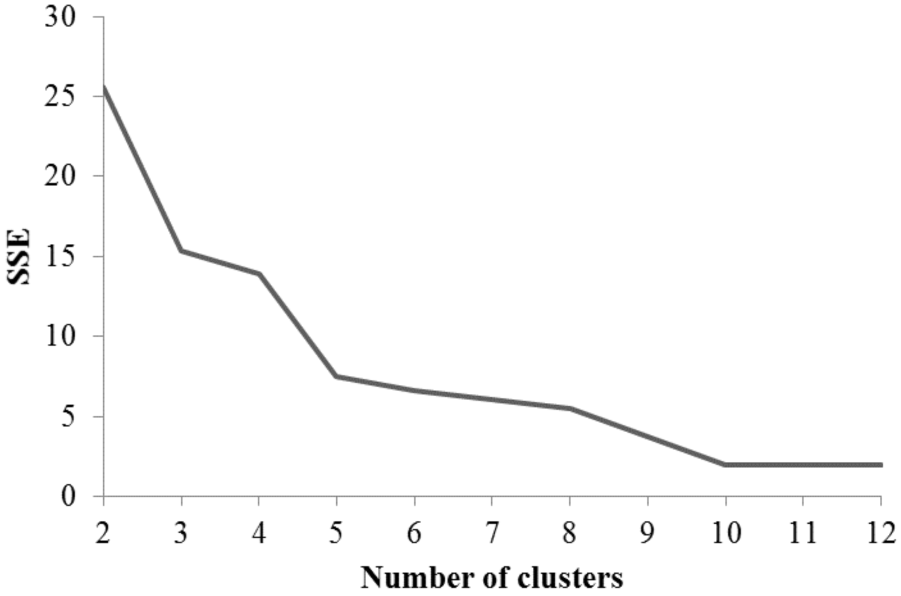

Figure 6.11 K-means SSE plot of Port au Choix-3 cluster analyses.

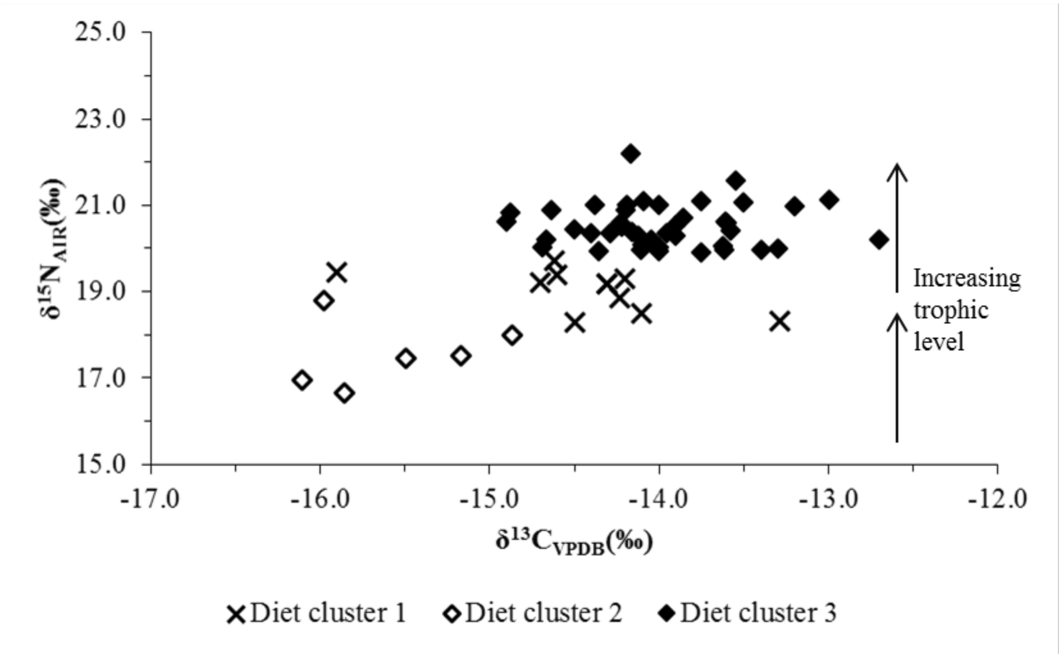

Figure 6.12 Three isotope clusters of Port au Choix-3 data.

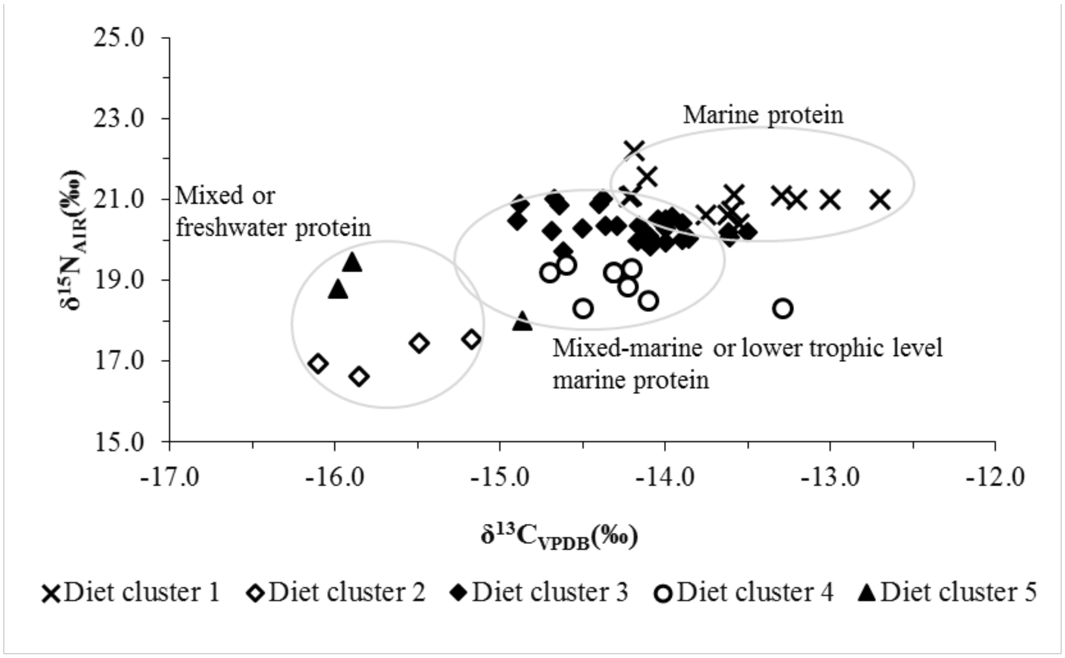

Figure 6.13 Five isotope clusters of Port au Choix-3 data.

The three cluster solution explains some of the variation with the adult data, but as with the hierarchical clustering using Ward's method, the range of $\delta^{13}C$ values within each cluster is not consistent with an isotopically homogenous diet. Not surprisingly, within-cluster variance is reduced, but not eliminated, by the five cluster solution. All clusters, with the exception of diet cluster 2, include considerable spread in the $\delta^{13}C$ values. Diet cluster membership, in terms of sex, burial loci and cluster are summarized in Appendix 5. The three and five cluster solutions are interpretable in terms of the likely prey classes consumed. The human diet clusters are distant in isotopic space from the majority of the benthic aquatic animals, but fall in line with the pelagic aquatic animals. The diet clusters also crosscut the burial clusters, and largely include members of both sexes.

Diet cluster 1 (n = 14) is primarily composed of individuals from burial clusters B and C of Locus II, and includes both sexes. Individuals falling within this cluster appear to have consumed marine-based diets and occupy the highest trophic level with mean $\delta^{13}C$ and $\delta^{15}N$ values of -13.6 ± 0.5‰ and 21.0 ± 0.5‰, respectively. Diet cluster 2 (n = 4) is composed of four males from burial clusters B and C of Locus II. These individuals appear to have consumed more terrestrial or freshwater protein with mean $\delta^{13}C$ and $\delta^{15}N$ values of -15.7 ± 0.4‰ and 17.1 ± 0.5‰, respectively. Diet clusters 3 and 4 do not differ with respect to the $\delta^{13}C$ centroid, but there is a slight difference in $\delta^{15}N$ centroids. The separation of individuals into these two clusters may not be particularly meaningful with respect to diet and thus should be viewed with caution. Diet cluster 3 (n = 30) includes individuals from Loci I, II, and V. Males and females are roughly equally represented, as are burial clusters A, B, and C. The mean $\delta^{13}C$ and $\delta^{15}N$ values are -14.2 ± 0.4‰ and 20.3

± 0.4‰, respectively. Diet cluster 4 (n = 11) includes nine individuals from Locus II, and one individual each from Loci I and V. The mean δ^{13}C and δ^{15}N values are -14.3 ± 0.3‰ and 19.1 ± 0.4‰, respectively, and like Diet cluster 3, indicate a marine protein based diet, but one that lies at a lower trophic level than Diet cluster 1. This could be due to consumption of lower trophic level marine protein, small contributions from terrestrial protein, or regional variations in marine isotopic baseline (e.g. Nelson et al. 2012). Diet cluster 5 (n =3) includes one male from Locus II and two individuals of indeterminate sex from Locus V and Harp's Burial. The mean δ^{13}C and δ^{15}N values of -15.6 ± 0.6‰ and 18.8 ± 0.8‰, respectively, indicate greater consumption of terrestrial protein and potentially a contribution of freshwater protein (e.g. Schoeninger and DeNiro 1984).

In summary the δ^{13}C and δ^{15}N values of adults from Port au Choix-3 evidence multiple dietary strategies. Approximately 20% of the population consumed very high trophic level marine protein. There is little evidence that this group, composed of both males and females, supplemented their diet with any terrestrial protein, and likely ate seals, fish, and seabirds.The majority of the adults, including both males and females, consumed protein that was predominantly marine in origin, but may have supplemented this with some terrestrial protein. Finally, just under 5% of the burial population consumed a mixed diet that may have comprised terrestrial, freshwater, and marine protein. The implications for broader subsistence patterns will be explored further in Chapter 7.

6.6 Human radiocarbon dates from Recent Indian and Beothuk burials

The raw and calibrated dates from the Recent Indian and Beothuk burials are reported in Table 6.3. Complete details regarding MRE corrections and calibrations can be found in Appendix 3. The uncalibrated radiocarbon dates from Recent Indian and Beothuk bone collagen (including data from Grimes et al. 2011) range from 1335 ± 15 B.P. to 315 ± 25 B.P. with 26 of 27 dates falling within the historic period. The date from the Devil's Cove individual (NP 299) is the earliest. The remaining 26 Recent Indian radiocarbon dates fall between 770 ± 25 B.P. and 405 ± 20 B.P. As indicated by the $\delta^{13}C$ values, the dates require correction for the marine radiocarbon reservoir.

The calculated percent marine carbon contributions ranged from 39% to 89% (mean 75 ± 10%). For consistency, a ΔR of 140 ± 50 years was employed, although this correction may not be appropriate for the Recent Indian dates. If the Beothuk were consuming anadromous and near-shore species, freshwater species, and fully marine species, as indicated by the ethnohistoric and zooarchaeological evidence, then it is possible that a different ΔR will be required. The local radiocarbon reservoir in regions such as the Bay of Exploits and Notre Dame Bay may be influenced by freshwater inputs from the Exploits River. Additionally, the consumption of freshwater species, such as beaver and muskrat could be influential in contributing carbon from the freshwater reservoir to Beothuk bone collagen (Keaveney and Reimer 2012). Further research is needed to establish the radiocarbon reservoir for the protected nearshore regions of the northeastern shore, protected bays of the east coast, and freshwater systems of Newfoundland.

The calibrated median radiocarbon dates ranged from 1366 cal B.P. to 103 cal B.P. (mean 306 ± 324 cal B.P.), or from 585 to 1847 cal A.D. (mean 1644 ± 323 cal A.D.). The calibration produced five calibrated median dates that post-date A.D. 1829, the date that marks the death of Shawnadithit, long presumed to have been the last

Beothuk (Howley 1915). The young age of these samples could be an artifact of the calibration curve, and it is possible that a new calibration model could be designed that would incorporate the year A.D. 1829 as a boundary, allowing the probability associated with each date to be recalculated and thus reducing the confidence limits associated with each calibrated date, however, doing so is beyond the scope of this thesis.

Table 6.3 Raw and calibrated 14C dates from Recent Indian sites (human bone only). Calibrated with OxCal 4.2 (Bronk Ramsey 2009) against IntCal13 and Marine13 (Reimer et al. 2009).

Lab No.	NP	Site	^{14}C (± yrs B.P.)	cal A.D. (2σ)
UCIAMS 125901*	299	Devil’s Cove	1335 (15)	959 - 1233
UCIAMS 129845*	268	Rogers Cove	770 (25)	1445 -1680
UCIAMS 167188	270E	Fox Bar	755 (15)	1415 - 1691
UCIAMS 170511	XIII-A-2-1	Long Island	640 (15)	1459 - 1802
UCIAMS 125899*	151	Cranberry Island	655 (15)	1489 - 1846
UCIAMS 134695*	270B	Fox Bar	665 (20)	1489 - 1853
UCIAMS 167195	292	Swan Island	710 (15)	1494 - 1861
UCIAMS 170513	XIII-A/3c	Western Indian Island	630 (15)	1504 - 1875
UCIAMS 159452	270D	Fox Bar	595 (25)	1515 -
UCIAMS 154061	240	Big Island	675 (20)	1521 -
UCIAMS 134696*	270C	Fox Bar	700 (20)	1524 -
UCIAMS 170521	XIII-A-15	Swan Island	640 (15)	1535 -
UCIAMS 129840*	294	Comfort Cove	590 (25)	1550 -
UCIAMS 129841*	296	Comfort Cove	610 (25)	1569 -

continued

Table 6.3 continued

UCIAMS 170517	XIII-A-12a	Devil’s Cove	625 (20)	1584 -
UCIAMS 125898*	152	Comfort Cove	590 (15)	1639 -
UCIAMS 170518	XIII-A-13a	Charles Arm	480 (15)	1667 -
UCIAMS 125903*	290	High Grego	545 (15)	1675 -
UCIAMS 170512	XIII-A-2-2	Long Island	510 (15)	1678 -
UCIAMS 134694*	270A	Fox Bar	555 (20)	1677 -
UCIAMS 170510	XIII-A-1	Long Island	540 (15)	1678 -
UCIAMS 129844*	265	Big Island	500 (25)	1678 -
UCIAMS 129839*	291	Swan Island	530 (25)	1688 -
UCIAMS 170515	XIII-A-8	Long Island	525 (20)	1692 -
UCIAMS 129838*	266	Ladle Point	315 (25)	1680 -
UCIAMS 170516	XIII-A-10	Swan Island	430 (15)	1690 -
UCIAMS 170519	XIII-A-13b	Charles Arm	415 (15)	1689 -
UCIAMS 170520	XIII-A-14	Charles Arm	405 (15)	1688 -

*Denotes data from Grimes et al. 2011

6.7 Recent Indian and Beothuk diet

In addition to radiocarbon dating, two types of stable isotope analyses were conducted on the skeletal remains of Recent Indian/Beothuk individuals. To identify the average sources of dietary protein, the isotope ratios of carbon and nitrogen were measured in the bone collagen of each individual. The source of whole dietary carbon representing consumed carbohydrates, lipids and to a lesser extent, protein, was estimated by analysing the isotope ratios of carbon contained in enamel carbonate from the individuals with preserved permanent dentition. As the radiocarbon results indicate that the human skeletal assemblage spans the European contact period, the isotope data speaks directly to the influence of cross-cultural interactions on Beothuk subsistence.

6.7.1 Collagen $\delta^{13}C$ and $\delta^{15}N$ results

Carbon and nitrogen isotope data from 28 Recent Indian or Beothuk samples were included in the data analysis (Fig. 6.14) and are reported in Table A.2.c. The $\delta^{13}C$ values range from -16.6‰ to -13.8‰ (mean -14.7 ± 0.6‰). The $\delta^{13}C$ values are normally distributed ($W = 0.955$; $df = 34$; $p > .05$) with one outlying value. The outlier with the lowest $\delta^{13}C$ value of -16.6‰ is the probable female from Ladle Point. The $\delta^{13}C$ values are consistent with a diet composed of both marine and terrestrial protein, but the proportion of marine to terrestrial protein varies considerably between individuals. The $\delta^{15}N$ values range from 13.1‰ to 20.5‰ (mean of 16.6 ± 1.3‰). The $\delta^{15}N$ values are not normally distributed. This is in part due to the inclusion of two infants or juveniles (the fragmentary state of the remains makes ageing the individuals difficult) who have higher $\delta^{15}N$ values, but also to the lower values of the probable female from Ladle Point. If the infants/juveniles are excluded, the $\delta^{15}N$ values still indicate that there are individuals present who occupy different trophic levels, potentially through the consumption of different amounts of marine food, such as seal or anadromous fish. An approximate division is apparent between the skeletons dating to the 17th and 18th centuries, and those of the 19th century. The individuals from Charles' Arm and the female from Ladle Point date to the 19th century and have the lowest $\delta^{13}C$ and $\delta^{15}N$ values of the Recent Indian group. Although this is a small sample size, the results are consistent with the reported alteration of Beothuk lifeways that coincided with intensified European settlement of the island.

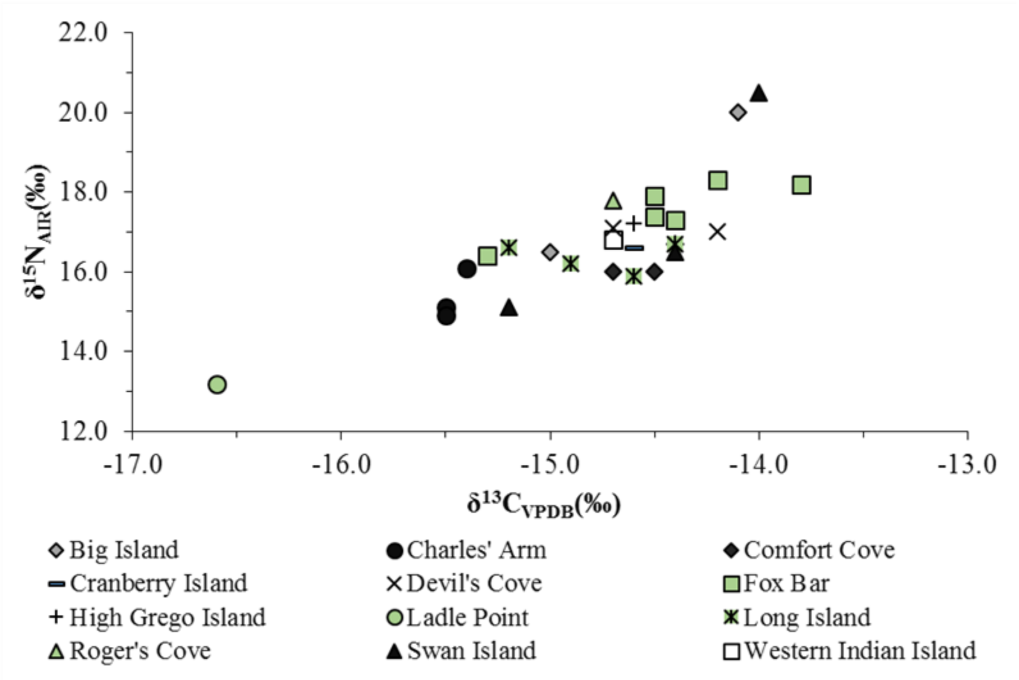

Figure 6.14 The δ^{13}C and δ^{15}N values of Recent Indian and Beothuk individuals. The individuals from Swan Island and Big Island with δ^{15}N values >20‰ are infants.

6.7.2 Enamel carbonate $\delta^{13}C$ results

Isotopes of carbon were measured in the tooth enamel of 11 Recent Indian/Beothuk individuals. The results are plotted relative to the δ^{13}C of bone collagen in Figure 6.15 and are reported in Table A.2.d. The $\delta^{13}C_{coll}$ values are related to those of dietary protein, while the $\delta^{13}C_{carb}$ are related to those of whole dietary carbon (including carbohydrates and dietary fat). The δ^{13}C values ranged from -9.5‰ to -11.9‰ (mean -10.2 ± 0.7‰). The $\Delta^{13}C_{carb\text{-}coll}$ ranged from 3.5 to 5.5. NP 266 was identified as a major outlier with a δ^{13}C value of -11.9‰. If this data point is removed, there is no significant correlation between the $\delta^{13}C_{coll}$ and $\delta^{13}C_{carb}$ values (Pearson correlation: $r = -0.593$; n = 9, *p* = >.05). This indicates that the isotopic value of dietary protein and that of whole diet differed. This is not unexpected and may indicate the consumption of plants, such as berries or roots, by the Recent Indian people (Deal 2005; Deal and Butt 2003), in addition to the meat of caribou and beaver. However, as indicated by the $\delta^{13}C_{coll}$ values of these individuals, marine animals supplied the predominant source of dietary protein. In constrast, the $\delta^{13}C_{carb}$ value measured in the enamel of NP 266 (Ladle Point) is just slightly higher than those measured in the enamel of modern Labrador caribou (Britton 2007) and indicates a greater reliance on terrestrial, C_3 foods than the other individuals.

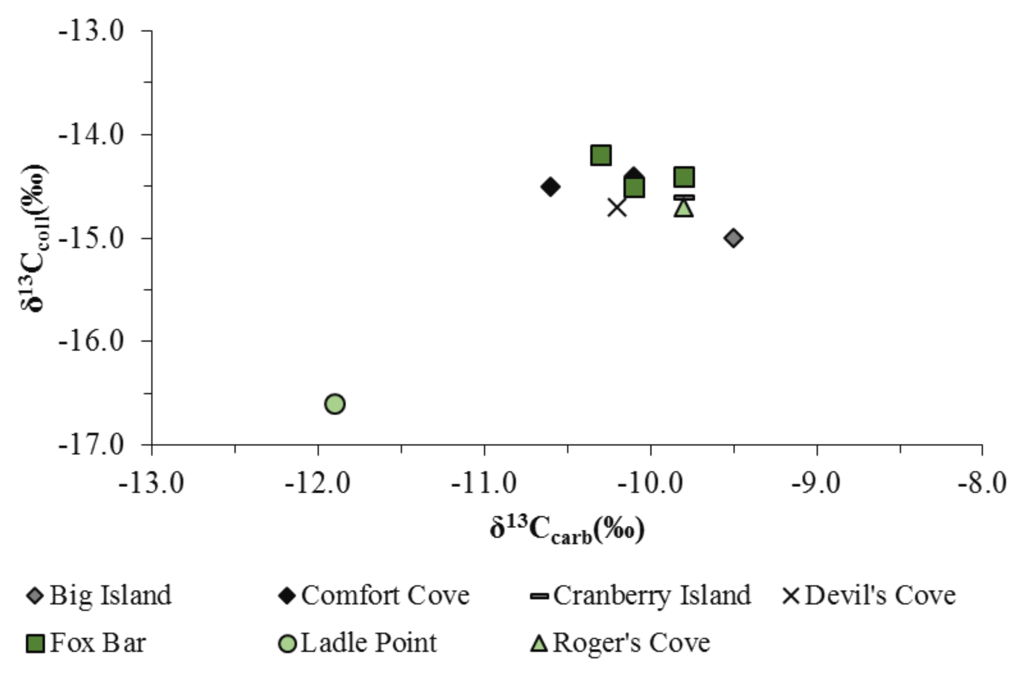

Figure 6.15 Enamel carbonate $\delta^{13}C$ values plotted against bone collagen $\delta^{13}C$ values.

6.8 Chapter summary

Collagen was successfully extracted and analysed from human and faunal remains. The isotopic composition of the faunal bones clearly distinguished marine and terrestrial animals, but isotopic overlap was observed in key prey species, namely seal and seabirds, limiting the potential of this research to speak to distinguish the roles that each prey class played in Amerindian subsistence. Cluster analysis of the fauna revealed that some benthic and pelagic species could be distinguished isotopically.

The Maritime Archaic human skeletons were dated to between 4700 cal B.P. and 3800 cal B.P. No significant differences were noted between burial loci. This study did find that the δ^{13}C values of adult males and females were significantly different, suggesting sex- or gender-based differences in diet, but it is not clear if the females buried at Port au Choix-3 were representative of all of the females in the living population. The range of δ^{13}C values measured in newborns and infants may imply that only certain females were interred at the ancient beach site. Finally, in contrast to earlier research, no statistically significant difference was apparent in the isotope values of the burial clusters. Even so, the presence of multiple dietary patterns in the burial population requires further consideration. The dietary strategies employed by different groups, as identified through statistical cluster analysis of the adult isotope values, are not only suggestive of different diets, but different settlement patterns. This has implications for the relationship of diet to status, and for the role of the cemetery in the social lives of Maritime Archaic people. These topics will be discussed in greater depth in Chapter 7.

In contrast to the diachronic invariability observed in the Maritime Archaic human samples, the collagen and carbonate isotope values of the Recent Indian/Beothuk skeletons varied over time. The stable isotope results and radiocarbon dates support current archaeological research in the province and suggested that prior to European settlement on the island, the Beothuk maintained a generalized mixed-marine adaptation. Following European settlement, the Beothuk obtained fewer marine resources.

CHAPTER 7: DISCUSSION

Previous studies of Amerindian subsistence in Newfoundland have evaluated the geographic distribution of archaeological sites, and the composition of faunal assemblages in order to determine the role of cultural and environmental factors in shaping human subsistence and settlement practices on the island. Clear differences have been demonstrated in the patterns of landscape use between Palaeoeskimo and later Amerindian populations, but comparisons between the much older Maritime Archaic population and later cultural groups have been challenged by changes in the landscape, limited archaeological survey of the interior of the island, and poor preservation of faunal skeletal remains. This research presented the results of stable isotope analysis of human remains affiliated with the Maritime Archaic and Recent Indian traditions as another line of evidence. This chapter discusses the stable isotope values obtained from 103 Maritime Archaic and 29 Recent Indian and Beothuk individuals. The data will be considered in relation to the local isotope ecology of Newfoundland, as determined through the analysis of bone collagen from archaeological animals, and compared to previous stable isotope studies. Intra-population dietary variation will be discussed relative to biosocial categories and chronological considerations, and related back to the archaeological record.

7.1 Isotopic ecology of Newfoundland

The carbon and nitrogen isotope composition of human bone collagen is directly related to the average sources of dietary protein consumed during life (Ambrose and Norr 1993). Therefore, comprehensive palaeodietary reconstructions require a comparative dataset of faunal isotope values to provide context for the human data (Schwarcz and

Schoeninger 1991). Faunal bone specimens were sampled from Beothuk and Dorset faunal collections to achieve this purpose. The results, presented in section 6.2, indicated that animals from marine and terrestrial environments were clearly distinguishable using their bone collagen stable isotope values. Discussion of Amerindian diet has tended to focus on the importance of particular prey classes, such as seabirds (Kristensen 2011; Kristensen and Curtis 2012), or seal (Lacroix 2015). In this context, it was anticipated that stable isotope analysis could provide an effective means of quantifying the role that different species may have played in Amerindian subsistence strategies. However, overlap between the isotopic ranges of different species of seal, seabirds, and fish limited the resolution of palaeodietary reconstruction. The faunal data were therefore regrouped using statistical cluster analysis, which identified two clusters of data that broadly correspond with marine pelagic (i.e. open water) and benthic, (bottom and nearshore) feeders. As is commonly observed in modern ecosystems (e.g. Sherwood and Rose 2005), the pelagic group (including seals, most seabirds, and codfish) had lower δ^{13}C and higher δ^{15}N values than the benthic group (composed of otters, shallow water fish, and birds that are found in nearshore or estuarine habitats). Therefore, although it is not possible to clearly distinguish seabirds from seals isotopically (using only the values from bulk bone collagen), it is possible to distinguish animals that feed in offshore marine systems from those feeding in nearshore, or shallow water systems.

7.2 Port au Choix-3

7.2.1 Chronology

A total of 31 new radiocarbon dates were obtained from human skeletons recovered from Loci I, II, and V of Port au Choix-3, plus an additional date from one of the skeletons given to Elmer Harp. These indicate that Loci I, V, and Harp's burial, with calibrated two sigma dates falling between 4825 cal B.P. to 4357 cal B.P., predated the majority of the burials in Locus II, although the chronological separation is not very wide, with some overlap occurring. The dated burials from Locus II range in age from 4526 cal B.P. to 3689 cal B.P. Overall, the dates suggest that the site was used continuously for approximately 1000 years. Tuck (1976a) had predicted a similar range based on the radiocarbon dates obtained from charcoal and human bone samples, shortly after the burial ground was excavated. The date range suggests that the burials were deposited over a relatively short span of time. No significant differences were apparent in any of the isotopic indicators between loci, and the greatest variation was observed in Locus II. This shifts the focus to other factors that could explain the variation within the burial population, namely social organisation, biosocial categories, and/or regional differences.

7.2.2 Diet and intra-population variation

The aim of this research was to provide a more nuanced palaeodietary reconstruction for the period of time represented by the Port au Choix-3 Maritime Archaic burial ground. This study sought to build upon the previous bioarchaeological and archaeological research conducted on the burial ground by employing stable isotope analysis and radiocarbon dating of the adult and subadult skeletal remains from five of the burial loci. By expanding the analysis to include more of the burial ground, including those areas that were not systematically excavated, this study was able to better characterize the range of dietary variation within the burial population. The addition of samples from newborns, infants and children afforded insights into both age- and gender-related dietary practices.

The stable isotope results from this study were combined with those from Jelsma's work and regrouped using K-means cluster analysis. A conservative interpretation of the diet cluster analysis of the bone collagen of Maritime Archaic adults (n = 68) indicates three to five diet clusters. The mean δ^{13}C and δ^{15}N values (summarized in Table 7.1) of diet clusters 1, 3, and 4, indicate that dietary protein was being sourced predominantly from the marine environment, perhaps with subtle variations in the trophic level of the principal prey consumed. The lower nitrogen values of cluster 4 could result from a greater consumption of seabirds, or fish, as these prey classes tend to have lower δ^{15}N values than seals, but isotopic overlap between species limits this interpretation. The values of Diet clusters 1 and 3 are consistent with a diet of seal, or other high trophic level marine animals. The δ^{13}C and δ^{15}N values of Diet clusters 2 and 5 are lower, and while these values still indicate a greater consumption of animals from marine environments, they indicate a significant contribution of terrestrial protein, or protein from freshwater or anadromous fish, to diet. All diet clusters are too distant in isotopic space to suggest significant consumption of nearshore/benthic species (Hückstädt et al. 2012). The marine species hunted and eaten most frequently would have had isotope values that were consistent with the pelagic faunal cluster.

Table 7.1 Summary of diet clusters obtained from K-means cluster analysis of Port au Choix-3 adults.

Cluster	**N**	**Mean δ^{13}C‰ (1σ)**	**Mean δ^{15}N‰ (1σ)**
1	14	-13.6 (0.5)	21.0 (0.5)
2	4	-15.7 (0.4)	17.1 (0.5)
3	30	-14.2 (0.4)	20.3 (0.4)
4	11	-14.3 (0.3)	19.1 (0.4)
5	3	-15.6 (0.6)	18.8 (0.8)

These results are largely consistent with the earlier findings of Jelsma (2000:118-121), however, this interpretation differs in way the diets of those with the lowest $\delta^{13}C$ and $\delta^{15}N$ values are reconstructed. For example, Jelsma attributed the relatively low $\delta^{13}C$ values of NP 35A to the consumption of beaver meat. It seems more likely, based on a comparison with the isotope values of the later Beothuk (section 7. 3.2), that the diet of NP 35A featured anadromous or freshwater fish, in addition to contributions from terrestrial species, such as beaver or caribou. Among the Beothuk, the consumption of caribou and beaver resulted in $\delta^{15}N$ values that are consistent with a lower trophic level than that occupied by NP 35A.

The isotopic results are consistent with current interpretations of the archaeological record of Newfoundland and Labrador. Working from zooarchaeological collections in the province, Spiess (1993) noted that the evidence strongly suggested a competent marine adaptation featuring specialized technology for hunting animals such as walrus and whale, seal, and fish species. Citing the sea mammal and fish remains found at L’Anse Amour (ca. 7500 B.P.) and the Fowler site (ca. 6500 B.P.) he argued that this marine adaptation possessed considerable antiquity (Spiess 1993: 170-171). More broadly, direct (zooarchaeological) and indirect (tools, site distribution) evidence for fishing, marine mammal hunting, and the harvesting of caribou and furbearers has been found throughout the geographic range attributed to the Maritime Archaic tradition (Bourque 1995; Spiess 1993).

Jelsma (2000; 2006) found that the isotopic variation in the cemetery corresponded with statistical significance to the cemetery’s spatial organisation and to several mortuary attributes, such as grave offering types and body position. Diet also appeared to be loosely related to biological sex, and to a lesser extent, age. The following section will only consider the relationship of the isotopic variation to the burial clusters and to biological sex. From an archaeological perspective, it is difficult to determine the cultural meanings that would have been attributed to different grave offerings (Parker Pearson 1999; Wright 2006) and thus what the relationship between mortuary attributes and stable isotope values would be. For example, Jelsma (2000) noted statistically significant differences between the δ^{15}N values of males buried with bayonets versus those buried with spearpoints. It may be expected that, as bayonets were likely used for sea mammal hunting (Tuck 1976a), the males with bayonets would have higher δ^{15}N values reflecting consumption of sea mammals, but in fact, the opposite result was found. Males buried with spear points had higher δ^{15}N values than males buried with bayonets (Jelsma 2000).

Within Locus II of Port au Choix-3, the burials were arranged in three clusters (Fig. 2.3). The three clusters were initially thought to represent three kin groups based on the distribution of auk, gull, and merganser or cormorant bones and effigies between the clusters (Tuck 1976a). Jelsma's analysis did not find genetic evidence of familial relationships between the clusters, but did find evidence for different levels of energy investment and quantity of grave offerings (Jelsma 2000). Additionally, he found differences in the amount of marine protein consumed by the individuals interred in burial clusters A and B (Jelsma 2000: 118). It was expected that the analysis of a larger skeletal sample would continue to uncover the same pattern between the spatial organization of the cemetery and the distribution of individuals with different dietary protein sources.

Instead, this study found that the different diets were not distributed across Locus II in any obvious pattern. Furthermore, the analysis of other burial loci did not provide statistically significant evidence of diachronic change in diet over time. The results raise doubts about the relationship of social status to diet, however, the argument for high and low status foods requires further discussion.

Jelsma (2000) argued that among the Maritime Archaic in Newfoundland, skilled hunters in the prime of life had the most diverse diets as they were physically able to harvest a wider variety of species. Furthermore, individuals with higher status were granted more terrestrial protein (Jelsma 2000: 121). The lowest $\delta^{13}C$ and $\delta^{15}N$ values of locus II were measured in NP 35A, an individual buried with a large assemblage of grave offerings including 200 great auk maxillae and 49 beaver incisors (Tuck 1976a:150-151). This individual is thought to have occupied a special social position, potentially that of a shaman or elder (Holly 2014, Jelsma 2000; Tuck 1976a). Jelsma attributed the low isotope values of this individual to the consumption of beaver meat. Beaver was identified as a high status food based on ethnographic accounts of Innu practices (Jelsma 2000: 142). The status afforded other prey species was related to the level of skill required in their harvest. Seal and fish were relatively easy to acquire and thus were consumed more frequently by women and less proficient hunters, such as unexperienced youths, or elderly men, while skilled hunters were able to obtain a wider variety of foods and were afforded greater dietary diversity (Jelsma 2000: 146-148). However, this study found no such relationship. The lack of statistical difference between burial clusters now erodes support for Jelsma’s hypothesis that certain food types were considered to be high or low status by the Maritime Archaic people.

The use of ethnographic data to inform archaeological interpretation has been widely critiqued, especially in the study of populations distantly located in time, such as the Maritime Archaic (Sheehan 2004). Ethnographic approaches ideally should inspire archaeological interpretation of material culture (Sheehan 2004), but there is a risk of denying the mutability of culture and instead reconstructing cultural practices as static phenomena (Hood 1993). A critique in Subarctic archaeology is that the use of ethnographic analogy will lead to the assumption that a similar environment will yield the same results in terms of cultural adaptations and social organisation (McCaffrey 2011). Finally, despite having occupied the same geographic space as the Innu, there is archaeological evidence for population discontinuity in the Far Northeast (Holly 2013). Therefore, care should be taken when using ethnographic analogs to reconstruct the attitudes held by past cultures towards animals and the natural world. It may have been a privilege to consume beaver meat among the Innu, but this was not necessarily the case for the Maritime Archaic. Holly suggest instead that beaver may have been consumed by NP 35A as an obligation to a spirit helper who took the form of a beaver, as indicated by the inclusion of beaver incisors and bones with the human body (Holly 2013:38). It bears repeating here that the stable isotope results do not unequivocally point to the consumption of beaver meat.

The processes of food production, preparation and consumption as a means to express and reinforce social difference has been well studied archaeologically with examples drawn from Medieval Europe (Grant 2002; Thomas 2006), the Canadian Arctic Archipelago (Whitridge 2002), and Pre-European contact Hawaii (Kirch and O’Day 2003). Van der Veen (2003:420) proposes that luxury foods are typically those deemed ‘extravagant and unnecessary’, and she makes a distinction between the way that food is used as a marker of status in hierarchical societies versus those with less complex social stratification. In societies with a rigid social hierarchy, such as the feudal states of Medieval Europe, the upper classes distinguished themselves through the acquisition and consumption of hard-to-get or exotic foods, and through the consumption of animals that provided little to no secondary products (Thomas 2006; van der Veen 2003). In contrast, less structured societies marked status through the consumption of more food, or better quality portions of food (van der Veen 2003). In some pre-European contact societies in North America, males consumed more animal protein than females, as a result of their social rank (Ambrose et al. 2003; Eerkens and Bartelink 2013). However, these comparisons are drawn from populations with a greater variety of dietary options, and in particular, agricultural produce, which raises the question: How do Arctic and Subarctic populations use foodways to express social difference? Whitridge reported that the North Alaskan Inupiat ranked different cuts of whale meat, and the *umialik*, or boat owner, received the choicest portions (Whitridge 2002: 67). Damas reports similar food sharing practices among the Copper Inuit of the Central Canadian Arctic (Damas 1972). In high-risk environments, using food in this way to express social difference may have had another purpose. Societies that have developed food sharing traditions have been shown to be better equipped to cope with resource stress than those that alter their dietary composition to deal with periodic shortfalls (Winterhalder 1986).

The status of the Maritime Archaic people as egalitarian hunter gatherers has recently come into question. Holly made a convincing argument for a degree of competition and social differentiation that may have been based on the control and distribution of raw materials, and in particular, Ramah chert (Holly 2013). Hood (1993) and Holly (2013) hypothesized that Maritime Archaic families could have gained status through their involvement in the trade of Ramah chert from its single source in remote Ramah Bay, down the coast of Labrador to the island of Newfoundland, the Maritime Provinces, and further south to New England. Did these families express and maintain their social position through the consumption of prized meats, such as beaver? Perhaps, but the isotopic evidence does not clearly support such a hypothesis. Holly (2013) suggests that of the species hunted by the Maritime Archaic, the walrus may have been one of the most prized. Walrus are dangerous animals that present a clear challenge to human hunters; a successful walrus hunt may have increased the reputation of the hunters, and sharing the meat may have served to consolidate power in the families of the most successful (Holly 2013: 43). Therefore, it seems that the link that Jelsma wrought between diet and status was somewhat weak. Furthermore, by basing status solely on the aspects of identity that dictate hunting prowess, it is possible that an opportunity to provide a more nuanced interpretation of mortuary patterning is being missed. From an isotopic point of view, such a stance, given the variation measured within each sex (2‰ for females; 3‰ for males), runs the risk of oversimplifying the range of isotope values in the burial population, and overlooking other potential sources of isotopic variation, such as sex, age and geographic origin.

A statistically significant difference was measured in the $\delta^{13}C$ values of adult males and females. This result was not unexpected. Isotopic differences in the diets of males and females have been discovered in other archaeological hunter gatherer populations (e.g. Pike 2014), although not in northern North American populations (e.g.

Byers et al. 2011; Chu 1998; Coltrain et al. 2004). Dietary differences between males and females have been shown to arise due to different gender roles in subsistence activities (Jolles 2006a, 2006b; Kelly 2013), status-differences between the sexes (e.g. Ambrose et al. 2003; Kirch and O'Day 2003), and specific gender-based dietary practices, such as food taboos relating to pregnancy and menstruation, or ritual (Speth 1990; Spielmann 1989; White 2005). However, if the adult females buried at Port au Choix-3 are not representative of women in the greater population, then the difference identified statistically in the $\delta^{13}C$ values of the adults may not be an accurate reflection of the dietary practices of this population. Judging by the range of $\delta^{13}C$ values measured in the bone collagen of newborns (reflecting the diet of their mothers) there is reason to believe that this may be the case. During pregnancy, chemical elements in the foods ingested by women are routed to form the tissues of their offspring. This has led to the assumption that the $\delta^{13}C$ and $\delta^{15}N$ values of fetal and newborn tissues should be very similar to samples from adult females in the same population (Jay et al. 2008). This assumption has been proven wrong in the case of $\delta^{15}N$ values, as alterations in metabolism and physiology related to pregnancy and episodes of maternal nutritional stress have been shown to elevate fetal and newborn $\delta^{15}N$ values relative to those of their mothers (Beaumont et al. 2015; De Luca et al. 2012; Fuller et al. 2004; Fuller et al. 2005). Minor offsets have been recorded in the $\delta^{13}C$ values of hair keratin from newborns and their mothers, on the order of approximately 0.4‰ (De Luca et al. 2012), indicating that $\delta^{13}C$ values are less affected by alterations in maternal physiology and reflect maternal diet in the tissues of newborns with greater fidelity than $\delta^{15}N$ values. As the consumption of breastmilk has been shown to elevate the $\delta^{13}C$ values of infants by approximately 1‰, it can be expected that infants should have $\delta^{13}C$ values that are slightly higher than those of the adult females, while newborns should have $\delta^{13}C$ values that are similar to the adult females. This is not the case for the Port au Choix-3 subadults. The mean $\delta^{13}C$ values of the newborns (-14.7 ± 1.1‰; n = 9) and to a lesser extent, the infants (-14.2 ± 0.4‰; n = 12) are lower than those of the adult females (-13.9 ± 0.5‰; n = 25). This implies that the mothers of the Port au Choix-3 infants, and particularly newborns, consumed more terrestrial or freshwater protein than the females actually interred in the cemetery. In turn, this casts doubt upon the validity of the results of the statistical comparison of male and female diets as it is likely that Maritime Archaic women may have consumed diets that were as isotopically variable as the men. Although it is possible that the lower $\delta^{13}C$ values in the newborns may testify to a special diet for pregnant women (Speth 1990), this seems unlikely. If women were allotted more terrestrial protein during pregnancy as a general dietary practice of this population, it would be expected that more of the newborns in the cemetery sample would exhibit lower $\delta^{13}C$ values relative to the older children. Instead, a range of $\delta^{13}C$ values was measured in the newborns implying different dietary practices among the adult females.

The data speak to previous assertions that burial at Port au Choix-3 was restricted to selected individuals (Jelsma 2000), or given the evidence for patrilocal marriage practices (e.g. Holly 2014; Jelsma 2000; Kennedy 1980), that the bodies of some females were returned to their families for burial. Wright (2006) pointed to the occurrence of several empty graves, and other instances of bundled or tightly flexed burials at Port au Choix-3 as evidence for secondary mortuary treatments that may have involved the return of individuals to or from Port au Choix-3. Isotopic and aDNA evidence have been used by others to investigate social organisation and post-marriage residence patterns in archaeological populations (e.g. Bolnick and Smith 2003; Haak et al. 2008). The assumption is that if a cultural group practices patrilocal post-marital residence, then a greater range of variation will be measured in both the mtDNA sequences of the females (reflecting the larger population pool from which the females are drawn), and in the isotope values of females (i.e. local men versus non-local women). Patrilocal residence patterns have been attributed to the Maritime Archaic in Newfoundland by previous authors based on biological and archaeological data. Kennedy (1980) analysed the occurrence of non-metric traits in the skeletal series and found a greater diversity in the expression of several traits among females than males. If the Maritime Archaic people interred at Port au Choix-3 practiced patrilocal post-marital residence patterns, then a greater range of traits would be expected in the females as the women would have been drawn from a larger population than the males (Kennedy 1980). Jelsma (2000: 134-135) expected, and found, similar results when he sequenced the mitochondrial genomes of 26 of the adults buried at Port au Choix-3. Twenty mitochondrial haplotypes were present, representing 20 maternal lines of descent and indicating that the “women of the Port au Choix-3 locus II society came from a larger biological population than the males did” (Jelsma 2000: 135).

At the time that Jelsma and Kennedy were conducting their research, it was held that Port au Choix-3 represented the cemetery of a nearby Maritime Archaic group and that the individuals interred there represented a sample of the local population (Tuck 1976a). It has since come to light, through the survey and excavation conducted by Drs. Priscilla Renouf and Trevor Bell, that there is no evidence for a nearby habitation site analogous to those uncovered at Rattler's Bight in Labrador, and the Curtis site, in northeastern Newfoundland (Renouf and Bell 2011). It seems more likely, based on the artifact assemblage, that the cemetery was situated near a territorial boundary and contained the remains of Maritime Archaic people from different communities (Lacroix 2015). If this is the case, then stable isotope or aDNA-based approaches that attempt to distinguish locally born individuals from those from other communities will be stymied. Additionally, as Jelsma has argued, using molecular-based sex estimations, interment in the burial ground was not equally afforded to everyone in the population, rendering the burial sample non-representative of the population as a whole (Jelsma 2000). Therefore, identifying non-locals, such as women who may have married into the local community, based on differences in their diet, or mitochondrial sequences as compared to a local population, is not possible with the Port au Choix-3 burial population.

On the basis of the data presented so far, it is suggested here that the isotopic groups may result from different land use strategies. Diet clusters 1, 3 and 4 are consistent with significant, prolonged consumption of high trophic level marine protein. Assuming a trophic level $\delta^{15}N$ shift of between 3‰ and 5‰ (Hedges and Reynard 2007), Diet clusters 1 and 3 may have relied on marine species that had $\delta^{15}N$ values greater than 15‰, namely harp seal, harbour seal, and some seabirds. Diet cluster 4 may have relied on species with $\delta^{15}N$ values greater than 13‰, such as those measured in fish and seabird species. Alternatively, the individuals in Diet cluster 4 may have relied on a greater diversity of species, including seal, seabirds, and terrestrial species. To understand how much marine protein would be required to raise the human nitrogen isotope values to those measured in these diet clusters, it is useful to compare them to the Dorset Palaeoeskimo, for whom diet is reasonably well understood. The bone chemistry of the Dorset skeletons from Newfoundland reflect a specialized marine adaptation focused on harvesting large numbers of harp seal every spring (Raghavan et al. 2014; Renouf 1993). The measured δ^{13}C values range from -12.5‰ to -14.0‰, and the δ^{15}N values fall between 19.7‰ and 21.5‰ (Raghavan et al. 2014). The Maritime Archaic individuals in the high marine protein cluster have isotope values that approach, and in some cases exceed those measured in the Dorset. This indicates a similar reliance on high trophic level marine protein, probably seal, but as evidenced by the marine fauna, may also include pelagic seabirds. This has implications for understanding Maritime Archaic site distribution and land use practices. The Dorset maximized yields of harp seal by aggregating at key locations along the coast, and residing in substantial, semi-subterranean dwellings (Renouf 1993). It does not appear that an analogous settlement pattern can be attributed to the Maritime Archaic people on the island of Newfoundland. Only one small habitation site has been found on the Northern Peninsula, the site of Big Droke-1 (Renouf and Bell 2011). Excepting Port au Choix-3 and the Gould site, all other sites along the western shore of the peninsula are lithic workshop sites (Renouf and Bell 2011). Therefore, the investment of energy into the harp seal hunt is not readily apparent from an archaeological perspective during the Maritime Archaic occupation (Lacroix 2015), even though the stable isotope values tell a different story. What is implied instead is movement along the coast which would provide continuous, seasonal access to a variety of marine animals.

Lacroix’s (2015) Least Cost Path analysis of traditional travel routes on the island provided evidence for several principal travel corridors, and it was argued that these corresponded to the geographic territories inhabited by distinct Maritime Archaic groups. One such route extended from the northern tip of the Northern Peninsula, down and across the northeastern coast to end at Bonavista Bay. This route could equate to a subsistence model wherein harp seal were hunted in the winter and early spring, from the Bonavista region, or the Northern Peninsula; seabirds and their eggs could be collected in the summer on the outer islands; and harbour seal could be hunted throughout the year (Lacroix 2015). Assuming limited use of the resources of the interior, this subsistence model is consistent with the human isotope values assigned to Diet clusters 1, 3 and possibly 4. It also suggests that a highly mobile, coastal-oriented adaptation may have been possible without recourse to the interior, such as was practiced by the Beothuk (Rowley Conwy 1990), or semi-permanent settlement along the coast, such as was practiced by the Dorset Palaeoeskimo (Renouf 1993).

Diet clusters 2 and 5 suggest a mixed marine-terrestrial adaptation. This type of diet is similar to that consumed by the Beothuk and Recent Indians, but does not appear to have featured as much terrestrial protein. This suggests that this group would have predominantly targeted marine resources, and likely would have lived much of the time by the coast, but also would have included an interior or riverine facet to their subsistence. Bell and Renouf (2004), and Renouf and Bell (2006) noted that while most Maritime Archaic sites were found along the coast, some sites (approximately 20%) were found in the interior, along riverine routes. Likewise, the analysis of travel routes indicated that, in addition to the northeastern coastal routes, modelled routes were often found in the interior, along rivers that could be used to travel from coast to coast (Lacroix 2015). Therefore, the subsistence patterns suggested by the Port au Choix-3 human carbon and nitrogen data may find support in the archaeological record. Rather than generalizing a marine adaptation, featuring small contributions of terrestrial protein, to the entire population, there may have been regional variants in diet that corresponded to different Maritime Archaic groups. Bourque and Krueger (1994) similarly argued that the isotopic variation observed among the Nevin site humans may evidence multiple geographic origins for members of the cemetery sample. Back in Newfoundland, Lacroix (2015) hypothesized, using evidence from site distribution, and material and mortuary culture analysis, that several Maritime Archaic 'countries' with distinctive material culture traditions and differential access to food resources existed. The research presented here will not go so far as to presume different ethnic groups, as Lacroix argued, but the isotopic evidence does support separate resource use strategies. An investigation of the natal origins of the individuals from Port au Choix-3 is ongoing, employing strontium and stable oxygen isotope analysis of human dental enamel. The forthcoming results of this study may shed light on the dietary variation among the adults of Port au Choix-3 in relation to geographic origin.

In summary, the results of this research have helped to clarify the chronology and subsistence practices of the people interred at Port au Choix-3. The cemetery is slightly older than previously thought, and in the absence of a radiocarbon date from Locus IV, Locus II appears to be the youngest. Even though the cemetery was in use for almost 1000 years, there is little evidence for dietary change over time. The stable isotope results indicated that multiple subsistence strategies were practiced by the Maritime Archaic who used the burial ground. Despite the previous claim that the dietary variation measured in the cemetery population related to the spatial organisation of the burial ground, or to social organisation (status and/or gender), this research did not uncover similar patterns. Instead, it is argued here that the isotopic variation relates to the geographic origin of the individuals.

7.3 Recent Indian and Beothuk samples

7.3.1 Chronology

The radiocarbon dates from the historic Recent Indian/Beothuk burials overlap, and in some cases intersect with the calibration curve multiple times (Appendix 3). This requires a conservative interpretation of the chronology. Unfortunately, with the exception of the Fox Bar burials, the European artifacts recovered from several of the burial sites are not sufficiently diagnostic to narrow the confidence intervals of the radiocarbon dates. For the purpose of this discussion, the burials are divided into four groups (Table 7.2). The division is based on the date range with the greatest probability, and agreement of the mean and median dates.

The Early Recent Indian group includes the individual from Devil's Cove. The Early Historic group includes all individuals with median/mean dates equal to, or earlier than A.D. 1600. The mid to late historic group includes all those with median/mean calibrated dates between A.D. 1600 and 1820, and the terminal Beothuk group includes all those who post-date A.D. 1820. The data from Nonosabasut and Demasduit (Kuch et al. 2007) are included in this latter group, as are individuals from Ladle Point, the Charles' Arm Rockshelter, Long Island, and Swan Island.

Table 7.2 Summary of chronological grouping and isotopic data obtained from Recent Indian samples.

ID No.	Site	Chronological group	$\delta^{13}C_{carb}$	$\delta^{13}C_{coll}$	$\delta^{15}N_{coll}$
299	Devil’s Cove	Early Recent Indian	-10.2	-14.7	17.1
268	Roger’s Cove	Early Historic	-9.8	-14.5	16.9
270E	Fox Bar	Early Historic		-14.4	18.5
XIII-A-2-1	Long Island	Early Historic		-15.2	16.6
151	Cranberry Is.	Mid to Late Historic	-9.8	-14.6	16.6
294	Comfort Cove	Mid to Late Historic		-14.7	16.0
152	Comfort Cove	Mid to Late Historic	-10.6	-14.5	16.0
296	Comfort Cove	Mid to Late Historic	-10.1	-14.4	16.7
240	Big Island	Mid to Late Historic		-14.1	20.0
265	Big Island	Mid to Late Historic	-9.5	-15.0	16.5
270A	Fox Bar	Mid to Late Historic	-9.8	-14.4	17.3
270B	Fox Bar	Mid to Late Historic	-9.8	-14.5	17.4
270C	Fox Bar	Mid to Late Historic		-13.8	18.2
270D	Fox Bar	Mid to Late Historic		-15.3	16.4
290	High Grego Is.	Mid to Late Historic		-14.6	17.2
292	Swan Island	Mid to Late Historic		-14.0	20.5
XIII-A-12a	Devil’s Cove	Mid to Late Historic		-14.2	17.0
XIII-A-1	Long Island	Mid to Late Historic		-14.6	16.1
XIII-A-2-2	Long Island	Mid to Late Historic		-14.9	16.2
XIII-A-3c	Western Indian Is.	Mid to Late Historic		-14.7	16.8
XIII-A-13a	Charles’ Arm	Mid to Late Historic		-15.4	16.1
291	Swan Island	Terminal Beothuk		-14.4	16.5
266	Ladle Point	Terminal Beothuk	-11.8	-16.6	13.2
XIII-A-10	Swan Island	Terminal Beothuk		-15.2	15.1
XIII-A-8	Long Island	Terminal Beothuk		-14.4	16.7
XIII-A-13b	Charles’ Arm	Terminal Beothuk		-15.5	15.1
XIII-A-14	Charles’ Arm	Terminal Beothuk		-15.5	14.9
	Red Indian Lake*	Terminal Beothuk	-12.6	-15.8	13.1
	Red Indian Lake*	Terminal Beothuk	-12.4	-15.2	13.2

*Denotes data from Kuch et al. (2007)

Disparate radiocarbon dates from five mortuary sites indicate possible evidence of site reuse. The individuals recovered from Devil’s Cove exhibit the greatest degree of temporal separation, with one individual dating from A.D. 959 to 1233, and the other postdating A.D. 1584. The Long Island, Swan Island, Fox Bar, and Charles’ Arm burials each appear to feature at least two separate burial events, with as many as four in the case of Fox Bar. Although each site was disturbed to a degree, limiting the interpretations that can be drawn from the mortuary record, the radiocarbon dates suggest that a reanalysis of Beothuk mortuary practices and the importance of place could be a worthwhile endeavour.

7.3.2 Diet

The results obtained from the early historic, and mid to late historic period burials suggest that Little Passage and early Beothuk subsistence could be characterized by a generalized marine adaptation consisting of roughly equal contributions of marine and terrestrial protein. This conclusion is supported by the $\delta^{13}C$ composition of tooth enamel carbonate. After Kellner and Schoeninger (2007), Figure 7.1 displays the relationship between the $\delta^{13}C$ values of later Amerindian bone collagen and enamel carbonate relative to two mixing lines representing C_3 and marine protein, respectively. The ends of the lines correspond to the $\delta^{13}C$ composition of whole diet. The lower ends represent a C_3 energy source and the upper ends represent a C_4 energy source. The regression lines were determined from experimental controlled feeding studies. As a result, few data points were available to develop the marine regression line, however, the model has been used to effectively estimate the diets of wild marine animals (Kellner and Schoeninger 2007). The early Recent Indian from Devil's Cove, early Historic, and mid Historic Beothuk cluster between the C_3 and marine protein lines, corresponding to a mixed marine-terrestrial diet. Their position closer to the end of the marine protein line than the C_3 protein line indicates that a portion of carbon in the whole diet is still being obtained from marine sources, likely sourced from marine mammal lipid which has been shown to have $\delta^{13}C$ values approximately 10‰ lower than bone collagen values (Cherry et al. 2011).

This is in contrast to the three Terminal Beothuk samples that, while still falling between the marine and C_3 lines, are closer to the end of the C_3 protein line, indicating that a greater proportion of dietary carbon was being sourced from the terrestrial environment (Kellner and Schoeninger 2007).

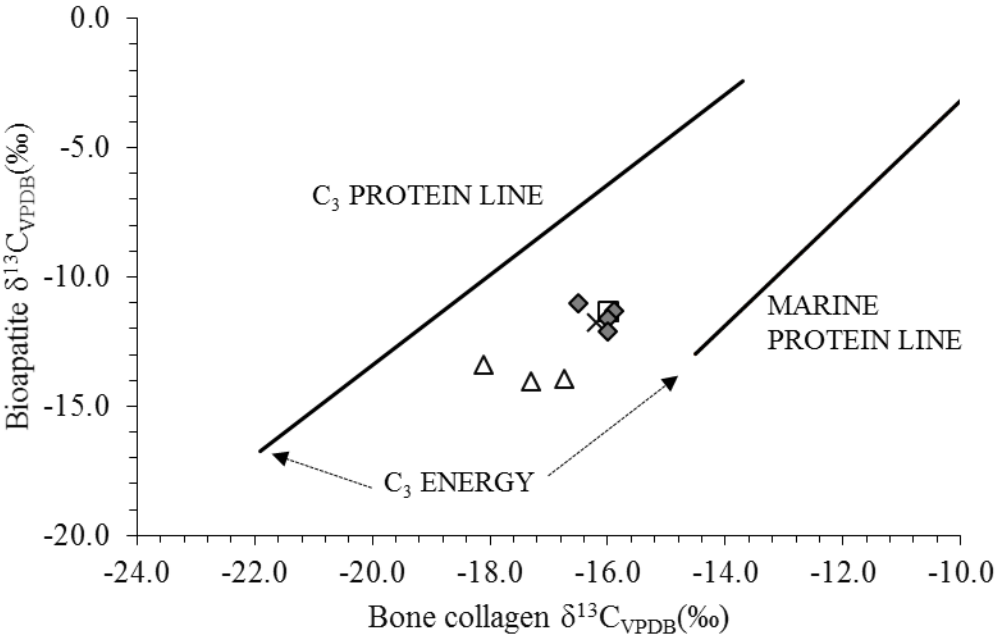

Figure 7.1 Amerindian enamel bioapatite δ^{13}C values plotted against bone collagen δ^{13}C values and corrected by -1.5‰ for the Suess effect after Kellner and Schoeninger (2007). Includes data from Kuch et al. 2007.

The narrative of the Beothuk cultural extinction has drawn on the archaeological record of the interior of the province to shed light on the final years of the Beothuk. The midden deposits of caribou bone, the remains of substantial dwellings, and ethnohistoric accounts of an increasing investment of energy in food storage all suggest a marked deviation away from traditional Beothuk lifeways during the historic period (Holly 1998;

LeBlanc 1973). The local isotope ecology of Newfoundland, featuring a C_3 dominated terrestrial landscape and high latitude marine-scape, makes this a testable hypothesis. Consumption of marine protein will result in higher bone collagen $\delta^{13}C$ and $\delta^{15}N$ values than consumption of terrestrial protein, therefore, if the Beothuk relied more heavily on caribou, beaver, and anadromous salmon in the years prior to cultural extinction, this change in diet should be apparent in the isotopic composition of individuals living during this time period compared to individuals living before permanent European settlement of the coast. Eight individuals appear to date to the end of the Beothuk period. The Recent Indian and Beothuk calibrated median radiocarbon dates are plotted relative to bone collagen $\delta^{13}C$ and $\delta^{15}N$ values in Figure 7.2 and Figure 7.3. These figures must be interpreted cautiously as there is considerable overlap between radiocarbon dates at two standard deviations.

The individuals that date to the early and mid to late historic periods have bone collagen isotope values that are consistent with a generalized marine adaptation, a pattern that seems to have been in place by approximately 900 years ago, as suggested by the early Recent Indian person from Devil's Cove. The isotope data support the archaeological evidence for Beothuk and Recent Indian subsistence presented in Chapter Four. These results could be expected for a population strategically exploiting marine and terrestrial resources from a central location, such as the nearshore region (Holly 2008). Alternatively, seasonal movement between the island's coast and interior may be implied, as marine and terrestrial foods both seemed to have made equal dietary contributions.

The occurrence of lower $\delta^{13}C$ and $\delta^{15}N$ values during the 19th century indicates greater consumption of terrestrial protein. As these low values are temporally restricted to the Terminal Beothuk occupation, they corroborate the archaeological evidence from the Exploits River and Red Indian Lake, lending further support to the archaeological narrative of Beothuk extinction, which has tended to focus on the disruption of the Beothuk subsistence patterns (Holly 2008; LeBlanc 1973; Marshall 1996). The lower $\delta^{13}C$ and $\delta^{15}N$ values do not reflect the same contribution of marine protein as observed in skeletons that predate the 19th century, however, some degree of coastal access and consumption of marine protein is still indicated, as the isotope values are still elevated relative to a pure terrestrial C_3 diet (Schoeninger and DeNiro 1984).

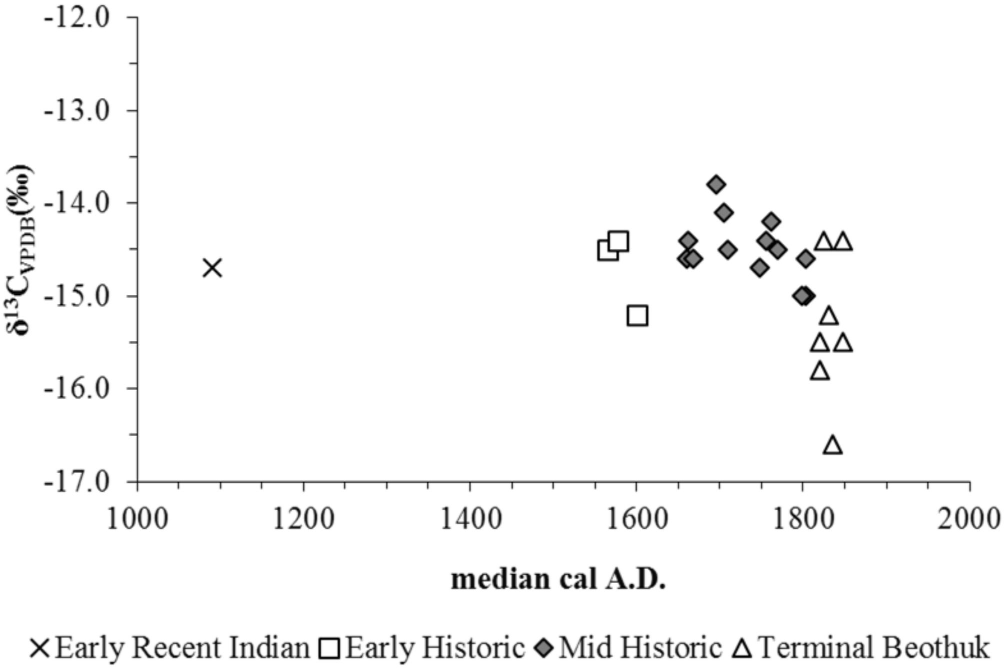

Figure 7.2 Bone collagen $\delta^{13}C$ values plotted against the median calibrated radiocarbon date. Terminal Beothuk points includes two data points from Kuch et al. (2007).

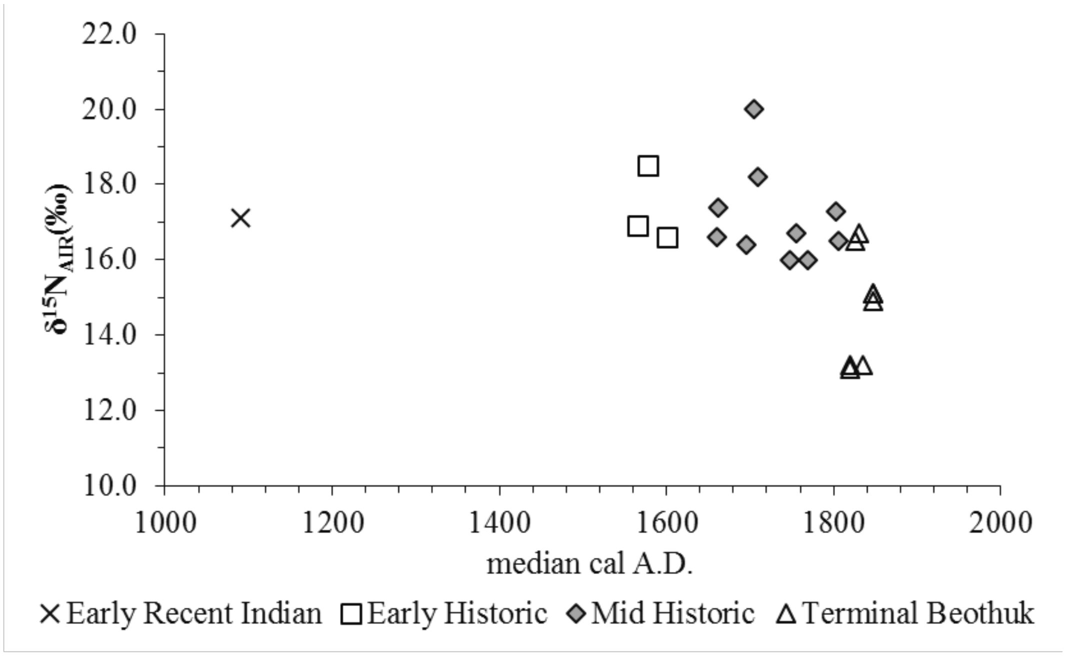

Figure 7.3 Bone collagen δ^{15}N values plotted against the corresponding median radiocarbon date for each Recent Indian individual. Terminal Beothuk data includes two data points from Kuch et al. (2007).

Shawnadithit's drawing of a Beothuk storage house, ca. A.D. 1825 (Fig. 7.4), portrays dried lobster tails and salmon, bladders of oil, seal blubber and skin, and birch bark vessels for boiling birds' eggs. Her drawings of specialized implements for seal hunting also demonstrate that she was familiar with the coast and its resources and that these must have been utilised to some degree by the Beothuk in the early 19th century (Howley 1915). Therefore, the implication is that during the 19th century, the Beothuk were able to maintain a component of their coastal hunting and harvesting practices, albeit in a more limited capacity than before European settlement of the region.

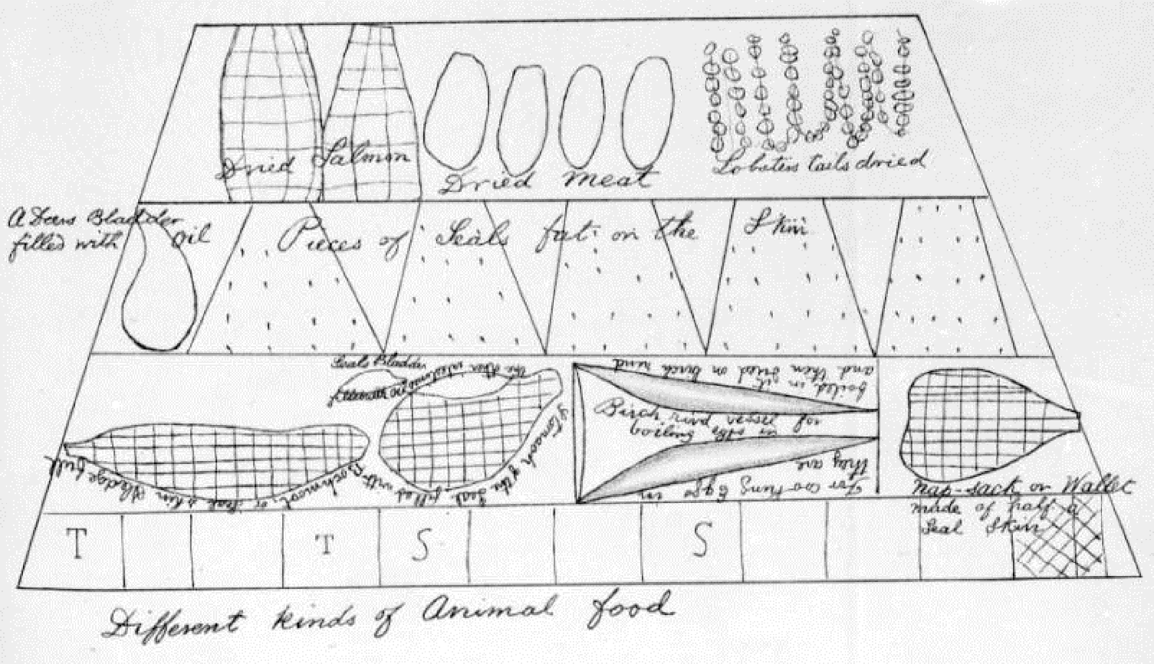

Figure 7.4 Shawnadithit's drawing, "Different kinds of Animal food", circa 1825. Accessed from http://collections.mun.ca/cdm/ref/collection/cns_images/id/71. Original from Howley (1915).

Food is instrumental in creating and maintaining cultural identity and negotiating social difference (Appadurai 1981). Food initially served to unify English and Beothuk people. The earliest cross-cultural encounters witnessed the sharing of food, as recounted by John Guy in a letter:

> 'When signs were made that they should be willing to suffer two of our company more to come on shore for two of theirs more to be landed, and that bread and drink should be brought ashore, they made likewise signs that they had in their canoes meate also to eate: upon this shallop rowed aboard and brought John Guy and Master Teage ashoare, who presented them with a shirt, two table napkins, and a hand towel, giuing them bread, butter, and reasons of the sunne to eate, and beere, and aqua-vitae to

> drinke…After they had all eaten and drunke one of them went to their canoe, and brought use deeres flesh, dried in the smoke or winde, and drawing his knife from out his necke, he cut euery man a peece, and that sauoured very well' [Howley 1915: 16-17].

Subsequent interactions had an adverse effect and served to solidify cultural differences between the Beothuk and Europeans. The coastal areas and the rivers acted as the frontlines of a tense negotiation between the Beothuk and European settlers over access to salmon, seals and seabirds (Holly 2000; Marshall 1996). The European salmon fishery seems to have been especially fraught as the arteries connecting the Beothuk settlements in the interior to the coast became punctuated by the presence of European nets (Marshall 1996). An increasing reliance on terrestrial sources of food may have impacted the distribution of foodstuffs among the Beothuk population, as well as the modes of food preparation and consumption (Smith 2006). The cultural meanings attributed to fish, seabirds and their eggs would have changed over this period, as marine resources may have come to represent the conflict between the Beothuk and European fishermen, reflecting the mutability of human-animal and human-environment relationships (Ingold 2000; Jones and Richards 2003). The caribou may have also borne a greater symbolic weight at this time. Holly (2000) writes that the forests of the island's interior may have served to unite the Beothuk over the historic period, as they offered shelter, and the freedom to pursue aspects of their way of life beyond the destabilizing influence of the Europeans. The Beothuk may have continued to enact the mokoshan ritual, documented at Boyd's Cove and at pre-European contact sites, as evidenced by

Buchan's 1812 account of hundreds of caribou leg bones arranged on poles in a Beothuk wigwam (Holly 2000).

In summary, the Recent Indian and Beothuk data indicate that for a period of approximately 800 years, Amerindian diets may have been isotopically consistent. Diet appears to have featured roughly equal contributions from the marine and terrestrial environments, suggesting a subsistence model that integrated the island's coasts and interior. When the data from bone collagen and enamel carbonate are considered relative to the archaeological record, later Amerindian diet can be reconstructed with a fair degree of confidence. The most parsimonious palaeodiet model would include either seasonal movement between major resource zones, or strategic settlement in nearshore regions from where marine and terrestrial resources could be monitored and accessed (Holly 2008). This model strikes a contrast with Amerindian diet during the 19th century which appears to have been predominantly composed of terrestrial resources, with a reduction in the consumption of coastal food resources.

7.4 Chapter Summary

A comparison of Maritime Archaic and Recent Indian/Beothuk stable isotope values indicated that the groups differed significantly with implications for the employed subsistence and settlement patterns. The variance within the $\delta^{13}C$ and $\delta^{15}N$ values should be considered in light of the different social and environmental parameters that appear to have shaped the adaptation of each group.

Maritime Archaic diet appeared to be relatively invariable from a diachronic perspective. Intra-population differences were observed in the $\delta^{13}C$ values of adult males and females from Port au Choix-3. This difference may be attributed to different gender roles in food procurement and preparation, but it is the view of this thesis that the equation of sex-specific diets to status is premature and not well supported by the bioarchaeological evidence. The variation within male and female diets, and within subadult diets suggests sex may not have been the only factor influencing diet. Here it is proposed that geographic origin should also be considered as a source of dietary variation within this population.

Recent Indian and Beothuk isotope values imply a generalist adaptation that incorporated a wide variety of marine and terrestrial resources. Later Beothuk diets bear the influence of the changing social landscape of Newfoundland. Isotope values indicate an increasing contribution from the terrestrial environment to Beothuk diet, highly suggestive of a reduction in Beothuk investment in the coastal landscape.

CHAPTER 8: CONCLUSION

8.1 Stable isotope evidence for Amerindian diet

This research sought to provide a nuanced, diachronic reconstruction of Amerindian subsistence practices through the application of stable isotope analysis and radiocarbon dating of human and faunal skeletal remains from the island of Newfoundland. The results indicated that subsistence was not dictated by environmental conditions, but was shaped by cultural determinants and varied over a period of approximately 4500 years. The diets of the earliest Amerindians to settle the island, the Maritime Archaic people, were surprisingly consistent over approximately 1000 years, or the time represented by the burial ground, Port au Choix-3. Even so, inter-individual differences in diet were observed that may have corresponded to sex, and potentially geographic origin. Later Amerindian diet varied significantly over 1000 years, with early people consuming protein that was mixed-marine in origin, to later people consuming a diet that was sourced predominantly from the terrestrial ecosystem. When these data were combined with radiocarbon dates, and evidence from the archaeological and historic records, they corresponded well to with archaeological evidence and ethnohistoric accounts of the Beothuk cultural extinction, and spoke to alterations in resource base used by the Beothuk.

Increasingly, archaeological research in Newfoundland is shedding the preconceived notions of marginality that shaped the practice in the 20th century, however, this conceptual shift has made more progress in the study of the later Amerindian cultures, namely the Beaches, Little Passage and Historic Beothuk. In Newfoundland, the subsistence practices of the Maritime Archaic people are still shrouded in an element of mystery. One of the critiques of the study of this culture is that it is plagued by overgeneralization as, in the absence of faunal bone remains and habitation sites, this culture is understood through ecological approaches that may miss nuances of culture and social life and hinder cross-cultural comparisons of life- and foodways (Lacroix 2015).

This research expanded on earlier stable isotope-based research by measuring isotopes of carbon and nitrogen in every skeleton in the Port au Choix-3 skeletal series, and by radiocarbon dating a larger representative sample from each burial locus than previous research (e.g. Jelsma 2000). The results of the $\delta^{13}C$ and $\delta^{15}N$ analysis of the human skeletal remains built upon the earlier work conducted by Jelsma (2000) and provided further support for at least three isotopically distinct groups, each consuming different proportions of marine and terrestrial protein. The isotope groups did not correlate significantly with the age of the burial loci, emphasizing that the isotopic composition of Maritime Archaic diets remained relatively constant over time. Instead, the isotope groups varied across the population, with sex, age and with other less obvious factors. This thesis is suggesting that some of this variability may find a source in the natal origins of the burial population. The differential consumption of marine protein between different isotope groups suggests that the groups employed different subsistence and land use strategies. The groups that consumed the most marine protein would have spent more time along the coast, either following harp seal and other high trophic level marine animals, or relying on stored food. The mixed marine-terrestrial groups may have moved between the coast and the interior of the province. These results find support in the recent research of Lacroix (2015) who proposed separate Archaic ‘countries’ in

Newfoundland and the Strait of Belle Isle that may have corresponded to differences in diet and material culture.

It was not possible to address inter-individual differences between the later Amerindians, except from a diachronic perspective, but this perspective proved to be thought provoking and shed light on the influence of European settlement on Beothuk lifeways. Carbon and nitrogen isotopes analysis was conducted on bone collagen of 13 Recent Indian/Beothuk individuals, and isotopes of carbon were measured in the enamel carbonate of 11 individuals. The results were added to those of an earlier pilot study and, combined with radiocarbon analysis, supported many of the findings of current archaeological research, namely the timing of the development of a generalized marine adaptation, and the maintenance of the adaptation until European fishermen began to settle the island's shores in earnest. Then, consistent with accounts of the restriction of the Beothuk from the coast, skeletons dating to the 19th century evidenced this with lower $\delta^{13}C$ and $\delta^{15}N$ values, indicative of a reduced consumption of marine protein relative to precontact and early historic skeletons.

8.2 Limitations of this study

Studies employing stable isotope analysis of bulk tissues are frequently restricted to drawing broad conclusions from their data, and the research presented here was similarly limited. Overlap in faunal isotope values, and the averaging effects of the body's amino acid pool reduce the ability of this method to make meaningful, fine-grained palaeodietary reconstructions. Instead, this research is limited to making generalizations regarding the contribution of marine and terrestrial resources, rather than more detailed estimations of the prey classes consumed by Amerindian people.

Further sampling of faunal material provides one means of improving dietary resolution. This research did not sample faunal remains dating to Maritime Archaic period and thus, the geographic and temporal resolution of faunal remains sampled is not very representative. This could be masking temporal or geographic differences in the isotopic baseline that may affect the reconstruction of Maritime Archaic subsistence (Casey and Post 2011; Hedges et al. 2004). Although the Port au Choix-3 fauna do represent a mortuary assemblage and thus cannot be used to reconstruct subsistence using zooarchaeological methods, the cultural meanings attributed to the grave offerings have no bearing on the isotope ecology of the time period. Therefore, a discrete sampling of the assemblage should be conducted to broaden the carbon and nitrogen isotopic baseline to include the Maritime Archaic occupation.

Sample size is another obvious limitation faced by this study, and by many bioarchaeological studies. While the Port au Choix-3 skeletal sample featured a large MNI, far fewer Recent Indian skeletons were available for study. This raises the question of how representative these individuals were of the entire population. While, there is no way to be certain, the isotopic results did appear to be consistent with much of the archaeological record for this time period (e.g. Holly 2008), suggesting that the recovered skeletons may have been representative of broader population level dietary trends.

Finally, this research attempted to provide a diachronic reconstruction of Amerindian palaeodiet that was anchored to a radiocarbon-based chronology developed in large part from human bone collagen dates. Human bone dates have been widely avoided in Newfoundland archaeology as these are influenced by the marine radiocarbon reservoir (e.g. Renouf and Bell 2011). This research calibrated the dates using a mixed-marine curve and linear interpolation to estimate the amount of marine derived carbon in each sample. Considerable uncertainty was included in these calculations that increased the confidence limits associated with each date. This was not a serious issue for the Maritime Archaic sample as the calibration curve for this time period is relatively steep, reducing some of the calibration uncertainty. However, the probability associated with each Recent Indian date was reduced due to plateaus in the calibration curve, combined with uncertainty of percent marine carbon estimations. The Recent Indian dates must also be judged with extra caution due to uncertainty regarding the appropriate ΔR for Notre Dame Bay and the Bay of Exploits.

8.3 Recommendations for future research

One of the major findings of this research was the variation observed between and within sex and age groups of the Port au Choix-3 burial population. These results expanded on those of Jelsma (2000), but did not draw the same conclusions, suggesting that instead of status-specific diets, other sources of isotopic variation should be investigated. One of these, geographic origin, can be investigated by measuring isotopes of oxygen and strontium in the teeth of the people buried at Port au Choix-3. The ratio of oxygen-18 to oxygen-16, or $\delta^{18}O_{ew}$, of environmental water varies regionally with local climatic variables (Dansgaard 1964). This variation is recorded in new forming bone and enamel bioapatite of mammals. The oxygen isotope composition of enamel or bone phosphate has a roughly linear relationship with the composition of environmental water, allowing one to be estimated from the other (Longinelli 1984). Oxygen isotope analysis of tooth enamel is most commonly used in palaeoclimate studies as the oxygen isotope composition of environmental water is temperature dependent, however, given the relationship of $\delta^{18}O_{ew}$ to local climatic and geographic variables, it is also used in archaeological studies as an indicator of mobility (e.g. Evans et al. 2006). By measuring the oxygen isotope ratio in human dental enamel, this relationship is used to distinguish locals from non-locals in a burial population, based on a comparison of the human $\delta^{18}O$ values with the local $\delta^{18}O_{ew}$ as determined by measuring water samples, or through the analysis of local archaeological animals for whom the fractionation between $\delta^{18}O_{ew}$ and $\delta^{18}O$ of their body water and enamel phosphate is known (e.g. Budd et al. 2003; Bentley and Knipper 2005).

Strontium isotopes can be used as an independent geographic indicator to compliment and facilitate the interpretation of oxygen isotope data. The use of strontium isotopes in ecology and archaeology is rooted in observations of the variation in $^{87}Sr/^{86}Sr$ ratios and strontium concentrations between different rock types and rocks of different ages (Faure 1986). The $^{87}Sr/^{86}Sr$ ratio of the geology of a region weathers into the soil, is taken up by plants which in turn, are consumed by animals (Capo et al. 1998). The similarity of the atomic radius of strontium allows it to substitute for calcium in a variety of minerals, including the apatites of animal skeletons (Capo et al. 1998). The heavy atomic mass of strontium allows it to pass through low-temperature (relatively speaking) biological systems with minimal isotopic fractionation (Capo et al. 1998). The $^{87}Sr/^{86}Sr$ in plant and animal tissues should therefore be characteristic of their region of origin. This research is ongoing, but further work is required to develop a comparative dataset to enable interpretation of the human oxygen and strontium datasets.

Another worthwhile venture would involve expanding upon the marine radiocarbon reservoir dataset with a focus on determining the marine radiocarbon reservoir for the Bay of Exploits and Notre Dame and Bonavista Bays and providing a diachronic reconstruction of the ΔR of the province. This would allow for greater certainty in the calibration of the radiocarbon dates presented here, and future radiocarbon determinations.

Finally, new statistical models (e.g. Fernandes et al. 2014) are available that may allow for quantitative dietary reconstructions to be accomplished, but these require the use of multiple isotopic dietary proxies. Some promising lines of evidence include whole dietary carbon analysis of bone lipids (e.g. Colonese et al. 2015), or compound specific isotope analysis of individual bone collagen amino acids (e.g. Styring et al. 2010).

8.4 Chapter summary

This research conducted stable isotope analysis on Amerindian skeletal remains from Newfoundland with the aim of providing a better understanding of human subsistence on the island over a period of 5000 years. The results of this research yielded some insights into Maritime Archaic and Recent Indian subsistence practices that require further investigation. For example, the results suggested intra-population variation within the Maritime Archaic skeletal sample. Further investigation is required to assess the source of this variability, but these findings are notable as, through the bioarchaeological study of this population, a more detailed palaeodiet reconstruction was possible that moved beyond the coarse resolution provided by the limited archeological data.

With regards to the Recent Indian skeletal sample, stable isotope analysis and radiocarbon dating have provided direct evidence for the alteration of Beothuk lifeways over the historic period and have acted to ground truth the rich archaeological research of this period. This research has not been without its limitations. Faunal remains with which to anchor and interpret the human data are few for the Maritime Archaic occupation. The poor archaeological context and preservation of the Recent Indian skeletons limits the interpretations that can be drawn from the isotope data with respect to some of the cultural meanings that the Recent Indian people may have attributed to food.

This research was not meant to be the last word in biomolecular studies of the island populations. The results of this research have spawned further lines of questioning. Foremost of these is the investigation of the geographic origins of the Maritime Archaic people buried at Port au Choix-3 using strontium and stable oxygen isotope analysis. This research has been undertaken by the author, but considerable work remains to be invested in the development of appropriate isotopic baselines. The variability in Maritime Archaic diets can be further investigated through novel biomolecular methods. Further work needs to be completed to determine appropriate ΔR values for the coast of Newfoundland, as well as palaeoclimate reconstruction of the terrestrial environment.

The island of Newfoundland may seem like an ecological and economically marginal environment to members of the modern populations who inhabit it, but research suggests that it was not so to past archaeological populations. The research presented here provides further evidence that the island’s unique environmental and geographic parameters merely shaped, but did not determine the adaptive strategies employed by past people.

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PERSONAL COMMUNICATIONS

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APPENDIX 1

Table A.1.a Bone and tooth tissue samples from Port au Choix-3 (EeBi-2), reported by NP number, for isotopic, radiocarbon and ancient DNA analysis.

NP No.	Sex	Age	^{14}C	$\delta^{13}C$ and $\delta^{15}N$ collagen
1A	M	Old adult		*
1B	F?	Young adult		*
1C	?	Newborn		*
3	F?	Adolescent	Rib	*
4	F?	Adult		*
5	M	Young adult		Right metatarsal
6	F	Young adult	Rib	Rib
7	F?	Young adult		Rib
8A	M	Middle adult	Rib	Rib
9	F?	Adult	Mandible	*
10A	F	Old adult	Rib	*
11A	?	Infant		*
12	M	Adult		*
14A	M	Old adult	Rib	Rib
14B	?	Juvenile		Mandible
15	M	Adult		Right femur
16A	F	Adult		*
16C	?	Newborn		Temporal
18A	M	Adult		*
19	M	Adult		Long bone
20	?	Newborn		Temporal
21	F	Old adult		Rib
22A	?	Newborn		*
22B	?	Infant		Radius
22C	?	Infant		Radius
22D	M	Old adult		Long bone
23	?	Adult		Rib
24B	?	Adolescent		Phalange
25	F?	Young adult		*
26	?	Newborn		Right humerus
27A	M	Young adult		*

27B	?	Newborn		Ulna
28A	F	Young adult		Rib
28B	?	Adult		Mandible
29	M	Adult		*
30C	M	Old adult		*
31	M	Adult	Left humerus	*
32	M	Adult		*
33	?	Infant		*
34	M	Adult		*
35A	M	Adult		*
35B	?	Infant		Rib
36A	?	Juvenile		*
36B	?	Newborn		Long bone
37A	M	Adult	Right tibia	*
37A1	?	Juvenile		
37B	F	Adult	Right tibia	*
37B1	?	Adolescent		Right tibia
37C	F?	Adult		Fibula
37C1	?	Juvenile		Skull
37C2	?	Juvenile		Right tibia
37D	?	Adolescent		Radius
37E	?	Adolescent		Left femur
37F	?	Juvenile		Right femur
37G	?	Juvenile		Left ulna
37H	?	Juvenile		Long bone
37I	?	Juvenile		
37J	?	Newborn		Rib
37K	?	Juvenile		Rib
38A	?	Juvenile		Rib
38B	?	Newborn		
40A	M	Adult		*
40B	?	Newborn		Rib
41	?	Juvenile		Mandible
42	?	Infant		Femur
43A	?	Infant		Rib
43B	?	Adolescent		Rib
44A	F	Adult		*
44B	M?	Adult	Left fibula	Left fibula
45	?	Juvenile		Skull
46A	M?	Adult	Rib	*
46B/C	?	Adolescent		Fibula

47A	M	Middle to old adult	Rib	*
47B	M	Middle to old adult	Rib	Rib
48	?	Newborn		Temporal
49A	F	Adult	Rib	*
50A	F	Adult	Rib	*
50B	M	Adult	Skull	*
50C	?	Infant	Long bone	Rib
51	?	Adult		Rib
52	F	Old adult		*
60A	F	Adult		Right scapula
60B	F	Adult		Humerus
60C	?	Adult		
60D	M?	Adolescent		Left scapula
60E	F	Adolescent		Maxilla
60F	?	Adolescent		Left ulna
60G	?	Adult		Left tibia
60H	?	Juvenile		Palatine
60I	?	Juvenile		Right clavicle
61A	F	Young adult		Rib
61B	F	Adolescent		Rib
161	?	Infant		Rib
162A	F	Adult	Right ulna	Right ulna
162C	?	Juvenile		Left femur
162D	?			Rib
162E	?			Right radius
162F	?	Adult		Scapula
162G	?			Long bone
164	?	Adult		Left femur
171	?	Infant	Maxilla	Maxilla
275A	?	Adult		Left humerus
276	?	Adult		Left humerus
277	?	Adult	Skull	Parietal
282	?	Infant	Temporal	Long bone fragment
285	?	Adult	Right femur	Right femur and rib
286	?	Adult	Right femur	Right femur

*Sampled by Jelsma (2000)

Table A.1.b Bone and tooth tissue samples from Recent Indian and Beothuk individuals reported by site and NP/museum number for isotopic, and radiocarbon analyses.

Site	NP/ID	Sex	Age	^{14}C	$\delta^{13}C$ and $\delta^{15}N$ collagen	$\delta^{13}C$ enamel carbonate
Big Island	240	?	Juvenile	Rib	Rib	
Big Island	265	?	Middle adult		**	Left M^2
Charles Cove	XIII-A-12a	?	Adult	Left temporal	Left temporal	
Charles Cove	XIII-A-13a	M	Adult	Right tibia	Right tibia	
Charles Cove	XIII-A-13b	?	Adult	Right femur	Right femur	
Charles Cove	XIII-A-14	?	Juvenile	Right femur	Right femur	
Comfort Is.	152	M	Middle adult		**	
Comfort Is.	294	?	Adult		**	
Comfort Is.	296	M?	Adult		**	Left PM^1
Cranberry Is.	151	M	Middle adult		**	Left PM_2
Devil's Cove	299	?	Adult			Right M^1
Devil's Cove	XIII-A-15	?	Adult	Scapula	Scapula	
Fox Bar	270A	?	Young adult		**	Right PM_2
Fox Bar	270B	M?	Middle adult		**	Right M_3
Fox Bar	270C	?	Adult		**	
Fox Bar	270D	?	Juvenile	Left ilium	Left ilium	
Fox Bar	270E	?	Infant	Vertebra		
Fox Bar	270F	?	Adult			
Fox Bar	270G	?	Adult			Left PM_2
High Greco Is.	290	F?	Adult		**	
Indian Cove	297?	?	Adult		**	
Indian Cove	298	?	Adult		**	Left PM^1
Ladle Point	266	F?	Middle adult	Skull	Skull and molar root	Left M^2
Long Is.	XIII-A-1	M	Adult	Right	Right femur,	

				femur	radius, and rib	
Long Is.	XIII-A-2-1	?	Juvenile	Right temporal		
Long Is.	XIII-A-2-2	F	Adult	Left temporal	Left temporal	
Long Is.	XIII-A-8	F	Adult			
Rogers Cove	268	M?	Middle adult	Temporal	Temporal	Left M^3
Swan Is.	291	?	Adult		**	
Swan Is.	292	?	Juvenile	Zygomatic		
Swan Is.	XIII-A-10	?	?	Metacarpal	Metacarpal	
Western Indian Is.	XIII-A/3c	?	?	Long bone	Long bone	

** Previously sampled by Grimes et al. 2011

APPENDIX 2

Table A.2.a Measured $\delta^{13}C$ and $\delta^{15}N$ values, and collagen quality indicators in Newfoundland fauna from all Dorset and Recent Period archaeological sites.

Species	**Marc**	**% Yield**	**% C**	**% N**	**C:N**	**$\delta^{13}C_{VPDB}$ (‰)**	**$\delta^{15}N_{AIR}$ (‰)**
Boyd's Cove DiAp-3							
R. tarandus	3163	-	-	-	-	-	-
U. americanus	3164	-	-	-	-	-	-
B.canadensis	3165	7.6	38.2	14.1	3.2	-8.36	10.0
Somateria sp.	3166	6.7	39.8	14.0	3.3	-9.6	12.0
M.Americana	3167	10.0	42.2	15.0	3.3	-9.9	11.8
L.canadensis	3168	5.7	39.5	14.2	3.2	-8.9	16.2
Myoxocephalus sp.	3169	7.2	39.8	14.5	3.2	-10.7	14.4
B. canadensis	3170	-	-	-	-	-	-
Hermitripteridae sp.	3171		39.3	14.2	3.2	-10.4	14.6
Phalacrocorux	3172	9.5	38.4	13.9	3.2	-10.4	15.3
Cepphus grylle	3173	16.1	41.4	15.0	3.2	-15.1	13.8
Ursus maritimus	3174	4.8	39.3	13.8	3.3	-13.9	19.8
Castor canadensis	3175	9.2	40.4	14.2	3.3	-14.2	18.0
Phalacrocorux sp.	3176	12.1	42.3	15.2	3.2	-11.7	12.5
Osmeridae	3177	7.5	40.8	14.6	3.3	-18.7	10.3
			42.7	15.1	3.3	-19.4	10.0
B. canadensis	3178	16.6	42.9	15.7	3.2	-6.9	8.4
Erignathus barbatus	3179	11.9	44.0	16.1	3.2	-13.6	16.2
L. canadensis	3180	6.7	41.2	14.7	3.3	-9.7	15.7
Phoca vitulina	3181	1.6	9.26	2.24	4.8	-17.3	19.2
R. tarandus	3182	4.8	43.9	14.6	3.5	-20.5	2.0
Gavia immer	3183	10.9	44.9	12.9	4.1	-21.2	13.0
L. canadensis	3184	5.1	42.6	15.4	3.2	-9.9	15.8
Uria algaae	3185	8.0	27.2	9.0	3.5	-17.9	15.1
Beaches DeAk-1							
R. tarandus	3186	3.0	35.2	12.2	3.4	-18.0	5.8
			38.7	12.1	3.7	-19.8	5.6
C. canadensis	3187	15.0	42.5	15.5	3.2	-14.3	19.0
L. canadensis	3188	13.8	44.1	16.4	3.1	-11.5	18.4
P. vitulina	3189	8.5	36.4	13.6	3.1	-14.7	16.8
U. americanus	3190	10.5	42.8	16.1	3.1	-18.7	9.3
			44.3	16.4	3.2	-18.6	8.8
C. canadensis	3191	-	-	-	-	-	-
Seal sp.	3192	11.1	43.4	15.9	3.2	-14.4	17.4
Bird sp.	3193	12.7	43.4	15.5	3.3	-14.3	13.1
L. canadensis	3194	6.9	35.3	13.0	3.2	-10.7	18.7
Vulpes sp.	3195	5.3	40.7	14.1	3.4	-16.5	14.6
L. canadensis	3196	5.2	40.6	15.1	3.1	-12.1	17.9
C. canadensis	3197	8.7	41.1	15.0	3.2	-21.7	2.5
P. vitulina	3198	5.6	36.0	12.8	3.3	-15.2	15.6
P. groenlandicus	3199	11.4	42.7	15.7	3.2	-12.7	19.8

R. tarandus	3200	9.0	42.3	15.2	3.2	-18.7	3.3
Wigwam Brook DfAw-1							
R. tarandus	3201	9.5	43.3	16.3	3.1	-18.0	5.6
C. canadensis	3202	5.7	39.5	14.8	3.1	-22.2	1.7
U. americanus	3203	16.5	45.9	16.7	3.2	-19.6	7.2
R. tarandus	3204	17.4	41.8	15.4	3.2	-18.8	4.5
Parke's Beach DgBm-1							
Seal sp.	3205	3.4	37.5	13.2	3.3	-15.1	18.0
			38.2	13.4	3.3	-15.1	15.2
Seal sp.	3206	1.2	32.3	11.5	3.3	-15.3	16.4
R. tarandus	3207	10.4	40.2	14.2	3.3	-18.7	3.8
R. tarandus	3208	-	-	-	-	-	-
C. canadensis	3209	8.0	43.0	16.0	3.1	-22.9	1.6
Port au Port DdBq-1							
R. tarandus	3210	1.7	39.1	14.2	3.2	-18.5	4.4
R. tarandus	3211	11.4	36.6	12..2	3.5	-19.9	5.1
C. canadensis	3212	4.9	41.4	14.0	3.4	-22.5	2.9
Seal sp.	3213	5.4	43.1	15.4	3.3	-15.4	14.2
Indian Point DeBd-1							
R. tarandus	3214	14.2	84.2	30.2	3.3	-16.7	8.9
			44.6	16.0	3.3	-18.3	3.3
R. tarandus	3215	16.7	35.1	13.1	3.1	-18.2	4.6
R. tarandus	3216	12.4	44.4	16.4	3.2	-19.2	1.5
			45.5	16.3	3.3	-18.8	1.6
Peat Garden North EgBf-18							
P. groenlandicus	3291	8.0	42.2	14.6	3.4	-15.0	14.4
R. tarandus	3292	3.4	36.0	11.9	3.5	-20.5	3.2
Gull sp.	3293	11.1	43.8	15.4	3.3	-17.0	11.5
B. canadensis	3294	6.4	42.8	15.2	3.3	-14.7	6.6
B. canadensis	3295	10.5	43.4	15.3	3.2	-16.7	7.4
Seal sp.	3296	6.6	43.7	14.6	3.5	-13.7	16.0
U. americanus	3297	17.8	43.9	15.5	3.3	-20.7	8.4
Lepus arcticus	3298	14.3	43.3	15.3	3.3	-22.2	2.5
P. groenlandicus	3299	10.6	39.9	14.4	3.2	-12.5	17.1
R. tarandus	3300	4.9	33.3	11.0	3.5	-19.7	3.6
R. tarandus	3301	5.9	40.5	14.0	3.4	-18.9	1.5
B. canadensis	3302	4.6	39.1	12.7	3.6	-17.8	6.0
B. canadensis	3303	8.4	43.7	14.9	3.4	-19.6	6.6
Phocid sp.	3304	3.3	34.9	12.4	3.3	-14.5	15.4
R. tarandus	3305	5.2	-	-	-	-	-
P. groenlandicus	3306	9.4	44.4	15.3	3.4	-15.4	16.0
P. groenlandicus	3307	12.9	41.3	14.2	3.4	-15.1	14.7
Thunnus thynnus	3308	9.9	44.0	15.7	3.3	-12.9	10.8
Crow Head Cave EeBi-4							
Alle alle	2330	14.0	44.6	15.9	3.3	-16.2	14.8
A. alle	2331	15.9	41.8	15.1	3.2	-17.2	14.3
A. alle	2332	12.9	43.1	15.4	3.3	-16.3	13.5
A. alle	2333	13.6	44.8	15.7	3.3	-17.1	15.4

A. alle	2334	14.5	42.5	15.2	3.3	-17.5	15.8
A. alle	2335	14.2	44.6	15.8		-17.4	15.2
A. alle	2336	11.1	42.0	14.8		-17.1	14.3
A. alle	2337	8.5	40.8	14.6	3.3	-16.4	14.3
A. alle	2338	15.8	42.6	15.1	3.3	-17.0	14.6
A. alle	2339	13.9	41.6	14.8	3.3	-16.8	15.6
Uria algaae	2344	11.0	42.8	14.4	3.5	-15.9	16.9
U. algaae	2345	13.3	43.7	15.2	3.4	-16.4	18.0
U. algaae	2346	14.0	43.5	15.2	3.3	-16.2	17.6
U. algaae	2347	13.0	43.3	14.9	3.4	-16.8	17.7
U. algaae	2348	14.8	43.4	15.2	3.3	-15.6	17.6
Fratercula arctica	2349	14.8	43.5	15.1	3.4	-15.4	14.3
F. arctica	2350	14.3	42.9	15.1	3.3	-15.6	13.8
Penguinis impennis	3310	19.2	44.4	16.1	3.2	-16.1	11.8
P. impennis	3311	17.0	44.6	15.9	3.3	-15.9	13.2
P. impennis	3312	19.2	44.9	16.2	3.2	-15.8	14.8
Melanitta sp.	3321	16.9	42.6	15.1	3.2	-10.7	15.5
Melanitta sp.	3317	17.7	43.1	15.5	3.2	-10.6	15.6
Gadus sp.	2340	10.8	41.6	14.8	3.3	-13.9	16.7
Gadus sp.	3313		44.3	16.7	3.1	-14.4	14.2
Gadus sp.	3314	8.6	44.8	16.0	3.3	-16.1	14.9
B. canadensis	3315	19.5	43.0	15.6	3.2	-18.8	3.8
Lagopus sp.	3319	16.5	44.6	15.5	3.3	-20.2	0.5
Lagopus sp.	2355	15.0	39.7	14.1	3.3	-20.1	1.3
Lagopus sp.	2356	14.4	42.7	15.0	3.3	-19.2	1.2
Tautogolabrus sp.	3323	17.4	45.0	16.8	3.1	-16.4	12.1
Tautogolabrus sp.	3327	14.6	44.3	13.5	3.2	-15.1	13.5
Sebastes sp.	3324	9.7	41.2	15.5	3.1	-14.5	13.5
Myoxocephalus sp.	3325	10.9	44.0	16.4	3.1	-13.1	16.2
Myoxocephalus sp.	3326	12.9	44.3	16.2	3.2	-10.7	14.6
Myoxocephalus sp.	2342	10.6	42.6	15.4	3.2	-10.4	14.8
Myoxocephalus	2343	10.0	43.7	15.1	3.4	-12.7	13.6
Phocidae sp.	3328	17.9	39.1	14.2	3.2	-15.0	15.9
Phocidae sp.	2351	13.3	42.6	15.1	3.3	-13.7	16.4
Phocidae sp.	2352	19.0	41.6	15.0	3.2	-14.4	13.4
P. groenlandicus	3318	5.2	44.3	14.2	3.6	-15.7	16.0
Ursus arcticus	2353	23.0	44.1	16.2	3.2	-14.1	19.3
Martes martes	2357	20.0	43.8	16.0	3.2	-20.8	6.2
Ondontra zibethicus	3320	21.8	44.6	15.1	3.5	-22.5	5.9
C. canadensis	3322	13.7	45.0	16.3	3.2	-21.5	4.2
Lepus arcticus	2358	14.7	39.7	14.2	3.3	-20.6	0.5

Table A.2.b Measured δ^{13}C and δ^{15}N values, and collagen quality indicators from all Maritime Archaic human samples. δ^{13}C and δ^{15}N are expressed relative to VPDB and AIR, respectively.

NP	**Locus**	**Marc**	**% Yield**	**%C**	**%N**	**C:N**	**δ^{13}C (‰)**	**δ^{15}N (‰)**
1C	II	2729	3.4	43.4	12.5	4.1	-17.6	16.3
		3243	2.7	42.8	15.2	3.3	-14.7	22.4
4	II	2736	18.3	46.6	16.2	3.4	-14.2	20.4
5	II	2714	1.6	38.1	12.1	3.7	-15.8	20.1
		3244	2.2	42.5	15.7	3.2	-15.2	17.5
6	II	2646	-	-	-	-	-	-
7	II	2642	9.4	46.2	16.3	3.3	-14.0	20.3
		2642d	9.4	45.4	16.0	3.3	-13.8	20.4
8A	II	2727	22.2	43.2	15.1	3.3	-14.4	21.0
10A	II	2628	7.0	45.4	16.4	3.2	-14.3	19.2
14A	II	2636	14.4	44.5	16.0	3.3	-14.2	18.9
14B	II	3254	1.6	41.4	14.2	3.4	-14.1	22.1
15	II	2632	3.0	41.0	12.6	3.8	-16.5	19.5
		2632(b)	1.8	42.7	15.4	3.2	-14.3	20.4
16C	II	2716	2.3	45.2	13.2	4.0	-16.2	22.4
		3256	2.8	43.1	15.7	3.2	-13.0	23.3
19	II	2735	2.4	45.2	15.1	3.5	-14.7	21.0
20	II	3257	1.8	40.5	14.4	3.3	-14.4	23.6
21	II	2619	9.9	43.2	15.19	3.3	-13.6	21.1
22B	II	2725	12.7	46.4	16.1	3.4	-14.3	20.4
22C	II	2713	2.6	44.6	15.5	3.4	-14.0	22.2
22D	II	2645	7.8	44.0	14.0	3.6	-15.9	19.5
23	II	2732	7.4	40.3	13.8	3.4	-14.9	20.5
24B	II	2719	24.8	46.4	16.5	3.3	-13.8	20.6
26	II	2723	19.1	45.7	15.6	3.4	-16.8	19.6
27B	II	2730	1.8	45.7	14.6	3.7	-16.6	20.8
		3252	1.7	41.6	15.1	3.2	-15.0	21.9
28A	II	2614	13.7	45.7	15.6	3.4	-14.1	21.6
28B	II	2640	5.3	45.1	15.2	3.5	-14.2	21.1
30	II	2726	14.8	47.0	16.9	3.2	-14.0	20.5
35B	II	2738	13.9	38.8	13.0	3.5	-15.9	20.3
36B	II	3248	2.5	41.2	14.5	3.3	-15.4	22.0
37B1	II	2737	0.7	41.4	13.3	3.6	-15.4	20.6
37C	II	2715	3.5	46.1	15.4	3.5	-14.2	22.2
37C1	II	2731	11.4	41.9	14.9	3.3	-13.5	20.8
37C2	II	3250	5.9	43.8	15.8	3.2	-13.0	22.4
37D	II	2718	3.5	46.1	15.9	3.4	-14.9	20.9
37E	II	3247	5.2	41.9	14.7	3.3	-14.6	20.8
37F	II	3253	2.7	43.0	15.7	3.2	-13.3	22.5

37G	II	3246	2.3	42.9	14.9	3.4	-14.5	21.6
37H	II	3251	7.1	43.0	15.1	3.2	-14.1	21.8
37J	II	2721	18.3	46.4	15.8	3.4	-13.5	23.9
37K	II	2720	17.0	46.7	16.2	3.4	-13.9	21.1
38A	II	2624	24.0	46.4	16.6	3.3	-13.4	20.3
40B	II	2722	15.1	46.2	15.9	3.4	-15.6	20.4
41	II	2734	20.3	46.1	15.8	3.4	-14.8	18.4
42	II	2724	1.0	42.6	13.9	3.6	-14.3	22.0
43A	II	2728	11.6	-	-	-	-	-
43B	II	2717	5.8	47.0	15.9	3.5	-14.4	20.9
44B	II	2643	8.9	43.5	14.8	3.4	-14.7	20.2
45	II	2844	7.9	44.0	15.3	3.3	-15.1	20.2
46B/C	II	2845	18.1	46.5	16.1	3.4	-14.4	20.4
46D	II	2846	5.4	46.0	14.9	3.6	-15.7	22.5
47B	II	2611	18.3	45.0	16.0	3.3	-14.6	19.4
		2611d		45.8	16.3	3.3	-14.6	19.6
48	II	3258	10.3	41.8	14.8	3.3	-14.2	22.6
50C	II	3249	8.6	44.3	15.5	3.3	-13.3	18.3
51	II	2621	8.9	44.3	14.8	3.5	-14.4	19.4
		2621d	8.9	44.5	14.9	3.5	-14.4	19.4
60A	I	2626	19.8	46.4	16.6	3.3	-14.0	20.6
60B	I	2847	2.6	47.2	16.8	3.3	-13.5	20.3
60D	I	2618	25.7	46.4	16.5	3.3	-13.6	20.1
60E	I	2633	12.4	46.5	16.4	3.2	-13.8	19.9
60F	I	2612	12.8	43.8	15.7	3.3	-14.0	19.3
60G	I	2629	23.9	47.4	16.5	3.3	-14.3	19.4
60H	I	3241	7.2	43.8	16.1	3.2	-13.7	21.4
60I	I	2620	18.4	45.9	16.2	3.3	-13.9	20.1
61A	I	2623	13.9	40.6	14.5	3.3	-14.1	20.0
61B	I	2615	22.4	45.2	16.1	3.3	-14.4	19.5
161	V	2622	11.6	46.3	16.5	3.3	-14.2	23.0
162A	V	2739	19.6	46.2	15.7	3.4	-14.5	20.3
		2739d	19.6	43.3	14.9	3.3	-15.4	20.2
162C	V	2637	23.2	41.7	14.9	3.3	-14.0	18.9
162E	V	2641	2.7	40.9	11.4	4.2	-17.8	18.9
162E		3255	1.7	39.3	14.0	3.3	-15.0	19.1
162F	V	2853	9.8	43.8	15.5	3.3	-14.2	20.3
162G	V	2851	22.7	46.1	16.4	3.3	-14.0	19.4
171	V	2855	10.6	47.0	16.6	3.3	-13.7	22.1
275A	V	2856	15.4	45.0	15.5	3.4	-14.2	19.9
276	V	2625	22.4	43.4	15.4	3.3	-14.9	18.0
277	V	2857	1.2	45.5	15.2	3.5	-16.0	18.8
282	IV	2733	3.9	46.2	14.6	3.7	-16.7	17.9

285	V	2634	10.1	42.3	15.3	3.2	-13.4	20.6
286	V	2858	11.5	45.2	16.1	3.3	-14.0	20.0

Table A.2.c Measured δ^{13}C and δ^{15}N values, and collagen quality indicators from all Recent Indian and Beothuk human samples. δ^{13}C and δ^{15}N are expressed relative to VPDB and AIR, respectively.

NP	**Site**	**Marc**	**% Yield**	**%C**	**%N**	**C:N**	**δ^{13}C (‰)**	**δ^{15}N (‰)**
268	Rogers Cove	3242	11.0	43.4	15.8	3.2	-14.7	17.8
270D	Fox Bar	2513	16.7				-15.3	16.4
270F	Fox Bar						-14.5	17.9
270G	Fox Bar						-14.2	18.3
XIII-A-1	Long Is.	3485	9.0	47.0	17.2	3.2	-14.4	15.8
		3486	10.3	46.7	17.1	3.2	-14.8	16.7
		3476	11.1	45.9	16.7	3.2	-14.6	15.9
XIII-A-2-2	Long Is.	3479	9.7	45.3	16.5	3.2	-14.9	16.2
XIII-A3c	Western Indian Is.	3483	6.7	46.4	16.7	3.2	-15.1	17.0
XIII-A-12a	Devil’s Cove	3480	6.9	44.6	16.1	3.2	-14.2	17.0
XIII-A-13a	Charles’ Arm	3478	9.5	47.0	17.2	3.2	-15.4	16.1
XIII-A-13b	Charles Arm	3481	10.2	46.1	16.9	3.2	-15.5	15.1
XIII-A-14	Charles Arm	3484	6.8	47.6	17.5	3.2	-15.5	14.9
XIII-A-15	Swan Is.	3482	9.3	46.8	16.9	3.2	-14.3	16.7

Table A.2.d Enamel carbonate δ^{13}C values relative to VPDB.

NP/Museum No	**Site**	**Marc**	**δ^{13}C(‰)**
151	Cranberry Island	3405	-9.8
152	Comfort Cove	3403	-10.6
266	Ladle Point	3399	-11.9
265	Big Island	3401	-9.5
268	Roger’s Cove	3404	-9.8
270A	Fox Bar	3400	-9.8
270B	Fox Bar	3402	-10.1
270G	Fox Bar	3410	-10.3
296	Comfort Cove	3406	-10.1

APPENDIX 3: RADIOCARBON DATES

Table A.3.a Human radiocarbon ages, calculated percent marine carbon, and calibrated radiocarbon dates presented to 2σ. Data from Jelsma (2000) included.

NP	**Lab No.***	**^{14}C Age B.P.**	**Error ± Yrs.**	**Marine C (%)**	**Median cal BP**	**2σ range**	**Median cal BC**	**2σ range**
1B	GrA-6478*	4220	50	75	4275	4504-4065	2326	2555-2116
3	UCIAMS 167190	4085	15	73	4097	4285-3909	2148	2336-1960
6	UCIAMS 167196	4105	25	88	4035	4233-3838	2083	2284-1889
8A	UCIAMS 159440	4105	25	79	4092	4293-3890	2143	2344-1941
9	UCIAMS 167189	3985	15	82	3905	4085-3712	1956	2136-1763
10A	UCIAMS 159441	4135	25	80	4122	4343-3923	2173	2394-1974
12	GrA-6479*	4160	50	77	4181	4409-3963	2232	2460-2014
14A	UCIAMS 167192	4060	15	82	4005	4211-3827	2056	2262-1878
18A	GrA-6525*	4000	50	84	3913	4140-3689	1964	2191-1740
25	GrA-6526*	4150	50	95	4050	4340-3864	2101	2355-1868
30C	GrA-6501	4130	50	84	4089	4340-3864	2140	2391-1915
31	UCIAMS 159449	4050	25	52	4192	4400-4000	2243	2451-2051
35A	GrA-6527*	4110	50	48	4299	4510-4091	2350	2561-2142
36A	GrA-6495*	4150	50	89	4084	4339-3855	2135	2390-1906
37A	UCIAMS 159442	4065	25	86	3987	4213-3805	2038	2264-1856
37B	UCIAMS 159443	4035	30	82	3972	4174-3768	2023	2225-1819
40A	GrA-6496*	4000	50	59	4070	4291-3857	2121	2342-1908
44B	UCIAMS 167194	4110	15	73	4134	4348-3954	2185	2399-2005
46A	UCIAMS 167193	4335	20	88	4348	4526-4145	2399	2577-2196
47A	UCIAMS 159444	4045	25	93	3916	4121-3705	1967	2172-1756
47B		3995	15	75	3961	4149-	2012	2200-

						3802		1853
49A	UCIAMS 159445	4165	25	>100	4041	4216-3879	2092	2267-1930
50A	UCIAMS 159446	4125	25	91	4033	4238-3833	2084	2289-1884
50B	UCIAMS 159447	4175	25	84	4154	4378-3960	2205	2429-2011
50C	UCIAMS 159448	4170	25	98	4048	4222-3884	2099	2273-1935
60A	UCIAMS 125918	4430	20	86	4489	4775-4284	2540	2829-2335
60B	UCIAMS 125922	4360	20	84	4406	4605-4205	2457	2656-2256
60C		4460	20	83	4484	4775-4272	2535	2826-2323
60D	UCIAMS 125917	4420	20	93	4430	4645-4210	2481	2696-2261
60I		4435	20	88	4490	4778-4283	2541	2829-2334
61A	UCIAMS 125921	4365	20	84	4414	4611-4211	2465	2662-2262
61B	UCIAMS 125920	4355	20	79	4442	4628-4231	2493	2679-2282
162A	UCIAMS 154070	4345	15	77	4434	4612-4235	2485	2663-2286
162C	UCIAMS 154053	4420	15	86	4476	4699-4266	2527	2750-2317
164	UCIAMS 125916	4405	20	73	4543	4789-4395	2594	2840-2446
171	UCIAMS 154062	4450	15	89	44970	4778-4292	2548	2840-2446
285	UCIAMS 167195	4385	20	96	4357	4553-4141	2408	2604-2192
286	UCIAMS 159455	4485	30	86	4571	4800-4398	2622	2851-2449
277	UCIAMS 159453	4365	25	50	4649	4825-4450	2700	2876-2501

Note: * Denotes data from Jelsma (2000).

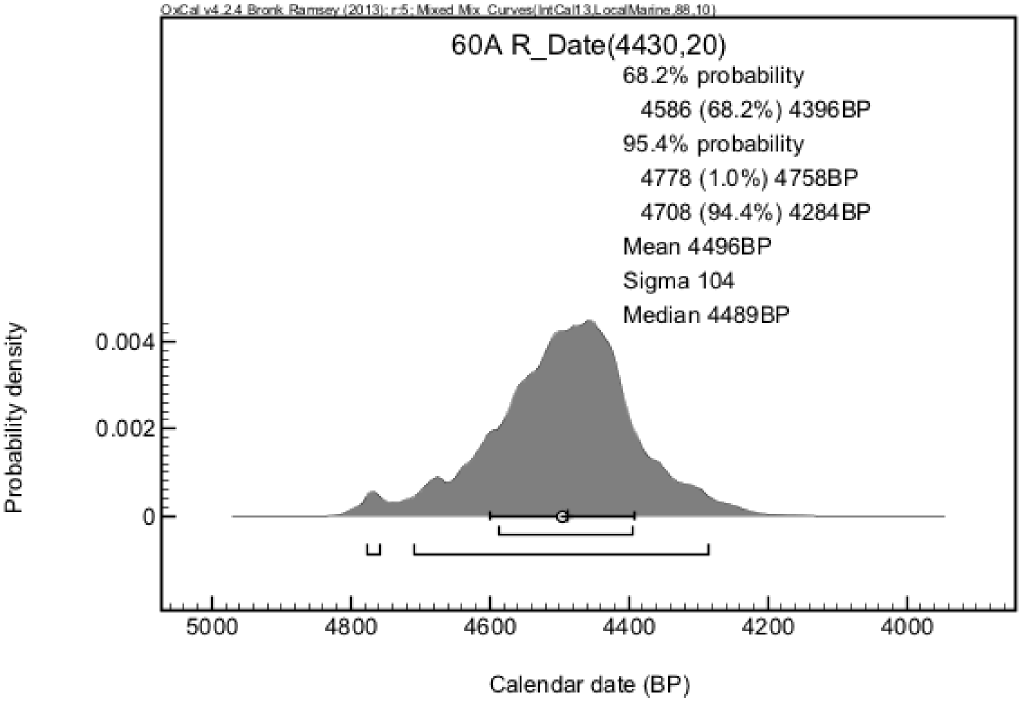
Table A.3.b Recent Indian and Beothuk radiocarbon ages, calculated percent marine carbon, and calibrated radiocarbon dates presented as median calibrated dates and to 2σ. Radiocarbon dates calibrated using OxCal v. 4.2.

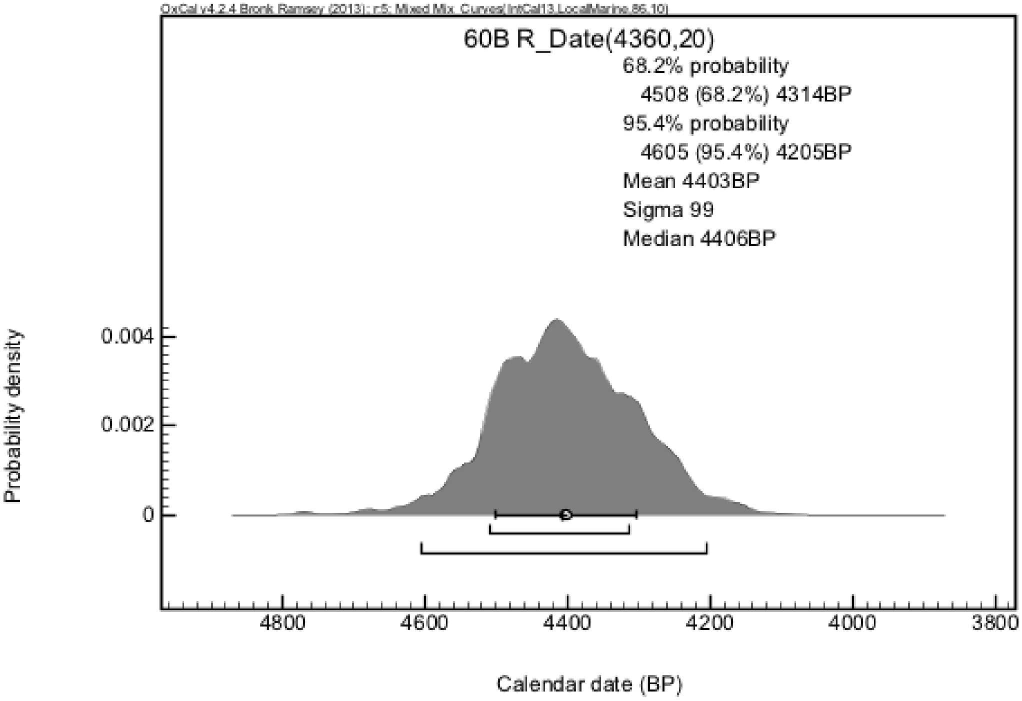
NP	Lab No.*	^{14}C Age	Error ± Yrs	Marine C (%)	Median cal BP	2σ range	Median cal AD	2σ range
151	UCIAMS 125899*	655	15	75	290	462-105	1660	1489-1846
152	UCIAMS 125898*	590	15	77	182	312-	1769	1639-
294	UCIAMS 129840*	590	25	73	202	400-	1748	1550-
296	UCIAMS 129841*	610	25	79	196	382-	1755	1569-
240	UCIAMS 154061	675	20	84	245	429-	1705	1521-
265	UCIAMS 129844*	500	25	68	145	273-	1806	1678-
266	UCIAMS 129838*	315	25	39	115	271-	1835	1680-
268	UCIAMS 129845*	770	25	77	385	506-271	1565	1445-1680
270A	UCIAMS 134694*	555	20	79	148	274-	1803	1677-
270B	UCIAMS 134695*	665	20	77	289	462-97	1662	1489-1853
270C	UCIAMS 134696*	700	20	89	242	427-	1709	1524-
270D	UCIAMS 159452*	595	25	68	256	435-	1695	1515-
270E	UCIAMS 167188	755	15	79	372	500-260	1578	1415-1691
290	UCIAMS 125903*	545	15	75	153	273-	1798	1675-
291	UCIAMS 129839*	530	25	79	126	262-	1825	1688-
292	UCIAMS 167195	710	15	86	282	456-90	1668	1494-1861
XIII-A-10	UCIAMS 170516	430	15	64	103	260-	1847	1690-
299	UCIAMS 125901*	1335	15	73	860	992-717	1090	959-1233
XIII-A-12a	UCIAMS 170517	625	20	82	190	366-	1761	1584-
XIII-A-1	UCIAMS 170510	540	15	75	148	273-	1803	1678-
XIII-A-2-	UCIAMS 170511	640	15	64	350	492-149	1600	1459-1802

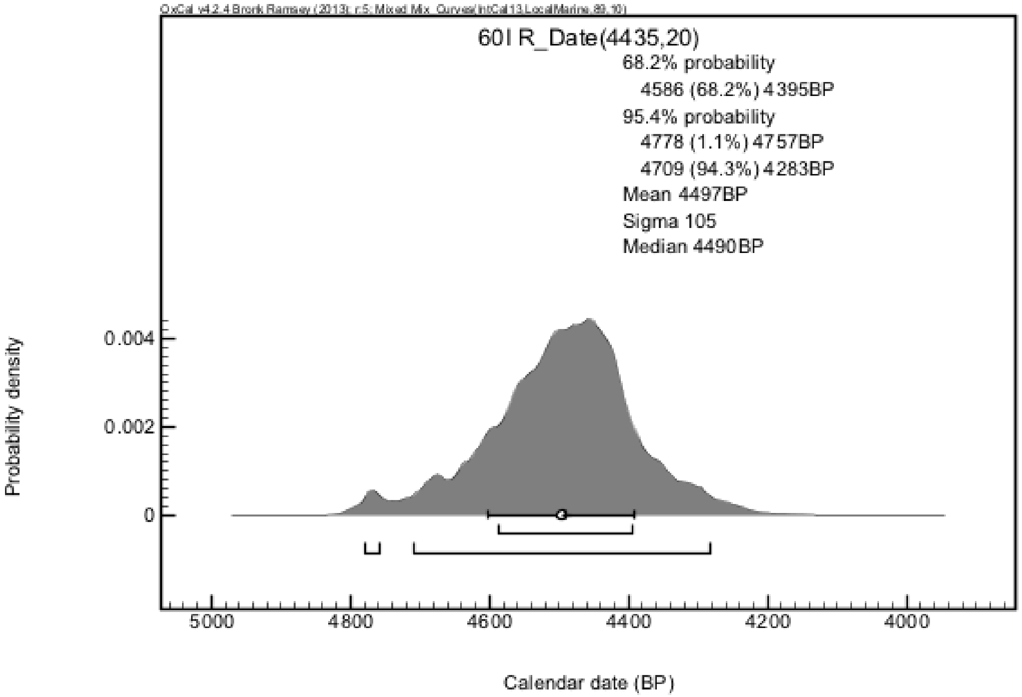
1								
XIII-A-2-2	UCIAMS 170512	510	15	70	149	273-	1802	1678-
XIII-A-8	UCIAMS 170515	525	20	79	121	259-	1830	1692-
XIII-A/3c	UCIAMS 170513	630	15	73	270	447-75	1681	1504-1875
XIII-A-13a	UCIAMS 170518	480	15	61	160	284-	1791	1667-
XIII-A-13b	UCIAMS 170519	415	15	59	103	261-	1847	1689-
XIII-A-14	UCIAMS 170520	405	15	59	104	262-	1847	1688-
XIII-A-15	UCIAMS 170521	640	15	80	221	416-	1730	1535-

Note: * Denotes data from Grimes et al. (2011)

Locus I Radiocarbon Plots



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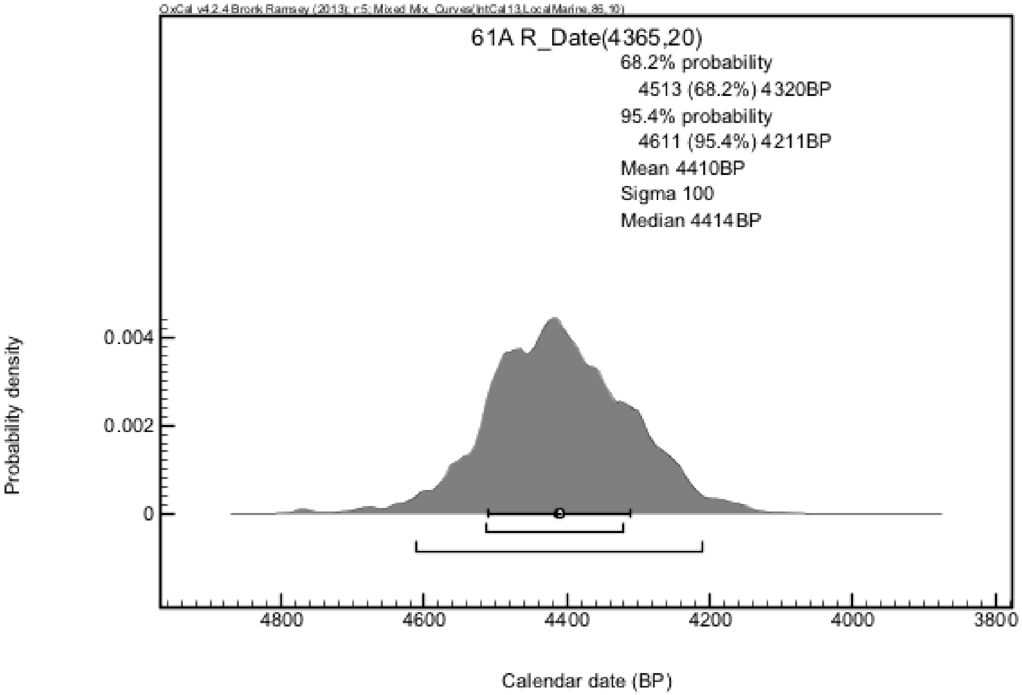
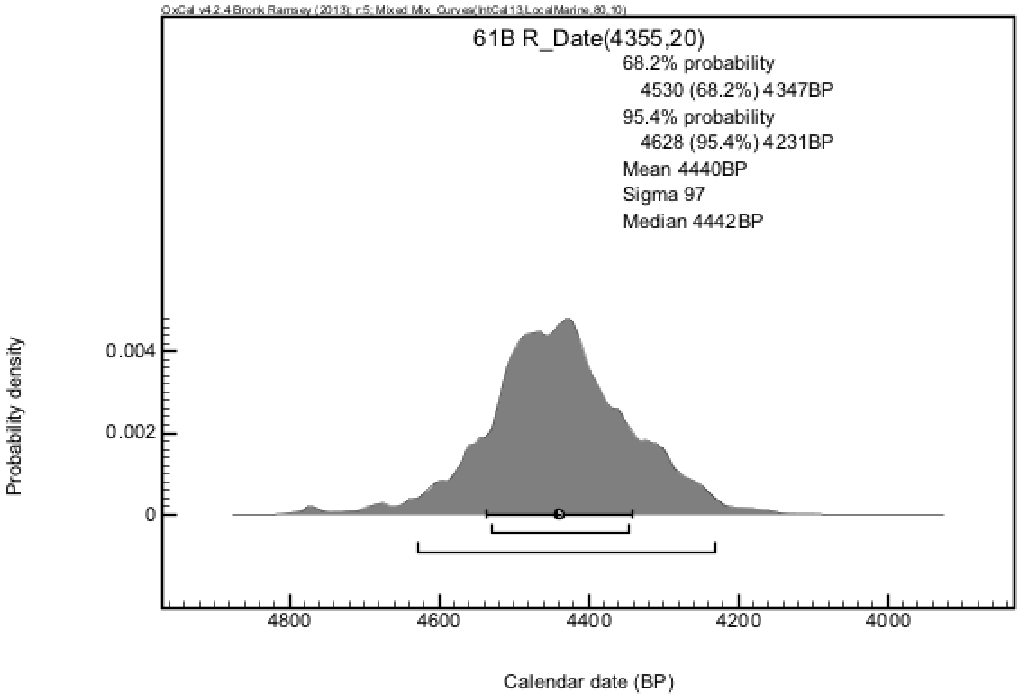
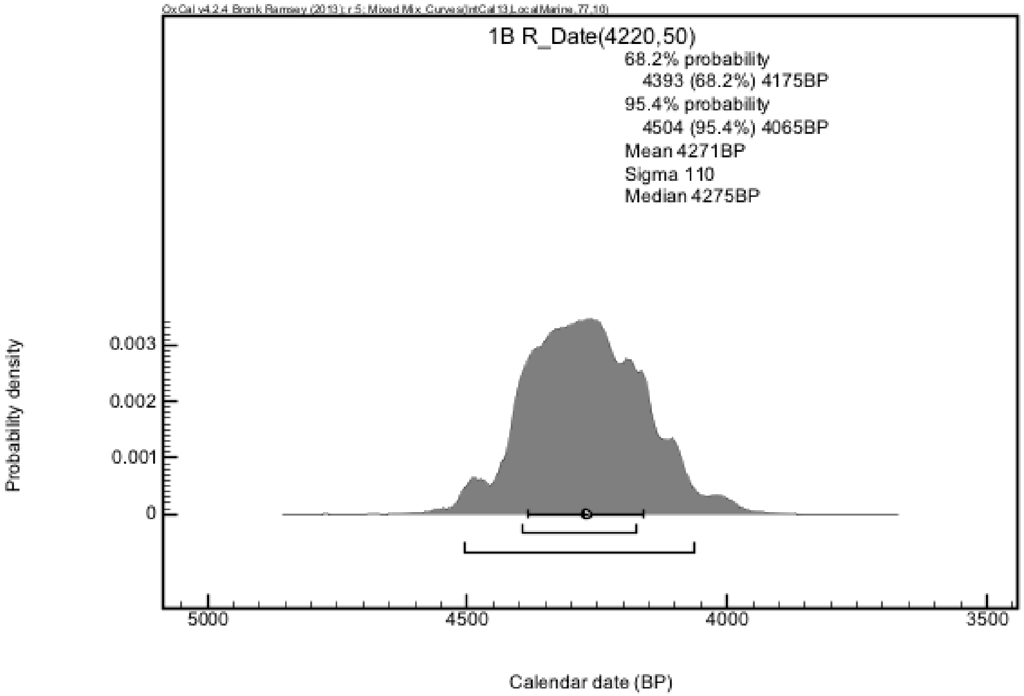
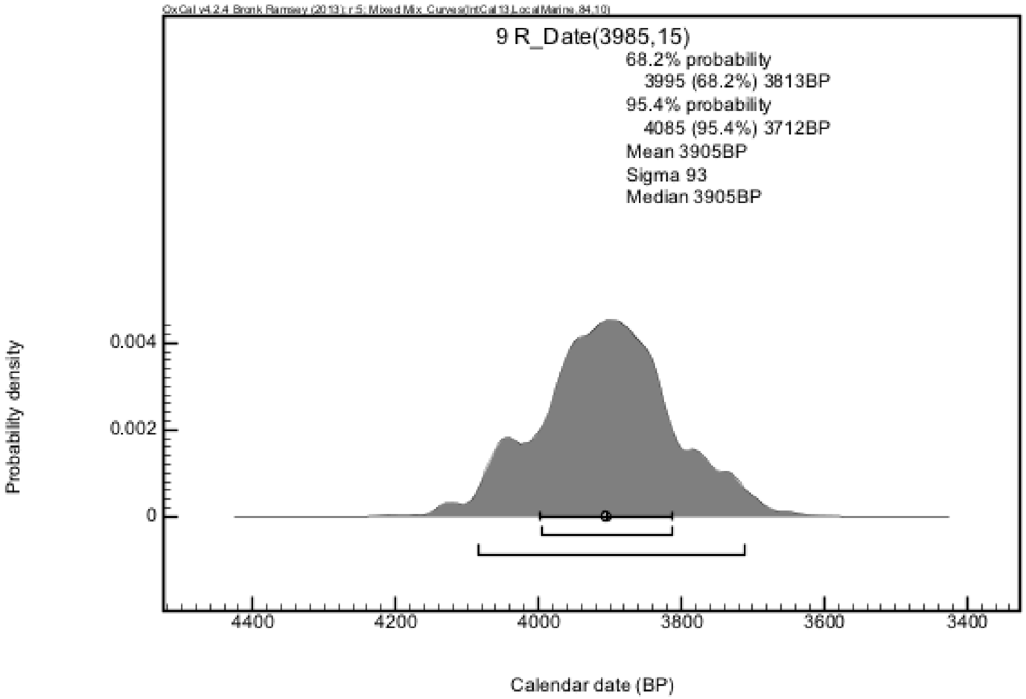
60I R_Date(4435,20)
68.2% probability
4586 (68.2%) 4395BP
95.4% probability
4778 (1.1%) 4757BP
4709 (94.3%) 4283BP
Mean 4497BP
Sigma 105
Median 4490BP
Probability density
0.004
0.002
0
5000
4800
4600
4400
4200
4000
Calendar date (BP)

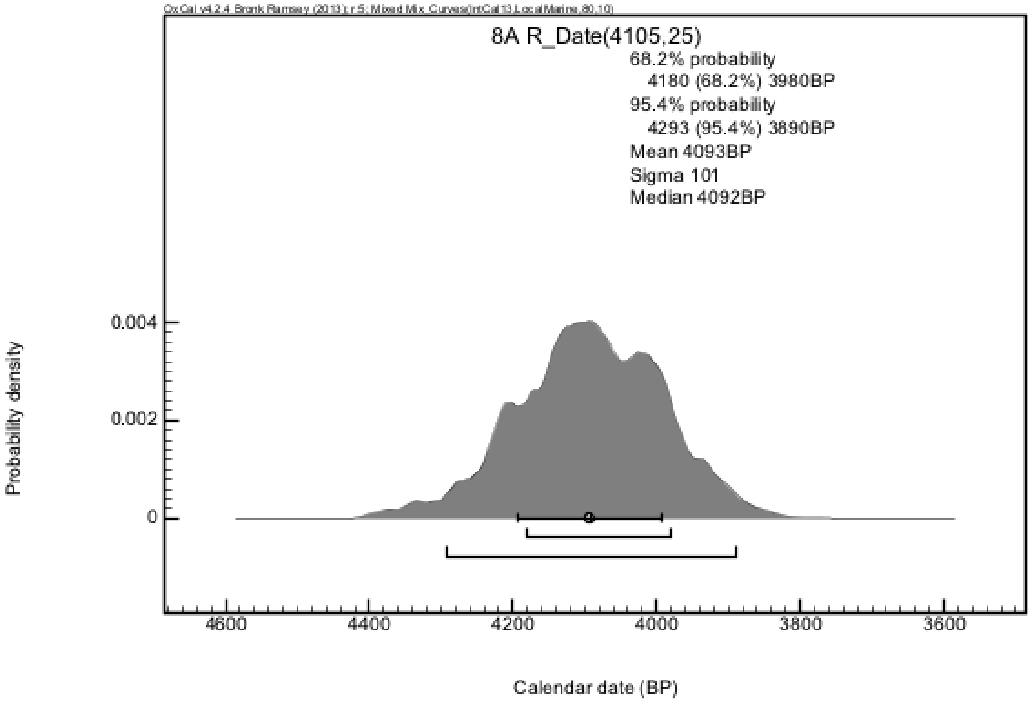

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,86,10)
61A R_Date(4365,20)
68.2% probability
4513 (68.2%) 4320BP
95.4% probability
4611 (95.4%) 4211BP
Mean 4410BP
Sigma 100
Median 4414BP
Probability density
0.004
0.002
0
4800
4600
4400
4200
4000
3800
Calendar date (BP)

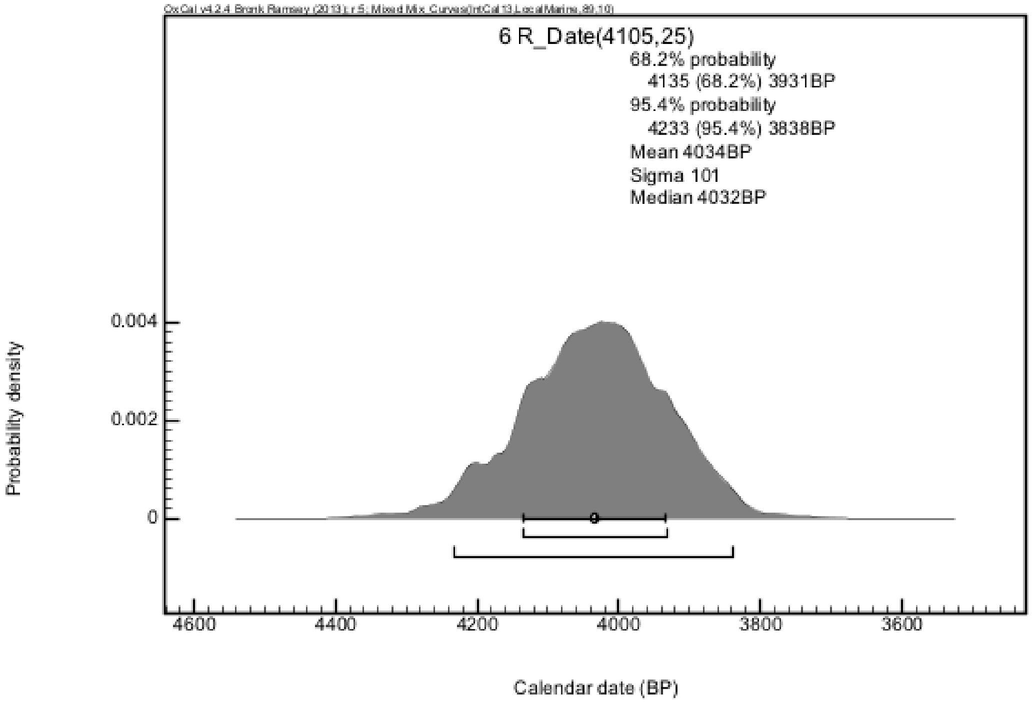


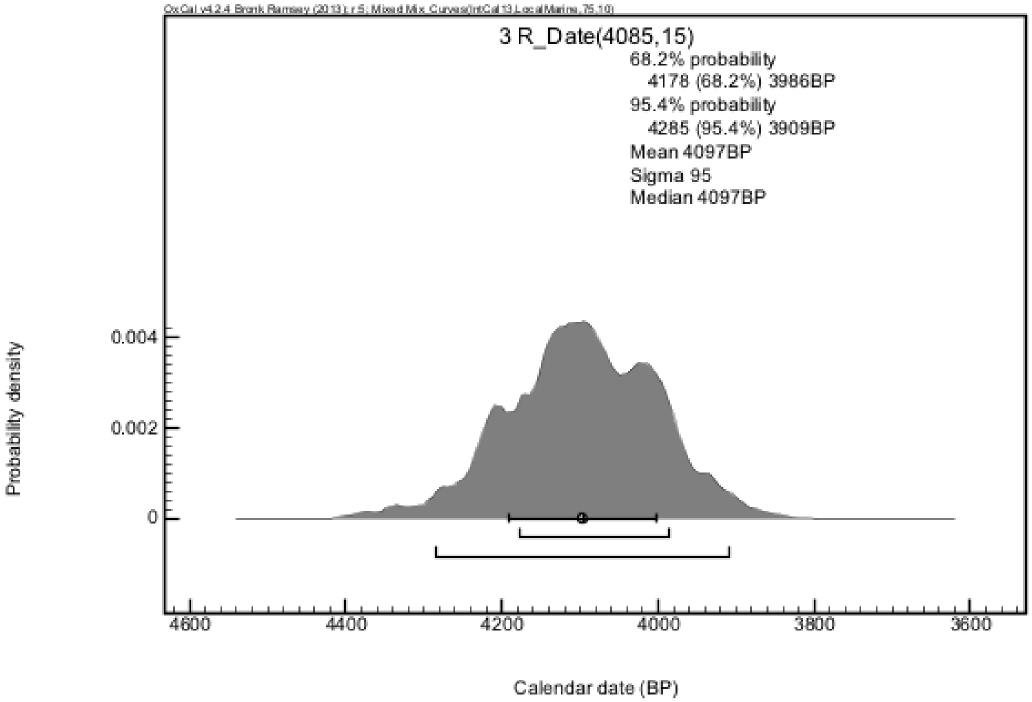
Port au Choix-3 Locus II Radiocarbon Plots

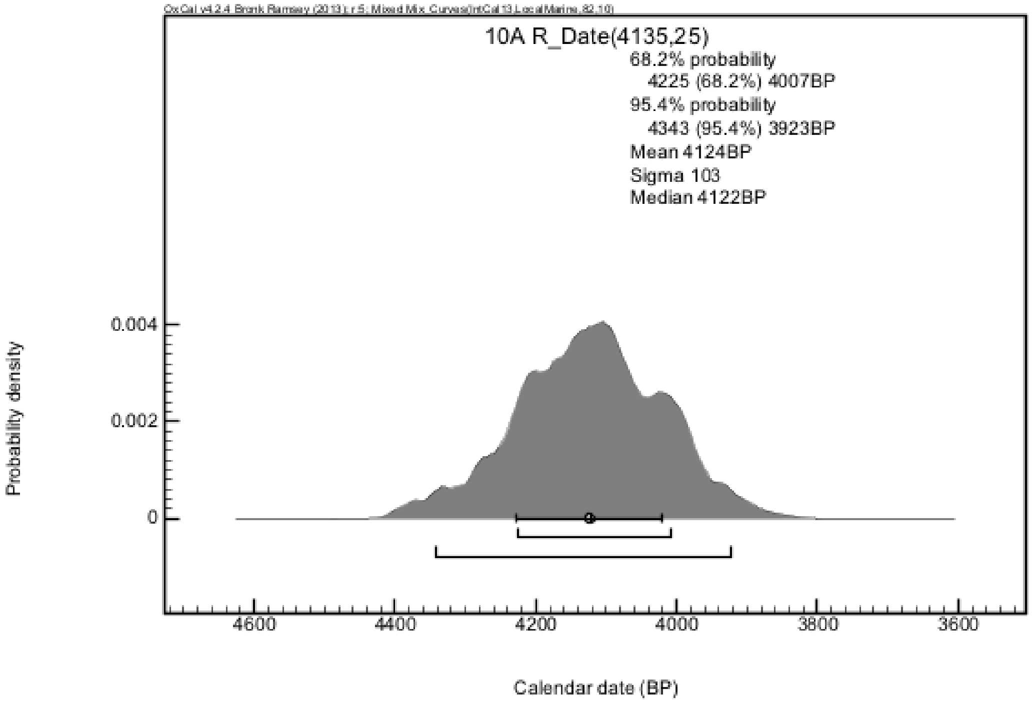


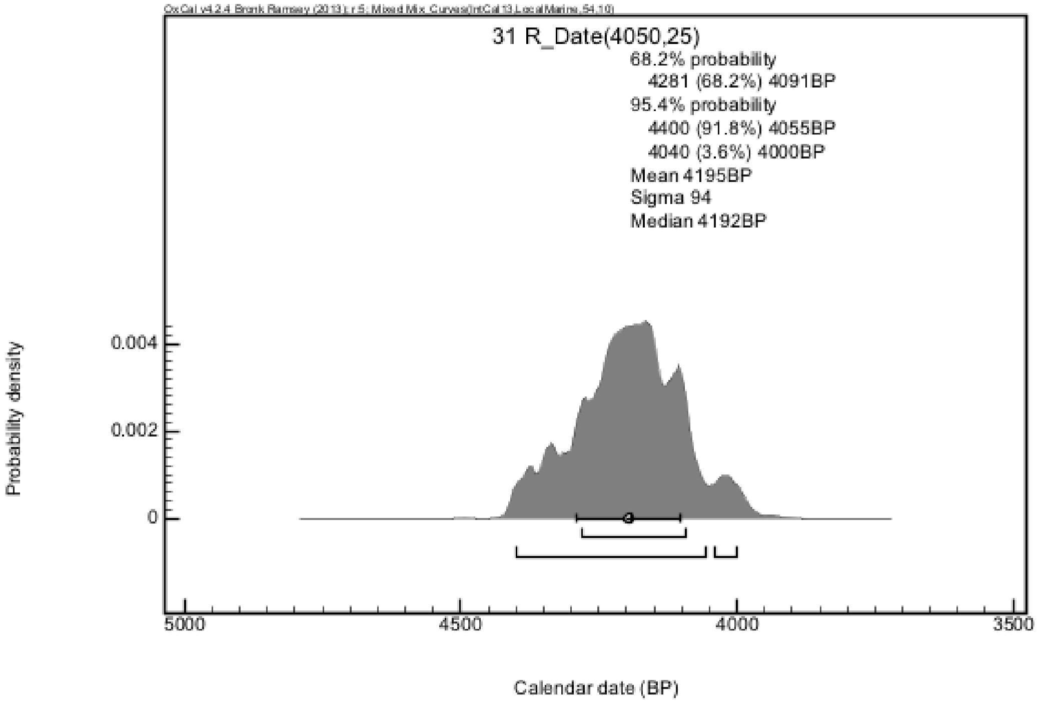

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,84,10)
9 R_Date(3985,15)
68.2% probability
3995 (68.2%) 3813BP
95.4% probability
4085 (95.4%) 3712BP
Mean 3905BP
Sigma 93
Median 3905BP
Probability density
0.004
0.002
0
4400
4200
4000
3800
3600
3400
Calendar date (BP)

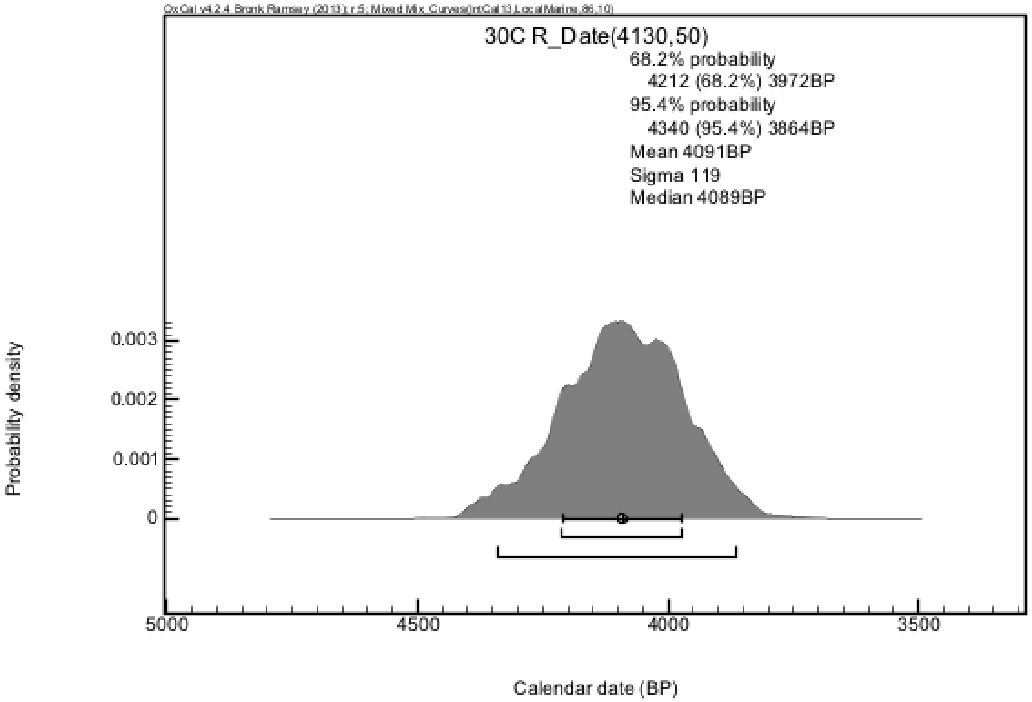

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,80,10)
8A R_Date(4105,25)
68.2% probability
4180 (68.2%) 3980BP
95.4% probability
4293 (95.4%) 3890BP
Mean 4093BP
Sigma 101
Median 4092BP
Probability density
0.004
0.002
0
4600
4400
4200
4000
3800
3600
Calendar date (BP)

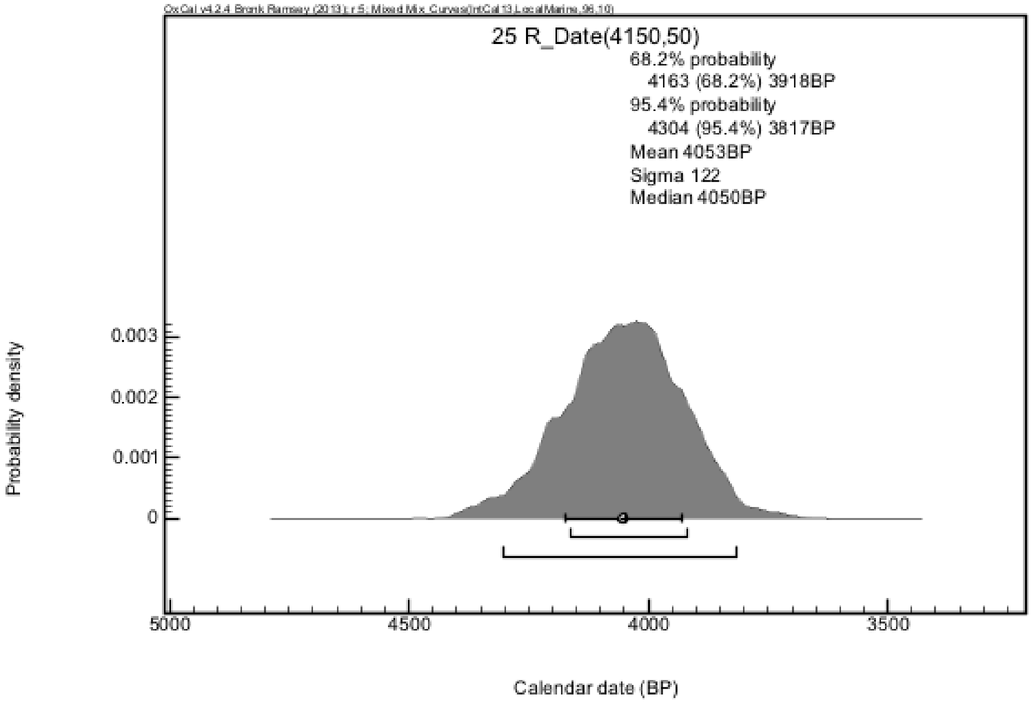

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,89,10)
6 R_Date(4105,25)
68.2% probability
4135 (68.2%) 3931BP
95.4% probability
4233 (95.4%) 3838BP
Mean 4034BP
Sigma 101
Median 4032BP
Probability density
0.004
0.002
0
4600
4400
4200
4000
3800
3600
Calendar date (BP)

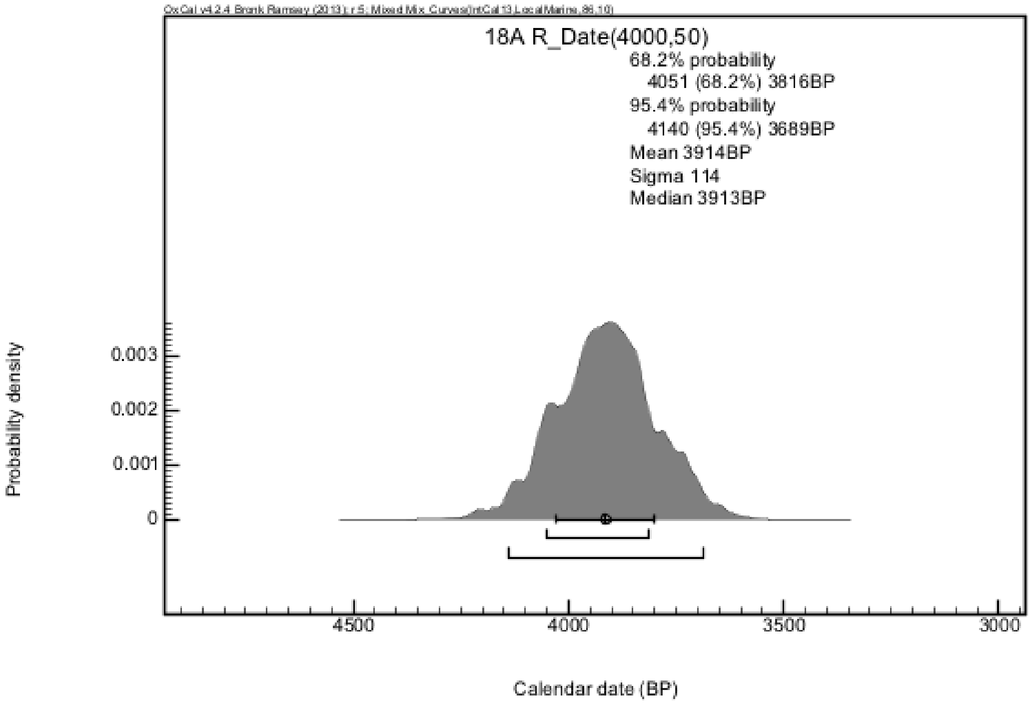

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
3 R_Date(4085,15)
68.2% probability
4178 (68.2%) 3986BP
95.4% probability
4285 (95.4%) 3909BP
Mean 4097BP
Sigma 95
Median 4097BP
Probability density
0.004
0.002
0
4600
4400
4200
4000
3800
3600
Calendar date (BP)

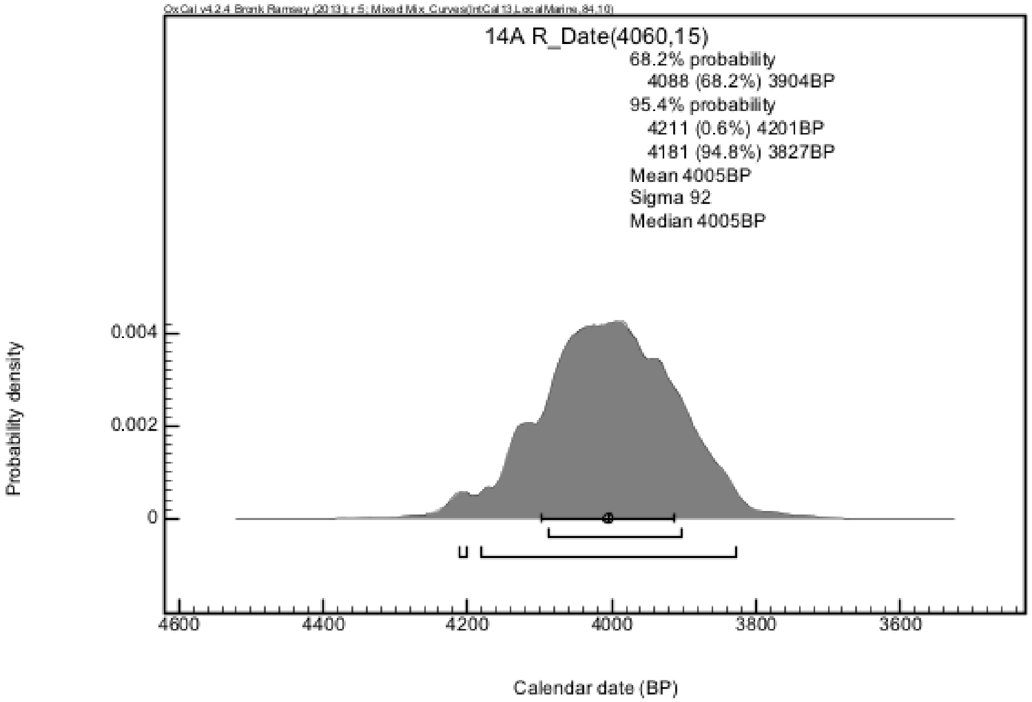

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,82,10)
10A R_Date(4135,25)
68.2% probability
4225 (68.2%) 4007BP
95.4% probability
4343 (95.4%) 3923BP
Mean 4124BP
Sigma 103
Median 4122BP
Probability density
0.004
0.002
0
4600
4400
4200
4000
3800
3600
Calendar date (BP)

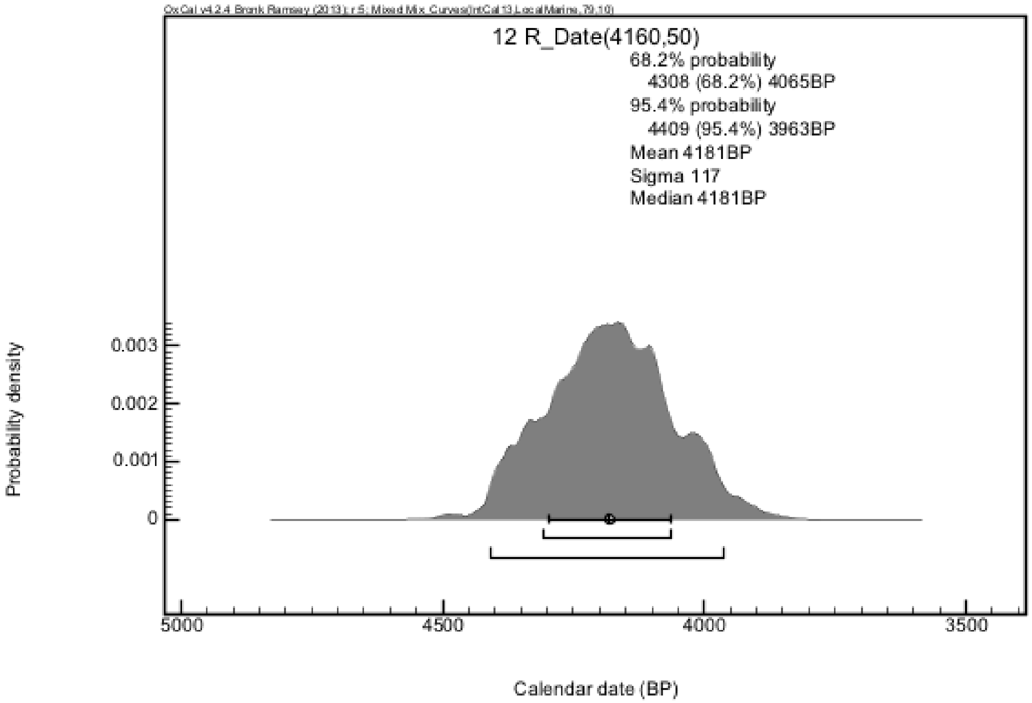

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,54,10)
31 R_Date(4050,25)
68.2% probability
4281 (68.2%) 4091BP
95.4% probability
4400 (91.8%) 4055BP
4040 (3.6%) 4000BP
Mean 4195BP
Sigma 94
Median 4192BP
Probability density
0.004
0.002
0
5000
4500
4000
3500
Calendar date (BP)

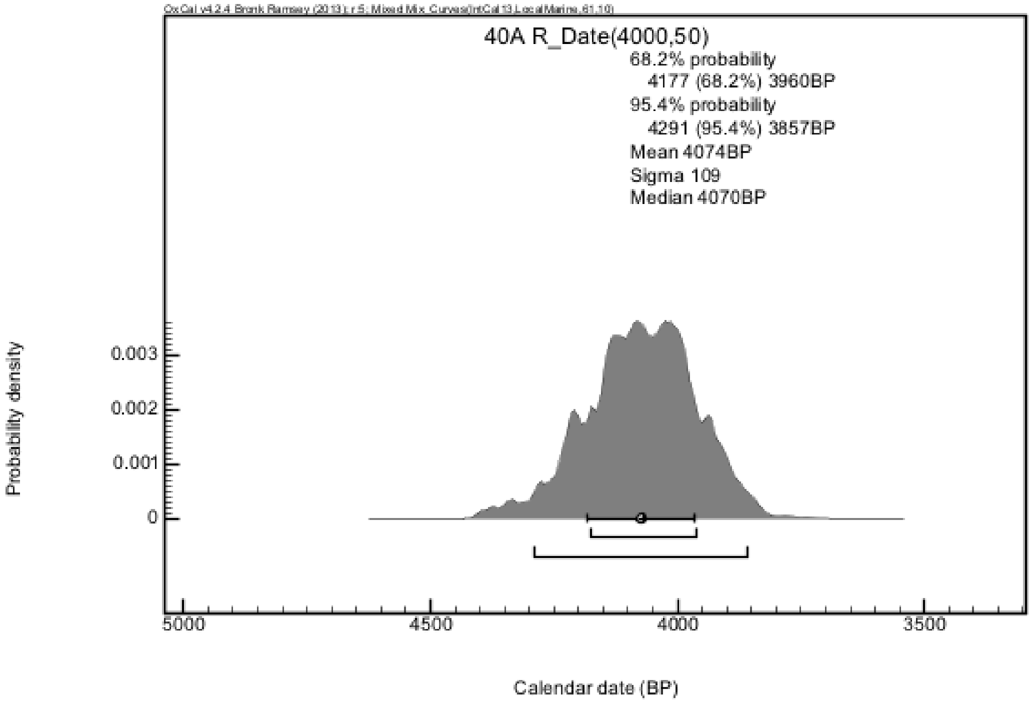

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,96,10)
30C R_Date(4130,50)
68.2% probability
4212 (68.2%) 3972BP
95.4% probability
4340 (95.4%) 3864BP
Mean 4091BP
Sigma 119
Median 4089BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

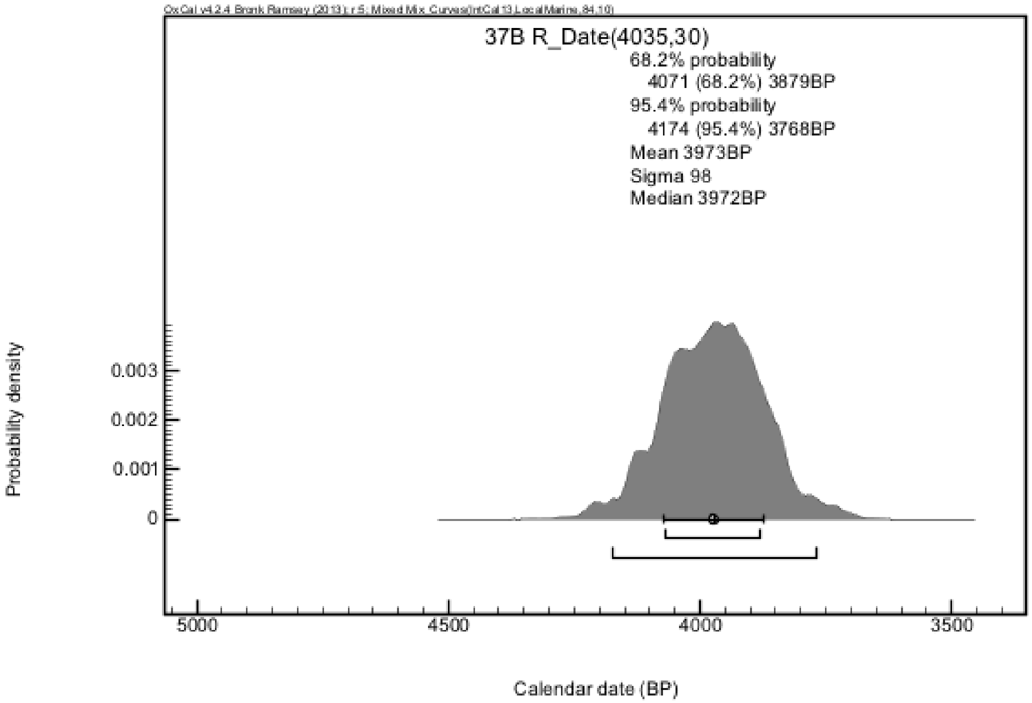

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,96,10)
25 R_Date(4150,50)
68.2% probability
4163 (68.2%) 3918BP
95.4% probability
4304 (95.4%) 3817BP
Mean 4053BP
Sigma 122
Median 4050BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

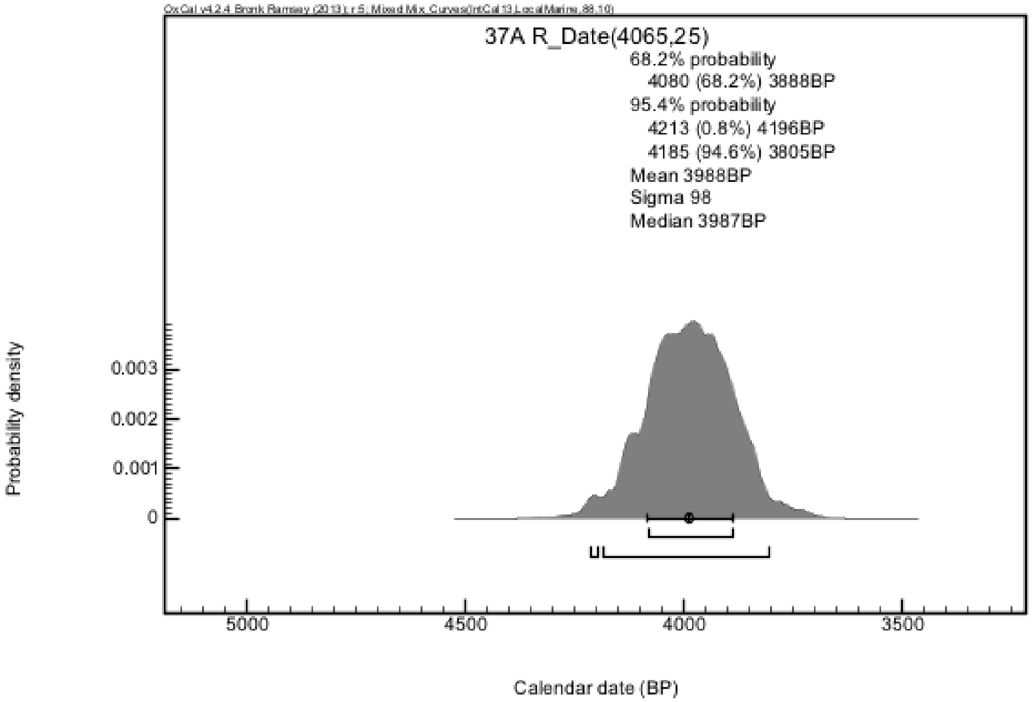

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,86,10)
18A R_Date(4000,50)
68.2% probability
4051 (68.2%) 3816BP
95.4% probability
4140 (95.4%) 3689BP
Mean 3914BP
Sigma 114
Median 3913BP
Probability density
0.003
0.002
0.001
0
4500
4000
3500
3000
Calendar date (BP)

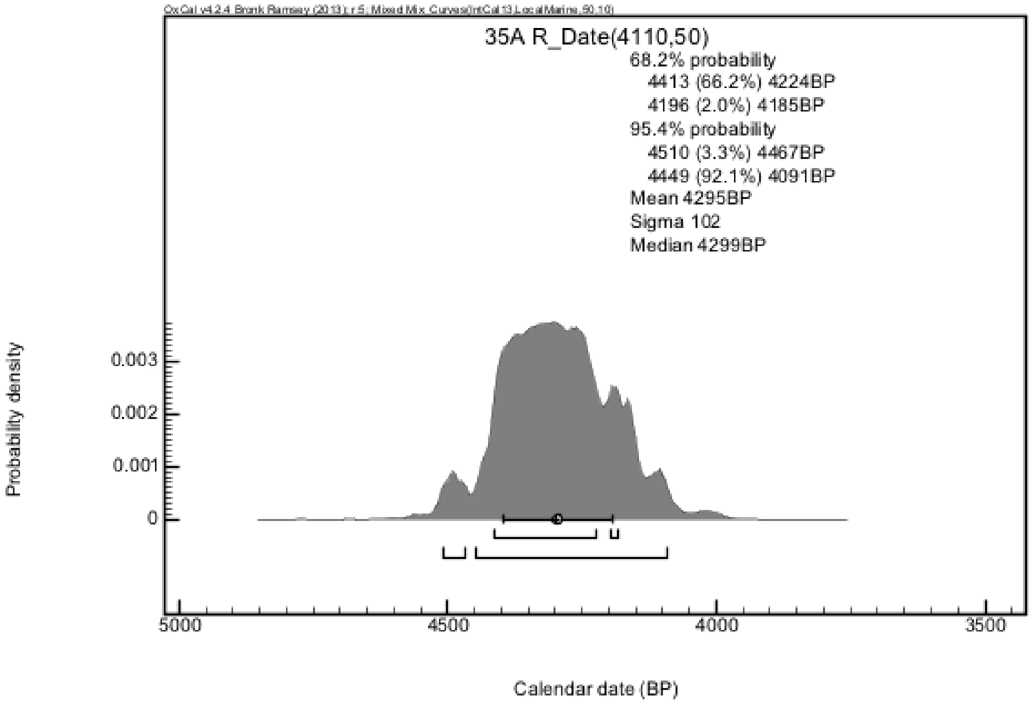

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,84,10)
14A R_Date(4060,15)
68.2% probability
4088 (68.2%) 3904BP
95.4% probability
4211 (0.6%) 4201BP
4181 (94.8%) 3827BP
Mean 4005BP
Sigma 92
Median 4005BP
Probability density
0.004
0.002
0
4600
4400
4200
4000
3800
3600
Calendar date (BP)

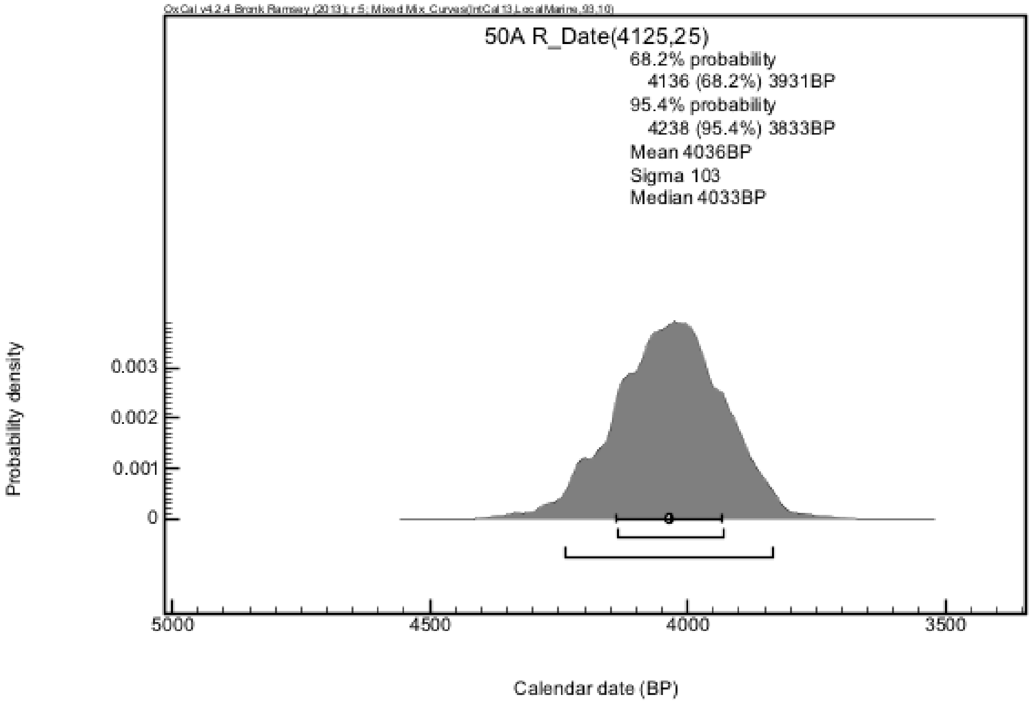

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,79,10)
12 R_Date(4160,50)
68.2% probability
4308 (68.2%) 4065BP
95.4% probability
4409 (95.4%) 3963BP
Mean 4181BP
Sigma 117
Median 4181BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

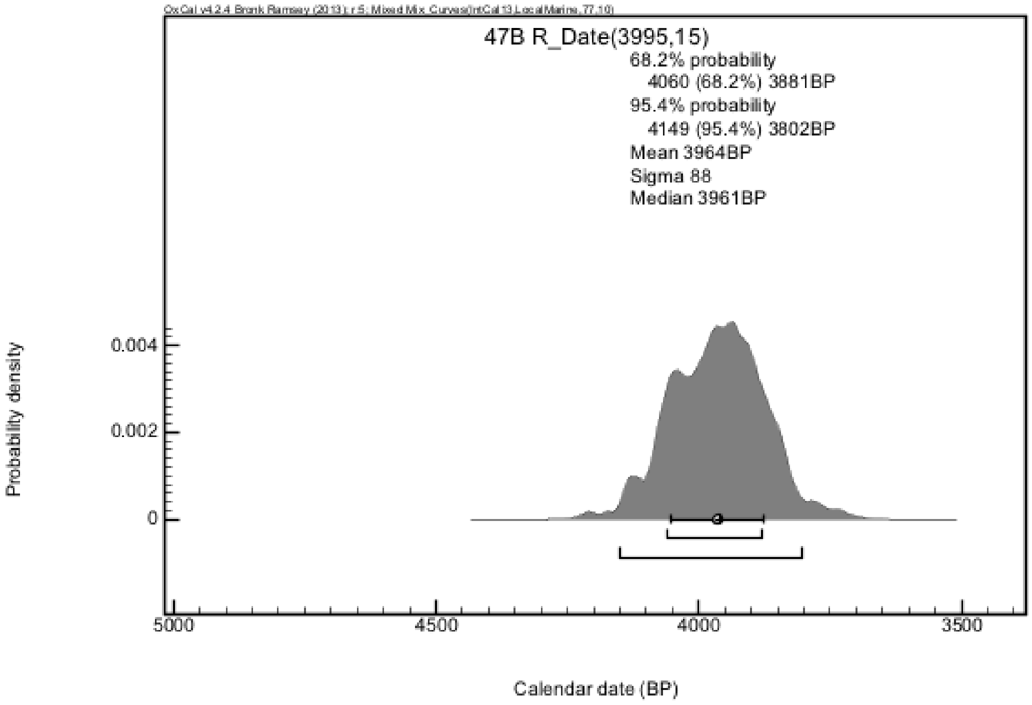

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,61,10)
40A R_Date(4000,50)
68.2% probability
4177 (68.2%) 3960BP
95.4% probability
4291 (95.4%) 3857BP
Mean 4074BP
Sigma 109
Median 4070BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

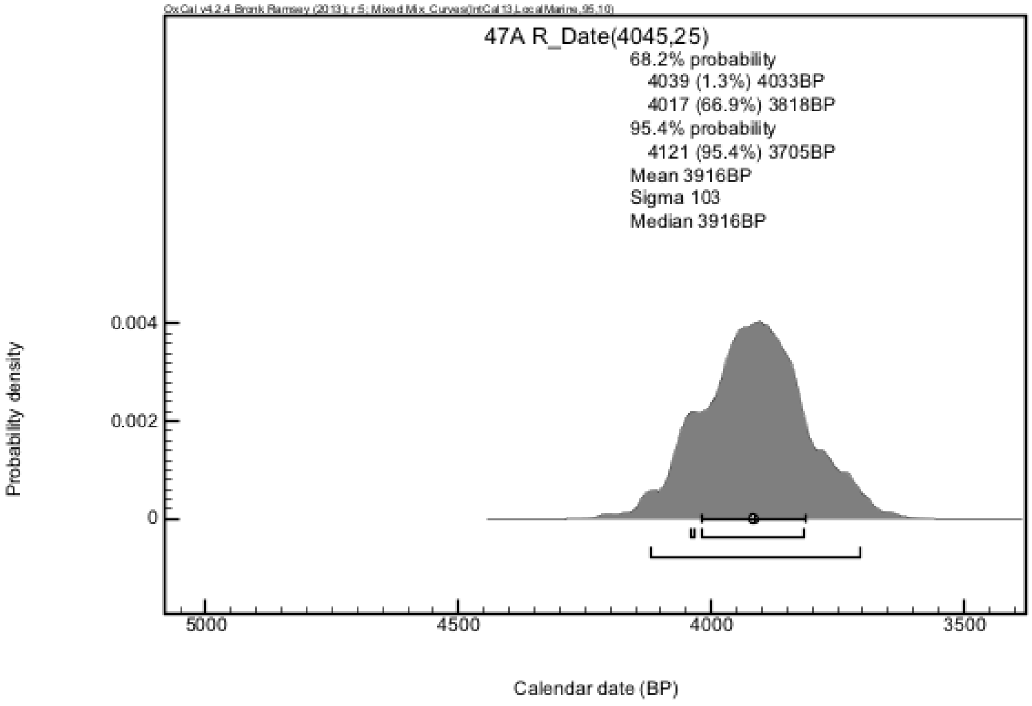

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,84,10)
37B R_Date(4035,30)
68.2% probability
4071 (68.2%) 3879BP
95.4% probability
4174 (95.4%) 3768BP
Mean 3973BP
Sigma 98
Median 3972BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

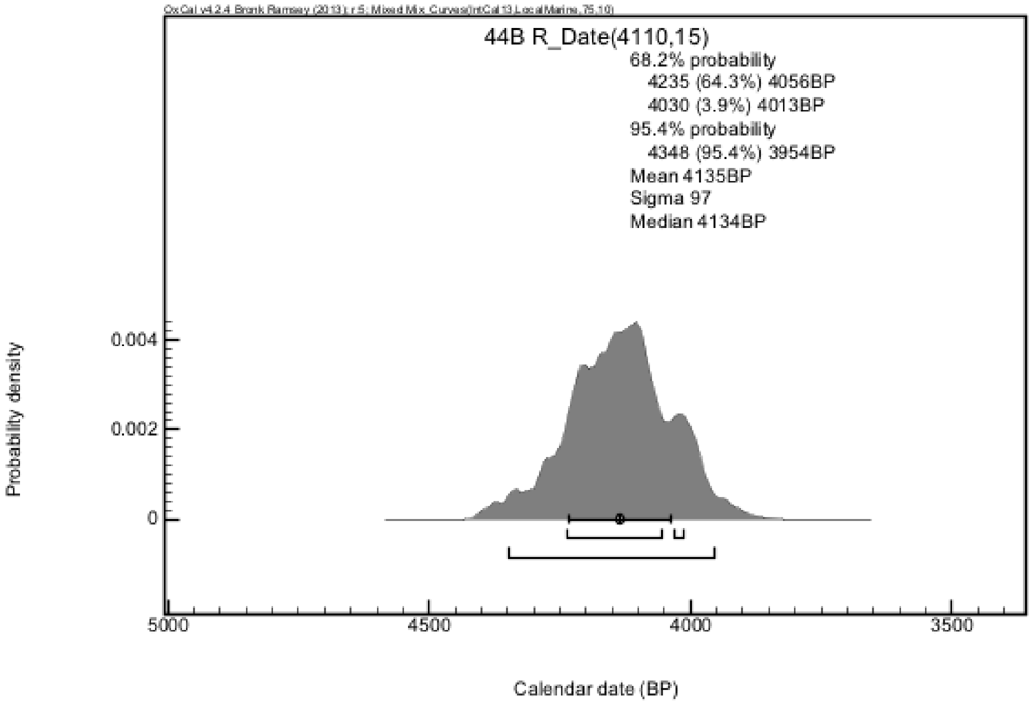

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,88,10)
37A R_Date(4065,25)
68.2% probability
4080 (68.2%) 3888BP
95.4% probability
4213 (0.8%) 4196BP
4185 (94.6%) 3805BP
Mean 3988BP
Sigma 98
Median 3987BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

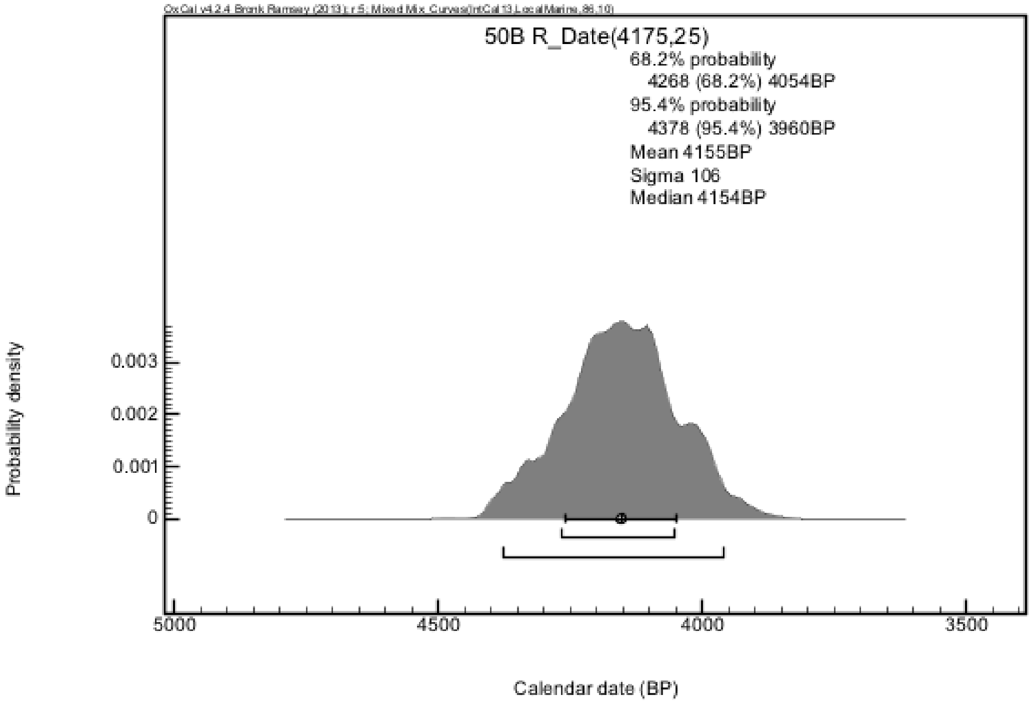

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,50,10)
35A R_Date(4110,50)
68.2% probability
4413 (66.2%) 4224BP
4196 (2.0%) 4185BP
95.4% probability
4510 (3.3%) 4467BP
4449 (92.1%) 4091BP
Mean 4295BP
Sigma 102
Median 4299BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,93,10)
50A R_Date(4125,25)
68.2% probability
4136 (68.2%) 3931BP
95.4% probability
4238 (95.4%) 3833BP
Mean 4036BP
Sigma 103
Median 4033BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

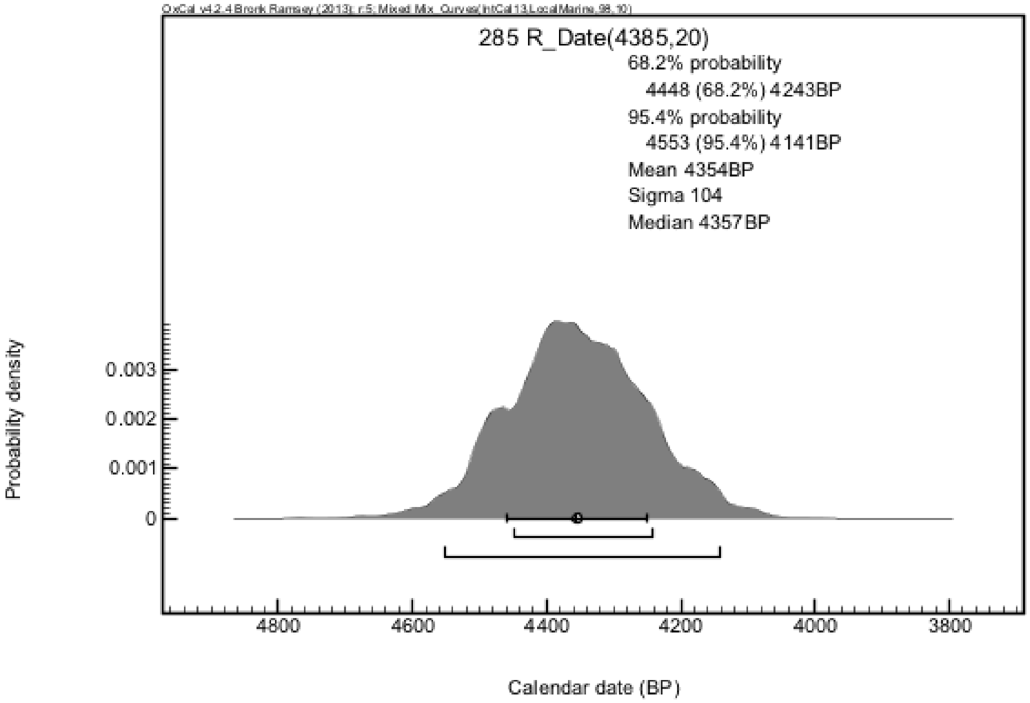

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,77,10)
47B R_Date(3995,15)
68.2% probability
4060 (68.2%) 3881BP
95.4% probability
4149 (95.4%) 3802BP
Mean 3964BP
Sigma 88
Median 3961BP
Probability density
0.004
0.002
0
5000
4500
4000
3500
Calendar date (BP)

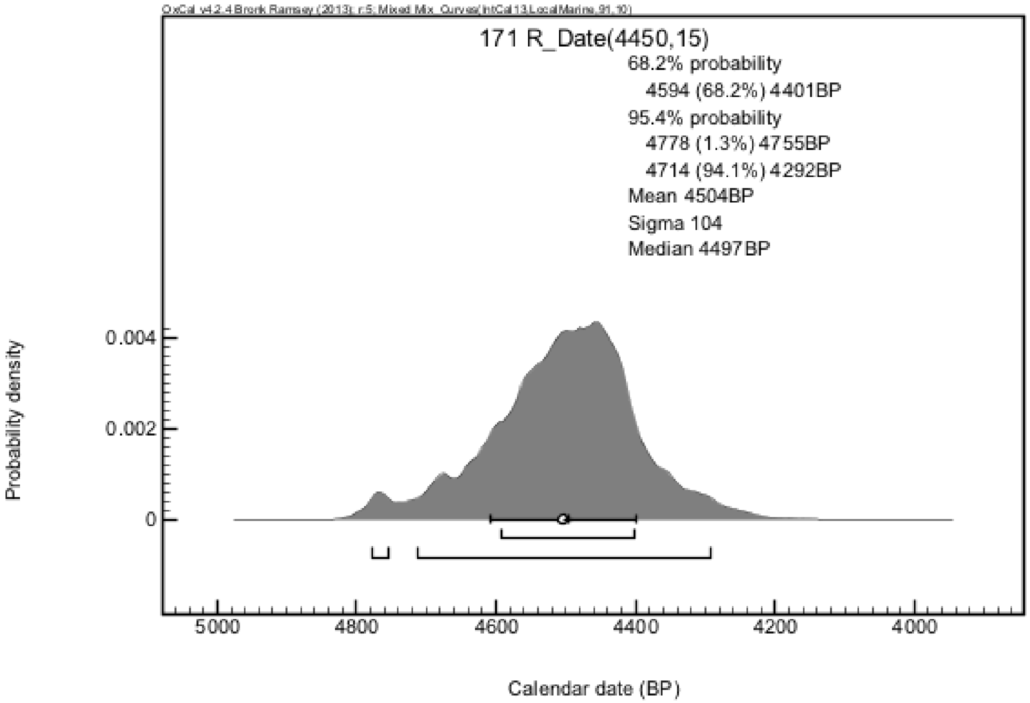

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,95,10)
47A R_Date(4045,25)
68.2% probability
4039 (1.3%) 4033BP
4017 (66.9%) 3818BP
95.4% probability
4121 (95.4%) 3705BP
Mean 3916BP
Sigma 103
Median 3916BP
Probability density
0.004
0.002
0
5000
4500
4000
3500
Calendar date (BP)

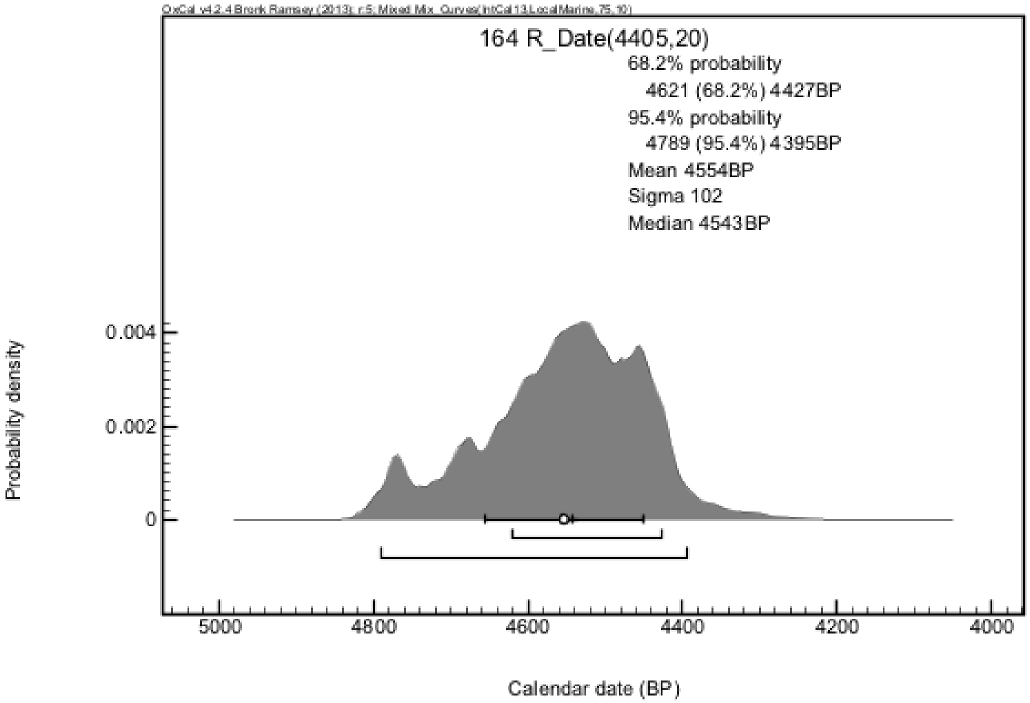

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
44B R_Date(4110,15)
68.2% probability
4235 (64.3%) 4056BP
4030 (3.9%) 4013BP
95.4% probability
4348 (95.4%) 3954BP
Mean 4135BP
Sigma 97
Median 4134BP
Probability density
0.004
0.002
0
5000
4500
4000
3500
Calendar date (BP)

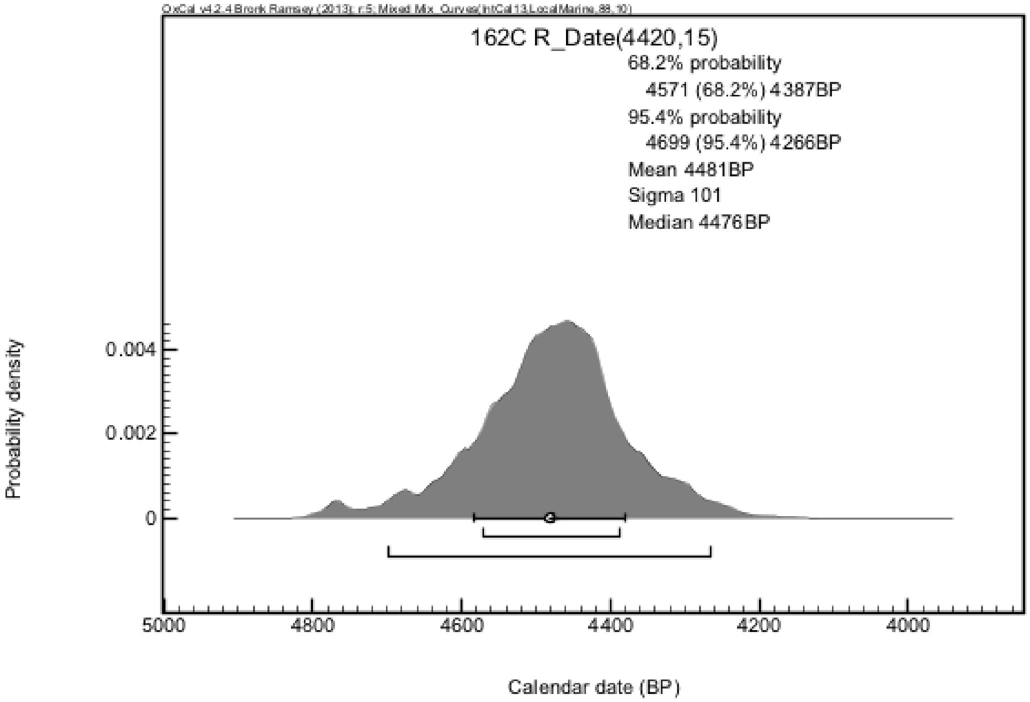

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,86,10)
50B R_Date(4175,25)
68.2% probability
4268 (68.2%) 4054BP
95.4% probability
4378 (95.4%) 3960BP
Mean 4155BP
Sigma 106
Median 4154BP
Probability density
0.003
0.002
0.001
0
5000
4500
4000
3500
Calendar date (BP)

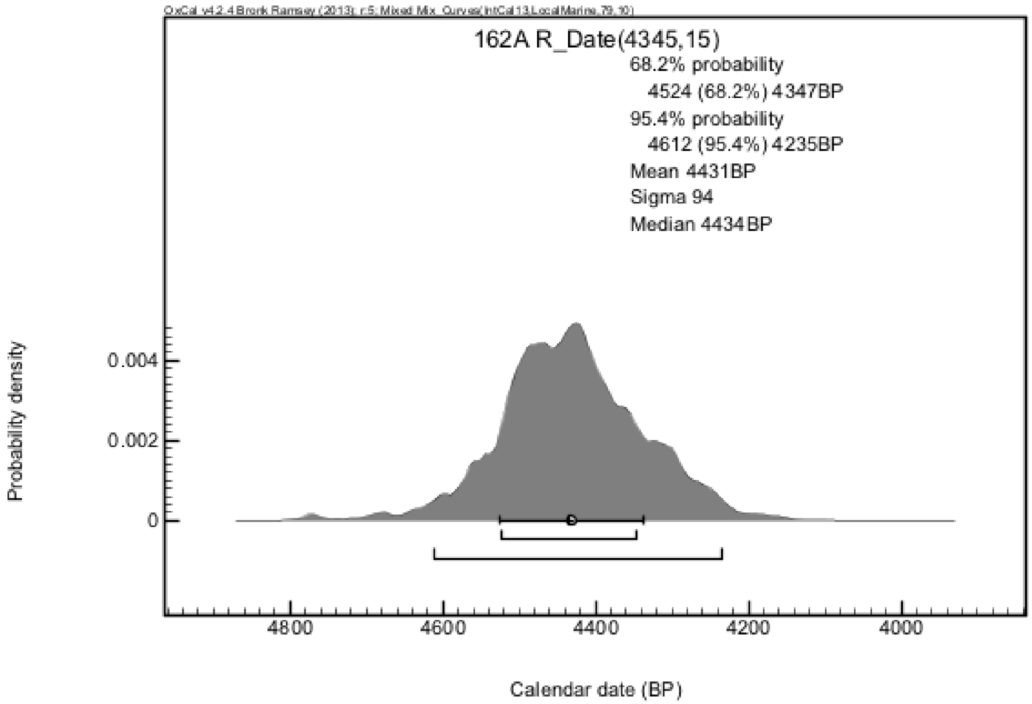
Port au Choix-3 Locus V Radiocarbon Plots

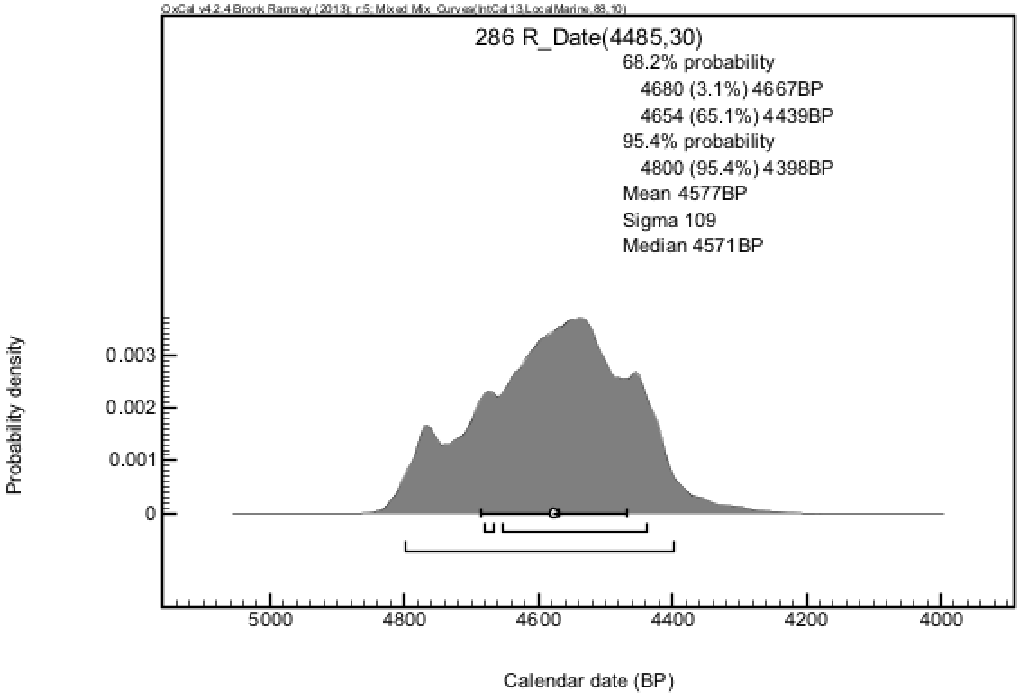




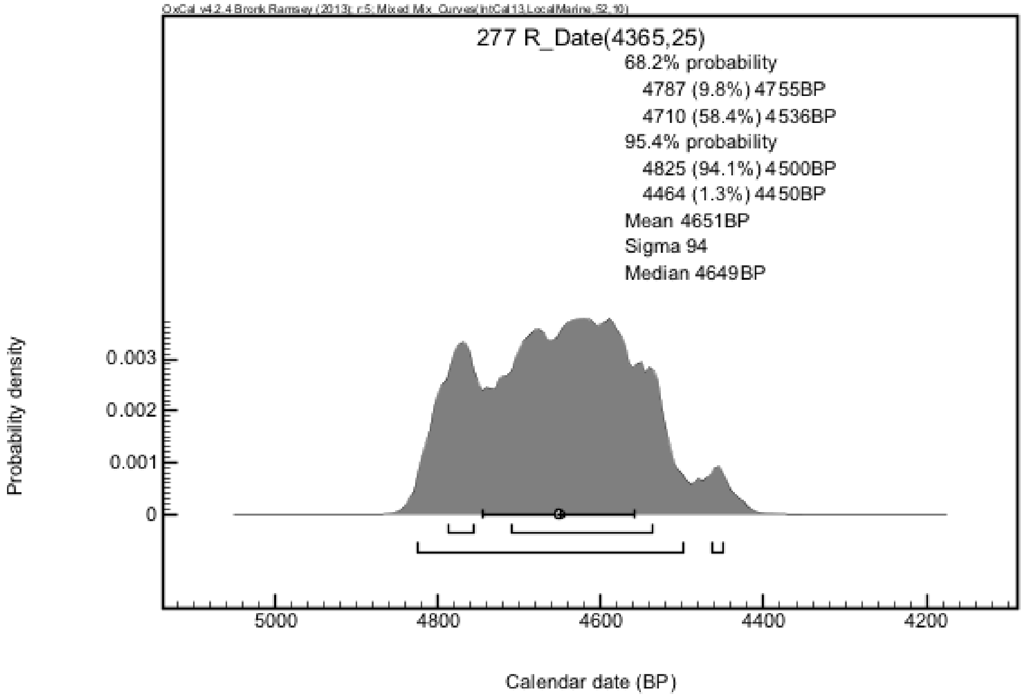

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
164 R_Date(4405,20)
68.2% probability
4621 (68.2%) 4427BP
95.4% probability
4789 (95.4%) 4395BP
Mean 4554BP
Sigma 102
Median 4543BP
Probability density
0.004
0.002
0
5000
4800
4600
4400
4200
4000
Calendar date (BP)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,88,10)
162C R_Date(4420,15)
68.2% probability
4571 (68.2%) 4387BP
95.4% probability
4699 (95.4%) 4266BP
Mean 4481BP
Sigma 101
Median 4476BP
Probability density
0.004
0.002
0
5000
4800
4600
4400
4200
4000
Calendar date (BP)

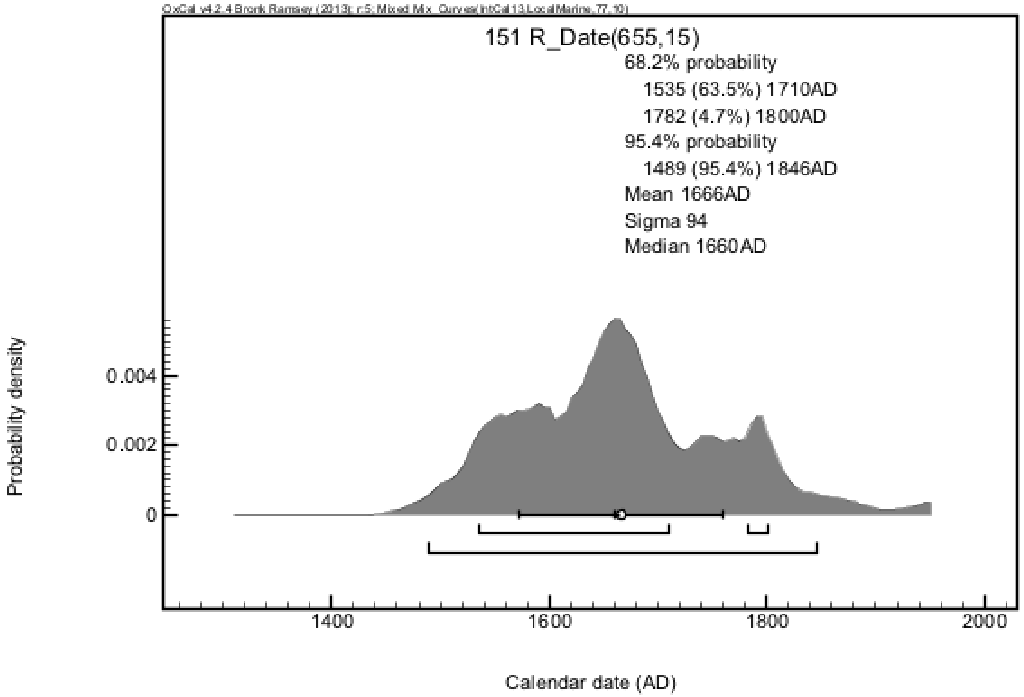

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,79,10)
162A R_Date(4345,15)
68.2% probability
4524 (68.2%) 4347BP
95.4% probability
4612 (95.4%) 4235BP
Mean 4431BP
Sigma 94
Median 4434BP
Probability density
0.004
0.002
0
4800
4600
4400
4200
4000
Calendar date (BP)

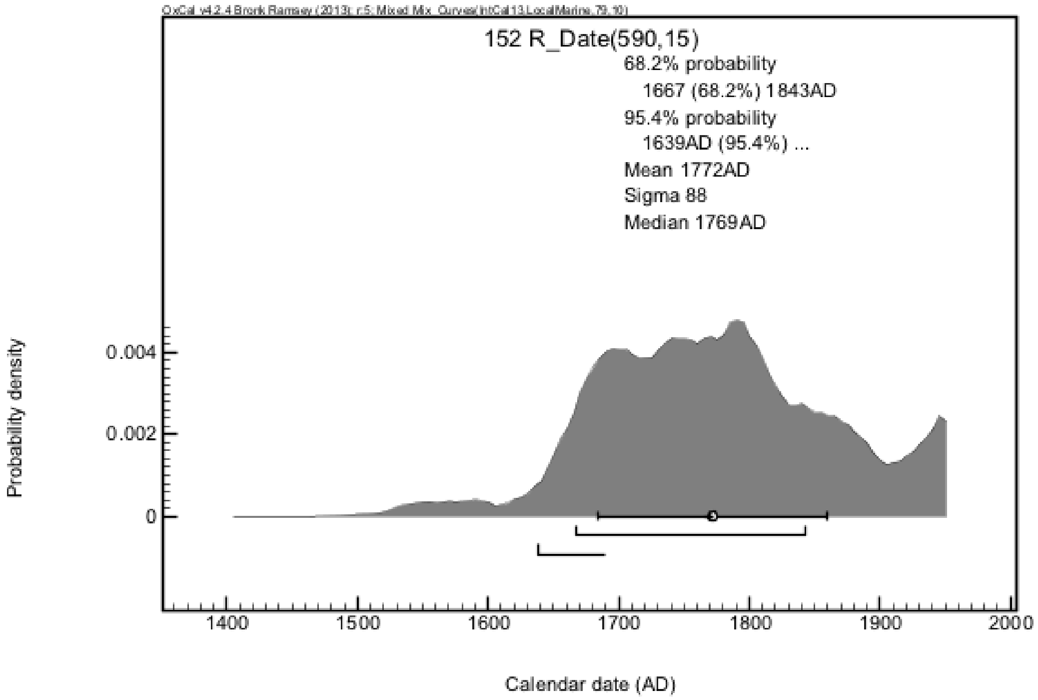

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,88,10)
286 R_Date(4485,30)
68.2% probability
4680 (3.1%) 4667BP
4654 (65.1%) 4439BP
95.4% probability
4800 (95.4%) 4398BP
Mean 4577BP
Sigma 109
Median 4571BP
Probability density
0.003
0.002
0.001
0
5000
4800
4600
4400
4200
4000
Calendar date (BP)

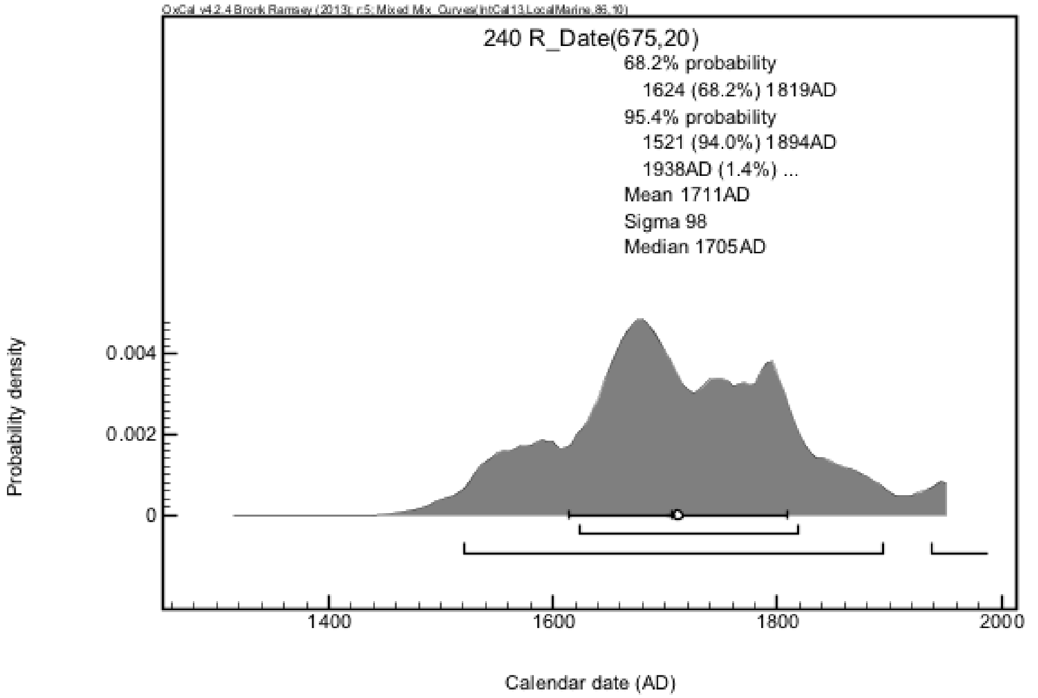
Port au Choix-3 Harp’s Burial Radiocarbon Plot

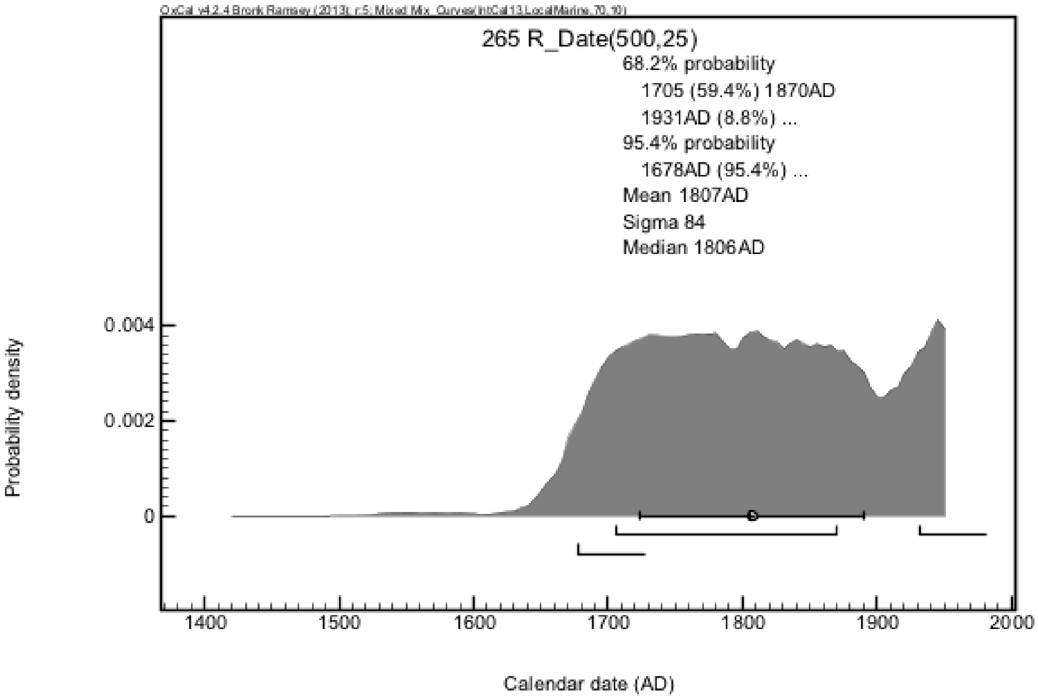


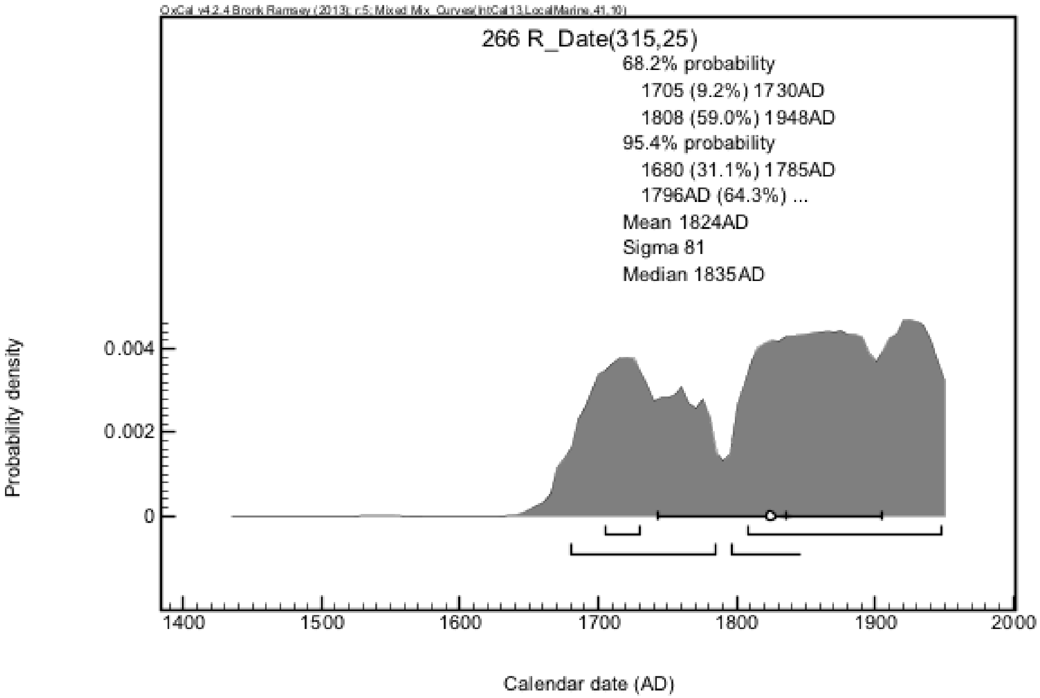
Recent Indian and Beothuk Radiocarbon Plots

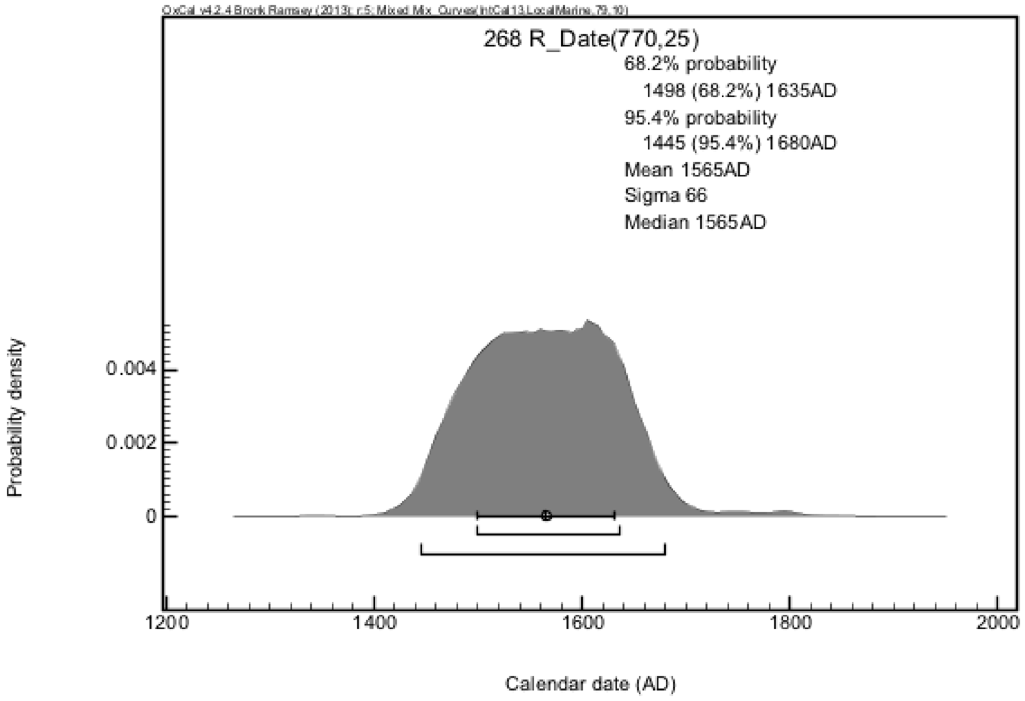


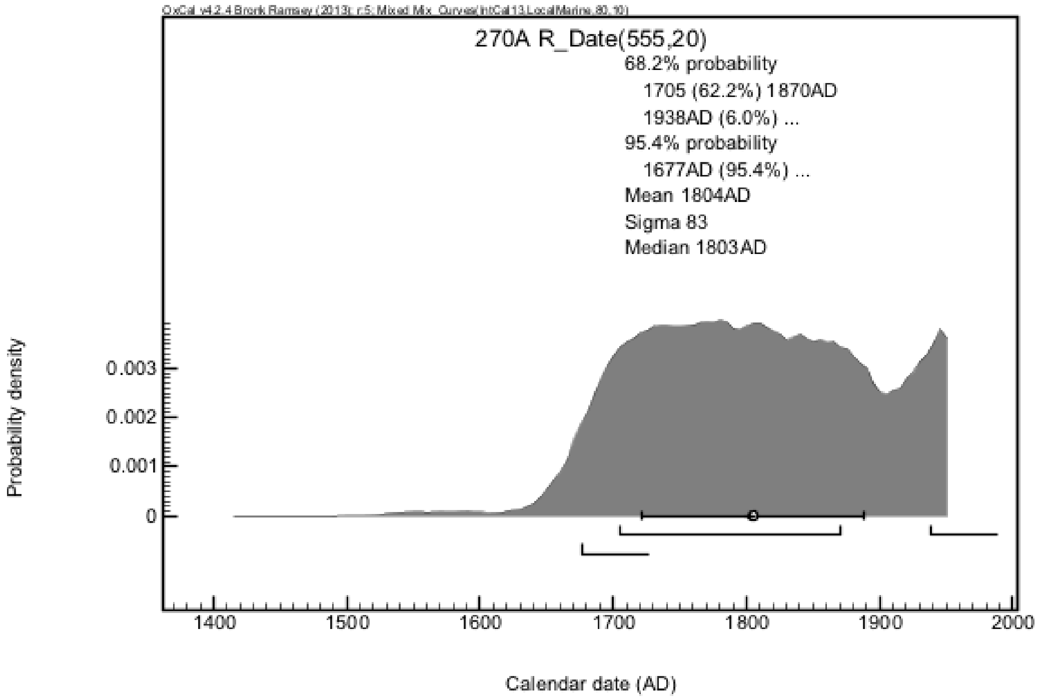

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,79,10)
152 R_Date(590,15)
68.2% probability
1667 (68.2%) 1843AD
95.4% probability
1639AD (95.4%) ...
Mean 1772AD
Sigma 88
Median 1769AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

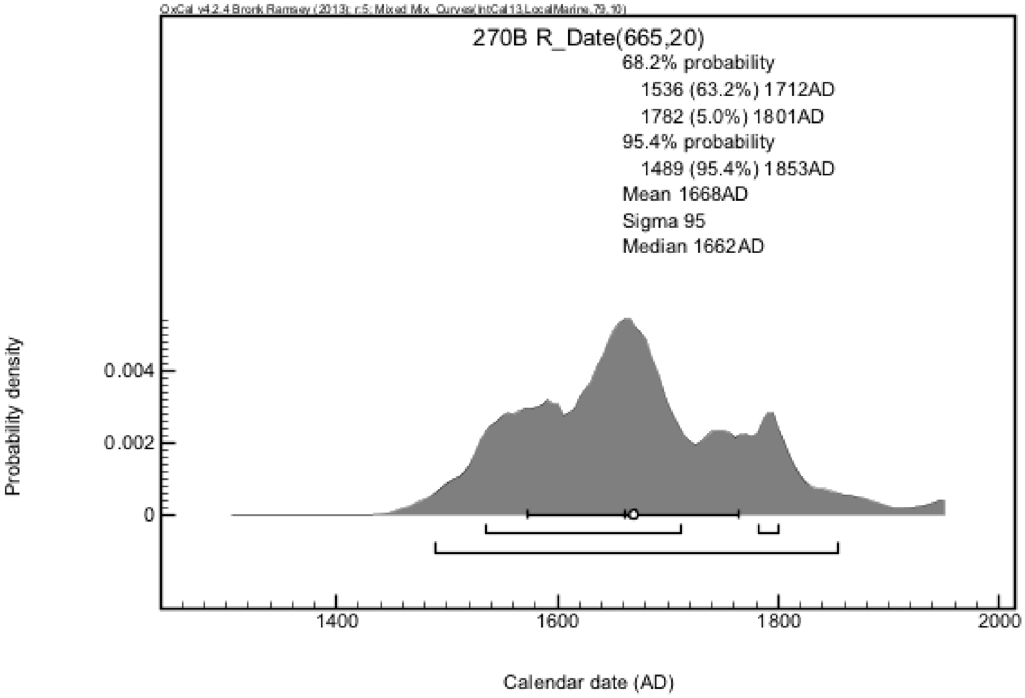

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,86,10)
240 R_Date(675,20)
68.2% probability
1624 (68.2%) 1819AD
95.4% probability
1521 (94.0%) 1894AD
1938AD (1.4%) ...
Mean 1711AD
Sigma 98
Median 1705AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

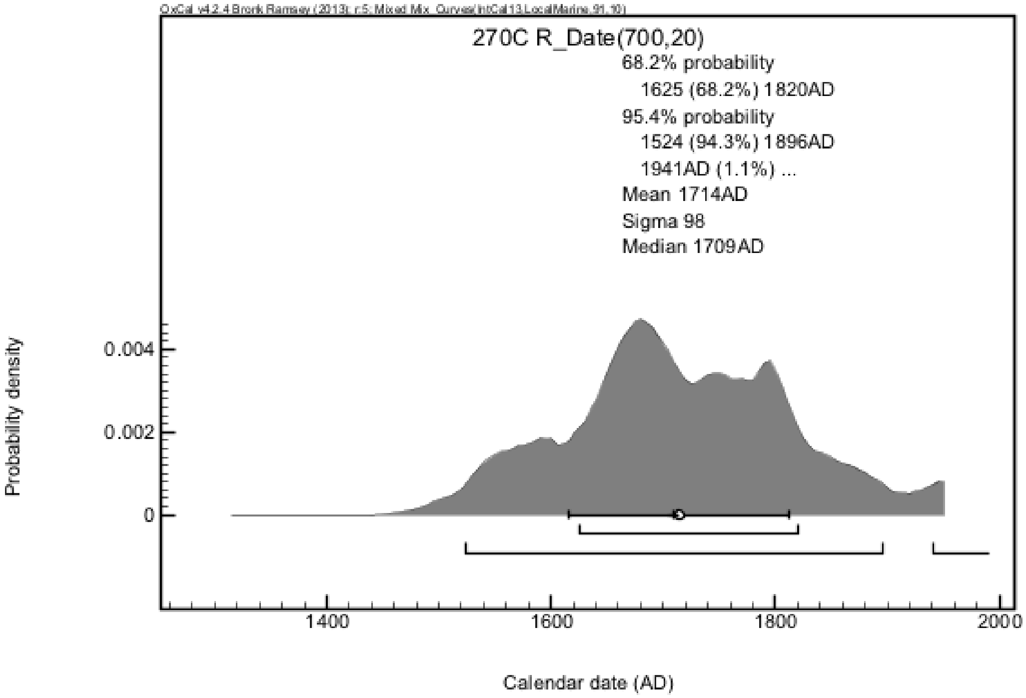

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,70,10)
265 R_Date(500,25)
68.2% probability
1705 (59.4%) 1870AD
1931AD (8.8%) ...
95.4% probability
1678AD (95.4%) ...
Mean 1807AD
Sigma 84
Median 1806AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

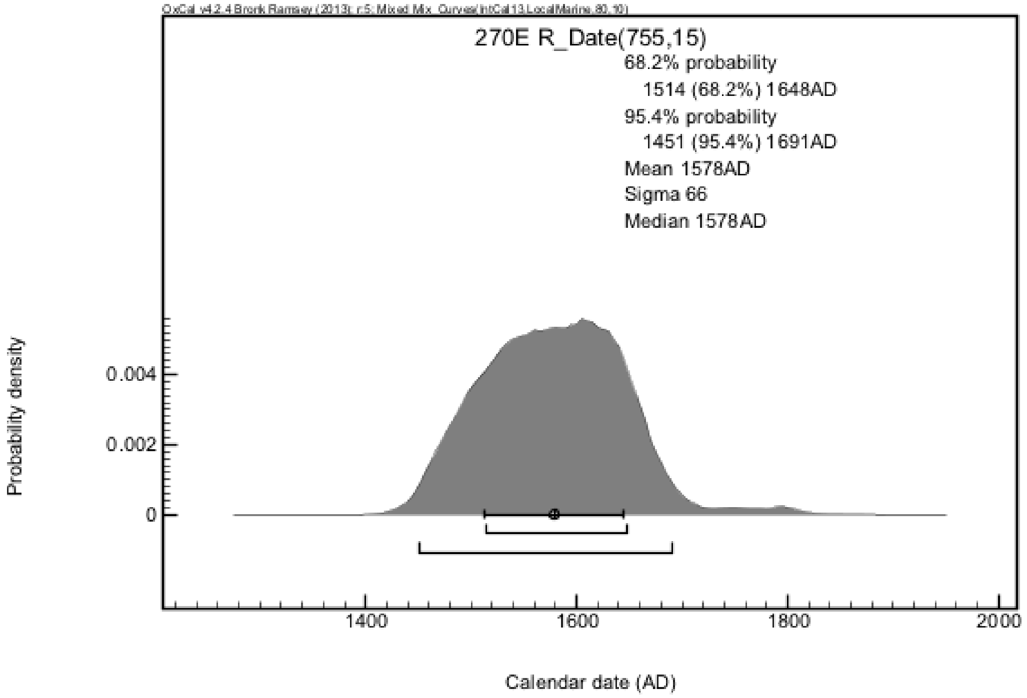

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,41,10)
266 R_Date(315,25)
68.2% probability
1705 (9.2%) 1730AD
1808 (59.0%) 1948AD
95.4% probability
1680 (31.1%) 1785AD
1796AD (64.3%) ...
Mean 1824AD
Sigma 81
Median 1835AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

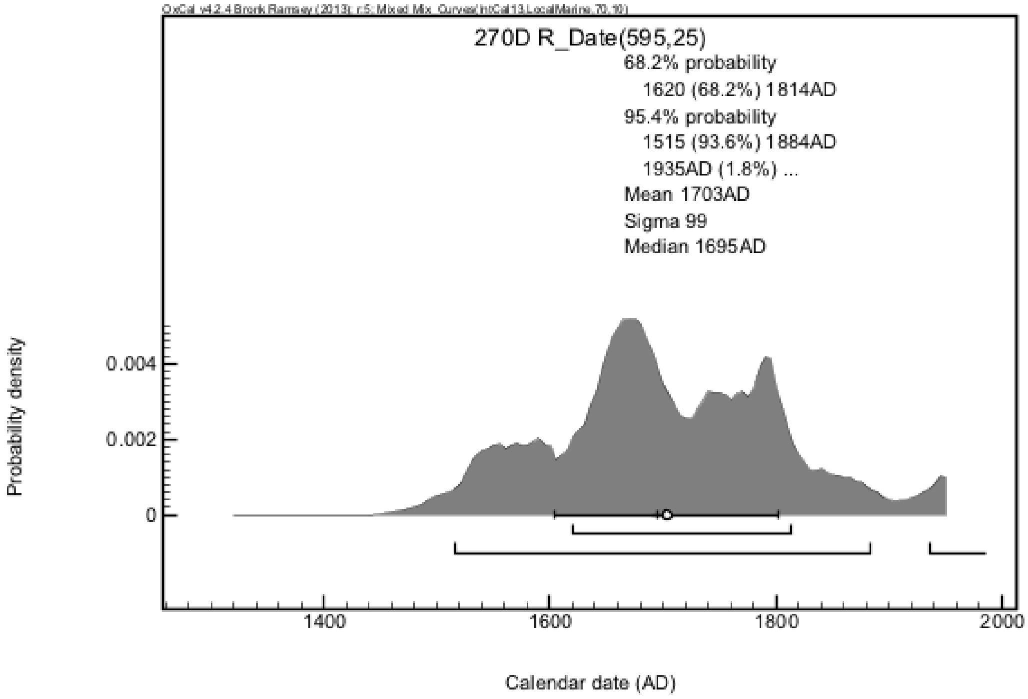

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,79,10)
268 R_Date(770,25)
68.2% probability
1498 (68.2%) 1635AD
95.4% probability
1445 (95.4%) 1680AD
Mean 1565AD
Sigma 66
Median 1565AD
Probability density
0.004
0.002
0
1200
1400
1600
1800
2000
Calendar date (AD)

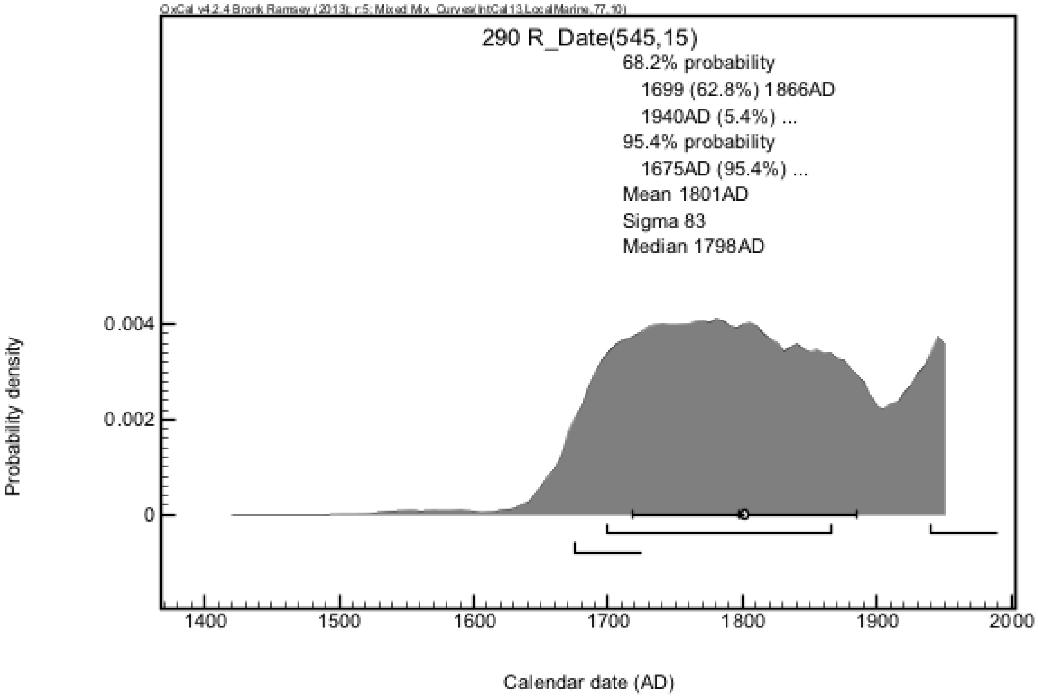

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,80,10)
270A R_Date(555,20)
68.2% probability
1705 (62.2%) 1870AD
1938AD (6.0%) ...
95.4% probability
1677AD (95.4%) ...
Mean 1804AD
Sigma 83
Median 1803AD
Probability density
0.003
0.002
0.001
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

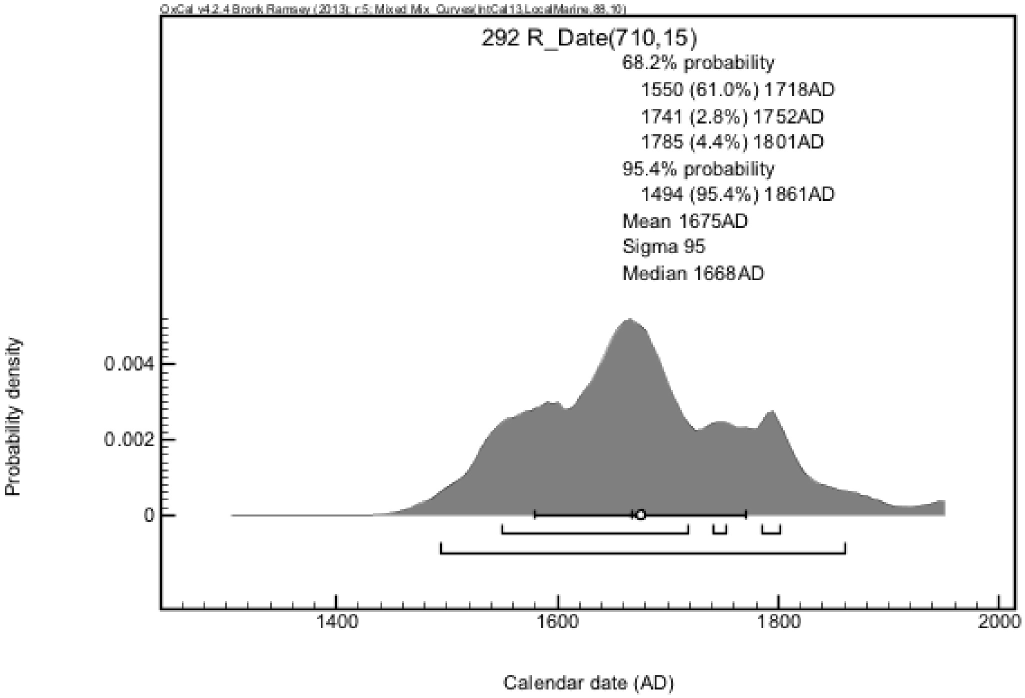

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,79,10)
270B R_Date(665,20)
68.2% probability
1536 (63.2%) 1712AD
1782 (5.0%) 1801AD
95.4% probability
1489 (95.4%) 1853AD
Mean 1668AD
Sigma 95
Median 1662AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

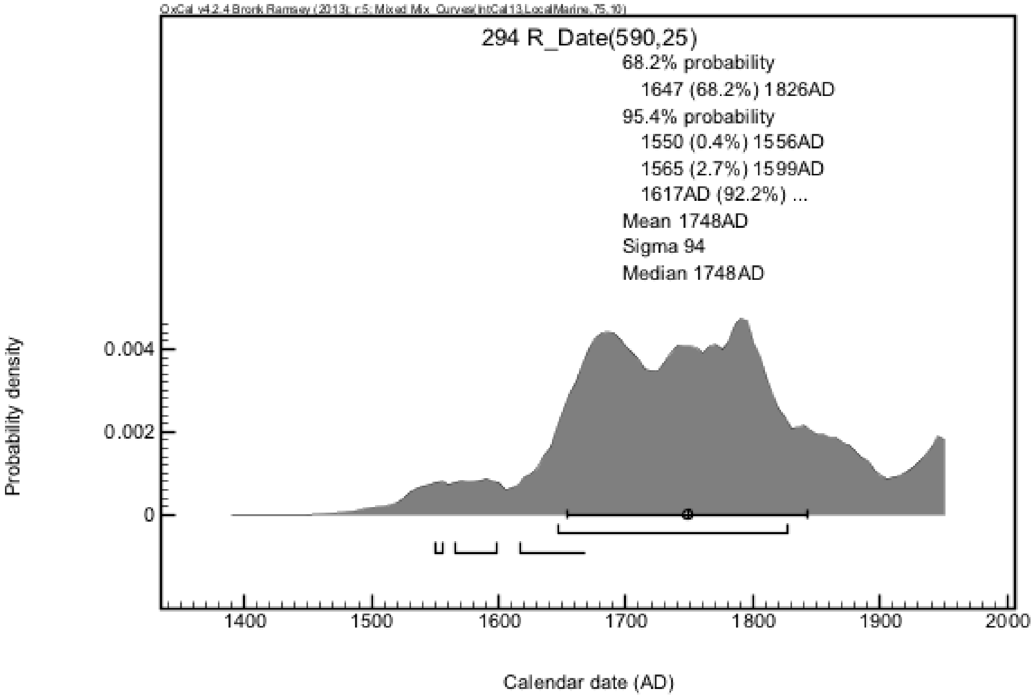

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,91,10)
270C R_Date(700,20)
68.2% probability
1625 (68.2%) 1820AD
95.4% probability
1524 (94.3%) 1896AD
1941AD (1.1%) ...
Mean 1714AD
Sigma 98
Median 1709AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

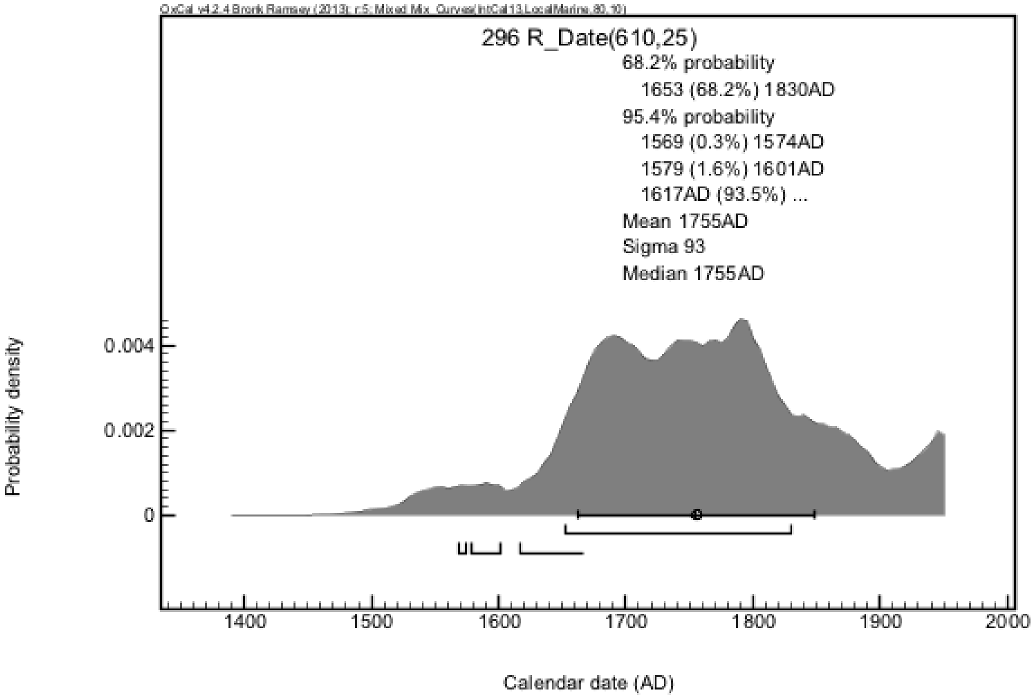

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,80,10)
270E R_Date(755,15)
68.2% probability
1514 (68.2%) 1648AD
95.4% probability
1451 (95.4%) 1691AD
Mean 1578AD
Sigma 66
Median 1578AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

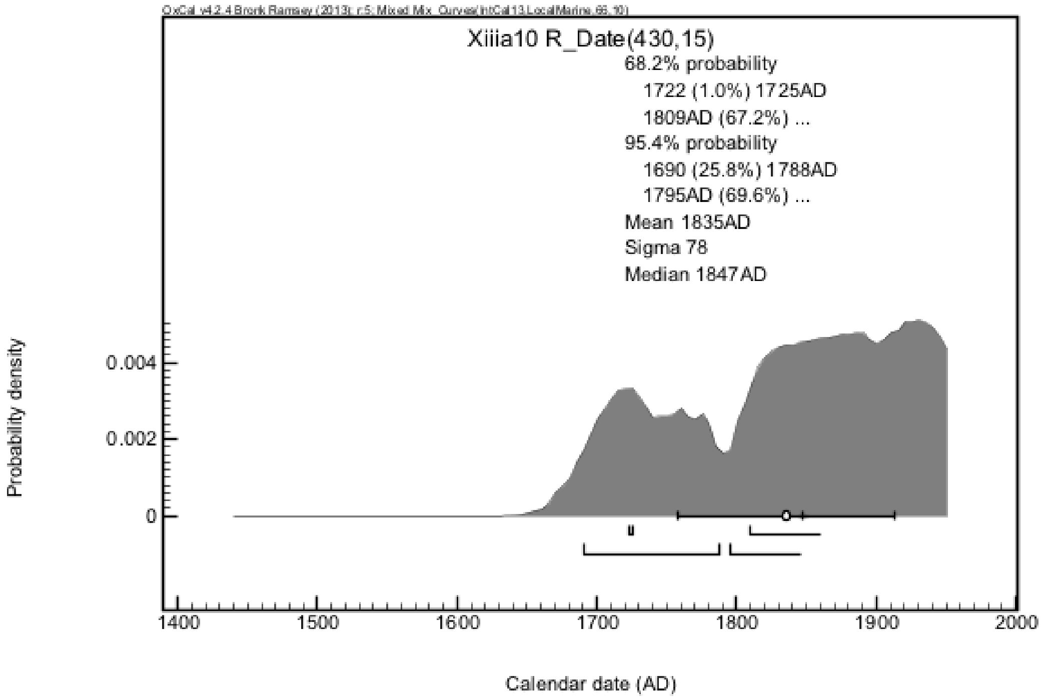

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,70,10)
270D R_Date(595,25)
68.2% probability
1620 (68.2%) 1814AD
95.4% probability
1515 (93.6%) 1884AD
1935AD (1.8%) ...
Mean 1703AD
Sigma 99
Median 1695AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

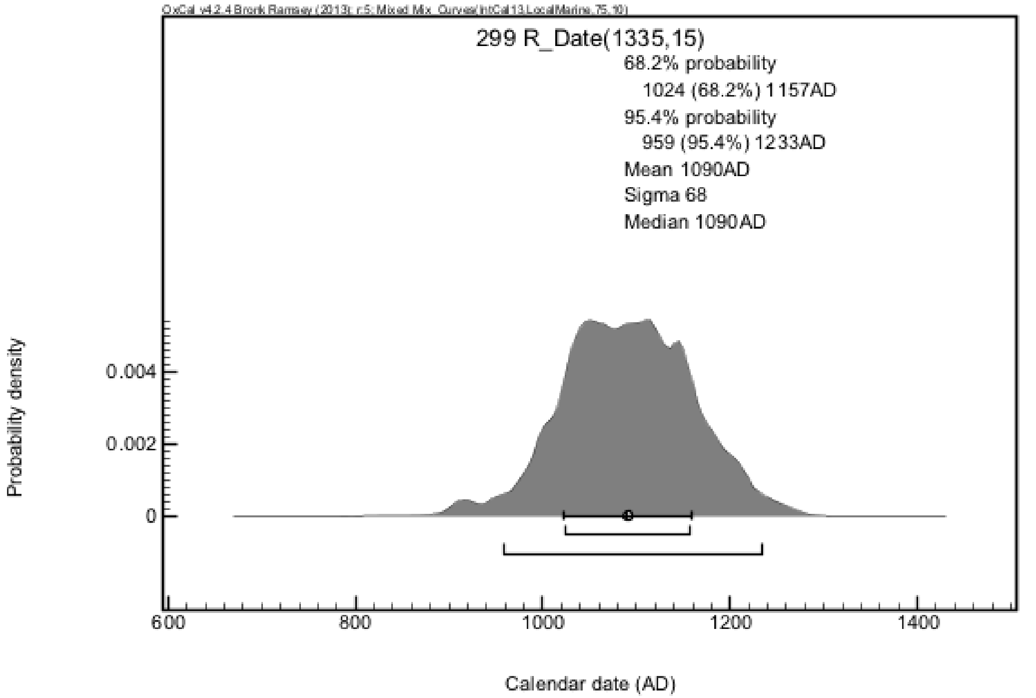

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,77,10)
290 R_Date(545,15)
68.2% probability
1699 (62.8%) 1866AD
1940AD (5.4%) ...
95.4% probability
1675AD (95.4%) ...
Mean 1801AD
Sigma 83
Median 1798AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

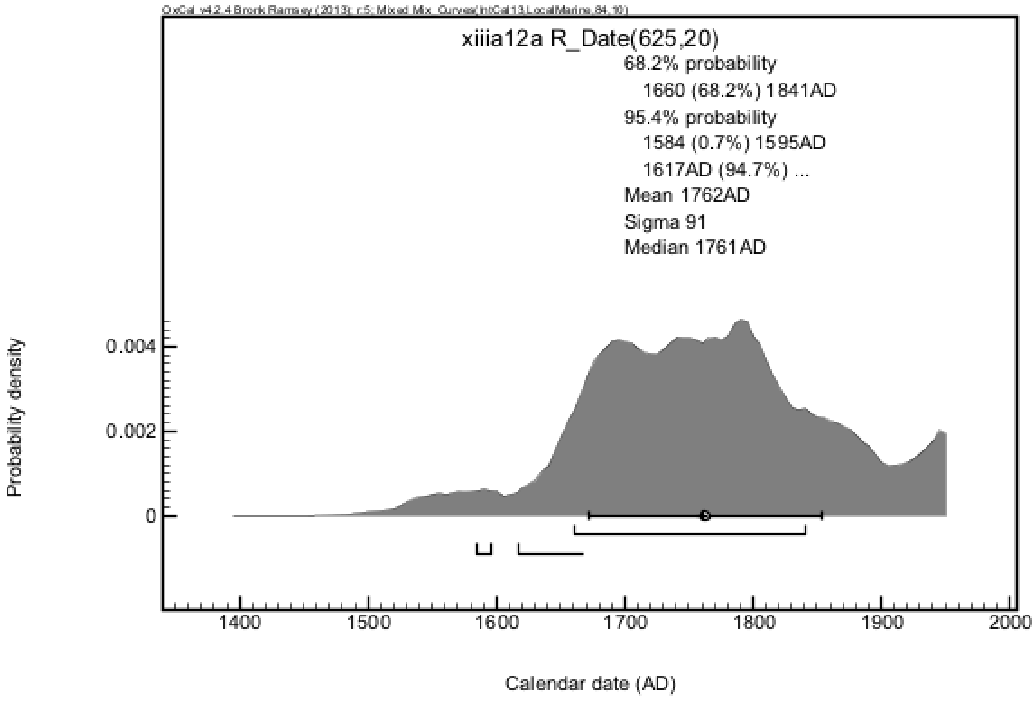

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,88,10)
292 R_Date(710,15)
68.2% probability
1550 (61.0%) 1718AD
1741 (2.8%) 1752AD
1785 (4.4%) 1801AD
95.4% probability
1494 (95.4%) 1861AD
Mean 1675AD
Sigma 95
Median 1668AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)

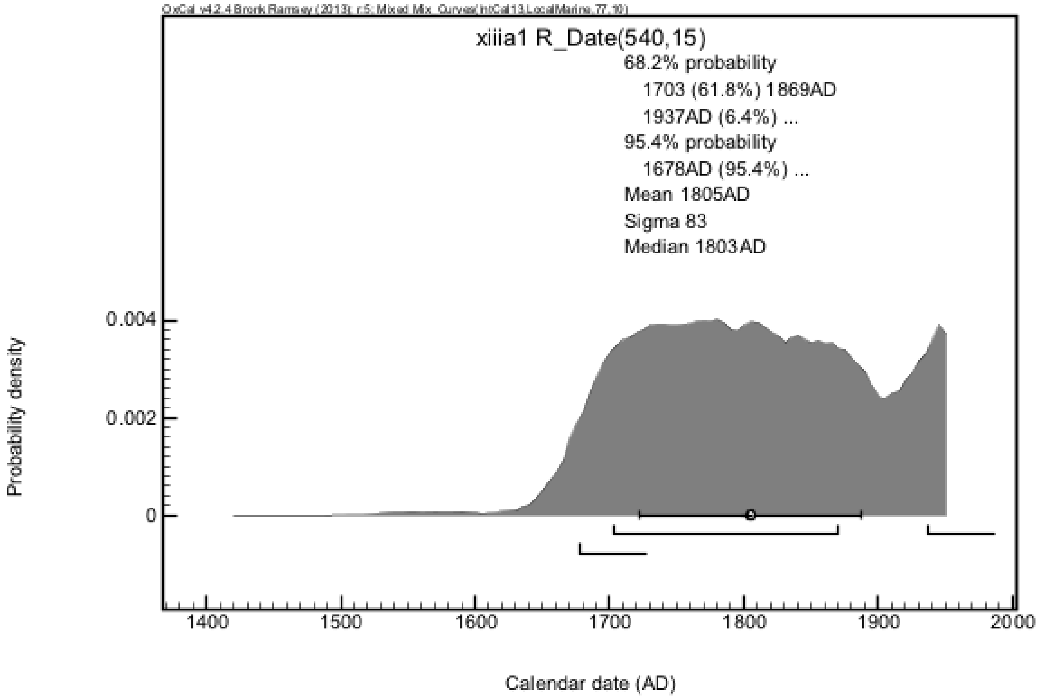

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
294 R_Date(590,25)
68.2% probability
1647 (68.2%) 1826AD
95.4% probability
1550 (0.4%) 1556AD
1565 (2.7%) 1599AD
1617AD (92.2%) ...
Mean 1748AD
Sigma 94
Median 1748AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

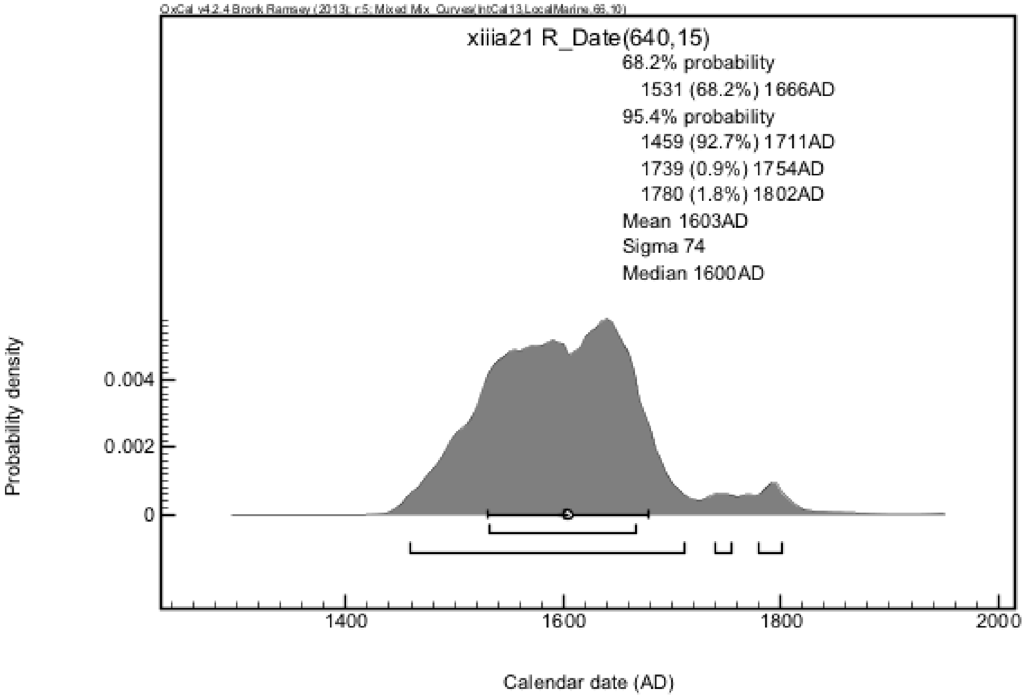

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,80,10)
296 R_Date(610,25)
68.2% probability
1653 (68.2%) 1830AD
95.4% probability
1569 (0.3%) 1574AD
1579 (1.6%) 1601AD
1617AD (93.5%) ...
Mean 1755AD
Sigma 93
Median 1755AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

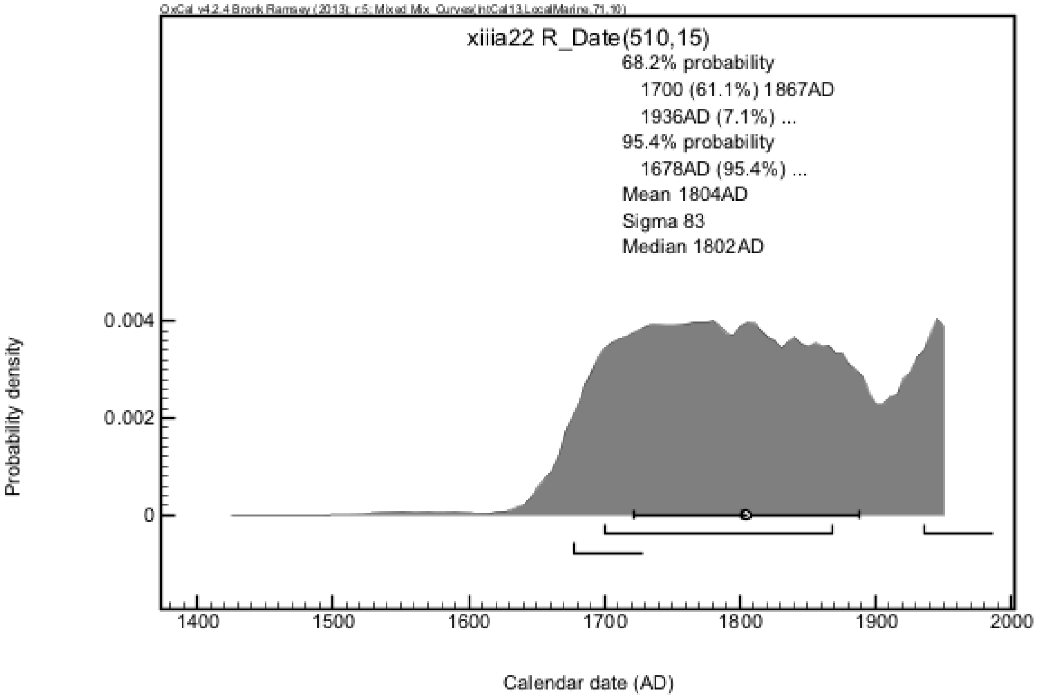

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,66,10)
Xiiia10 R_Date(430,15)
68.2% probability
1722 (1.0%) 1725AD
1809AD (67.2%) ...
95.4% probability
1690 (25.8%) 1788AD
1795AD (69.6%) ...
Mean 1835AD
Sigma 78
Median 1847AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

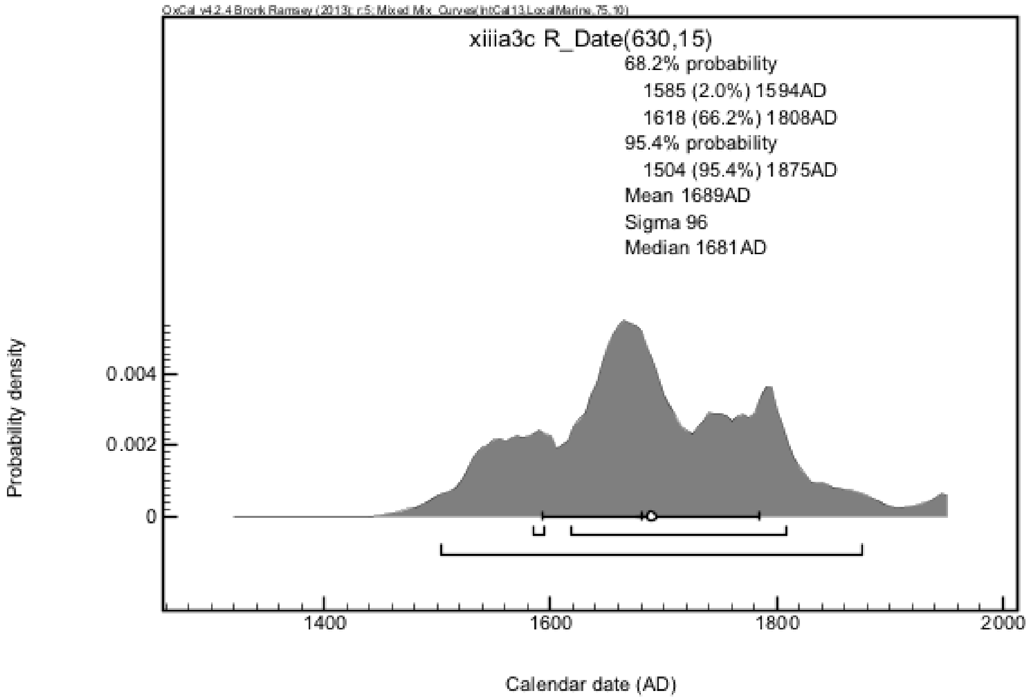

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
299 R_Date(1335,15)
68.2% probability
1024 (68.2%) 1157AD
95.4% probability
959 (95.4%) 1233AD
Mean 1090AD
Sigma 68
Median 1090AD
Probability density
0.004
0.002
0
600
800
1000
1200
1400
Calendar date (AD)

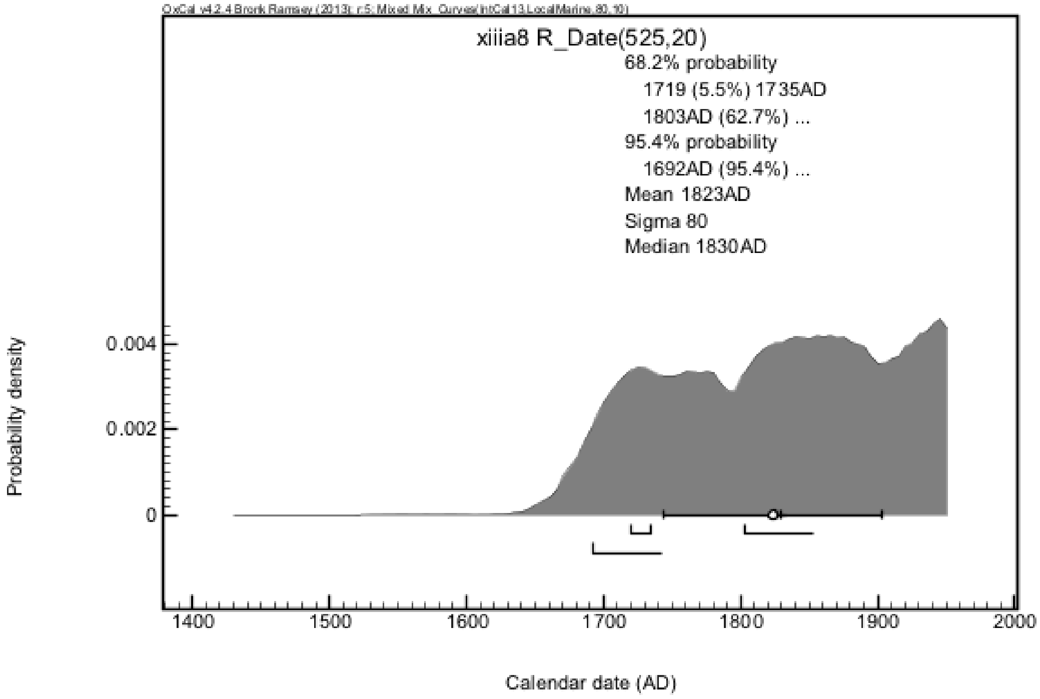

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,84,10)
xiiia12a R_Date(625,20)
68.2% probability
1660 (68.2%) 1841AD
95.4% probability
1584 (0.7%) 1595AD
1617AD (94.7%) ...
Mean 1762AD
Sigma 91
Median 1761AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

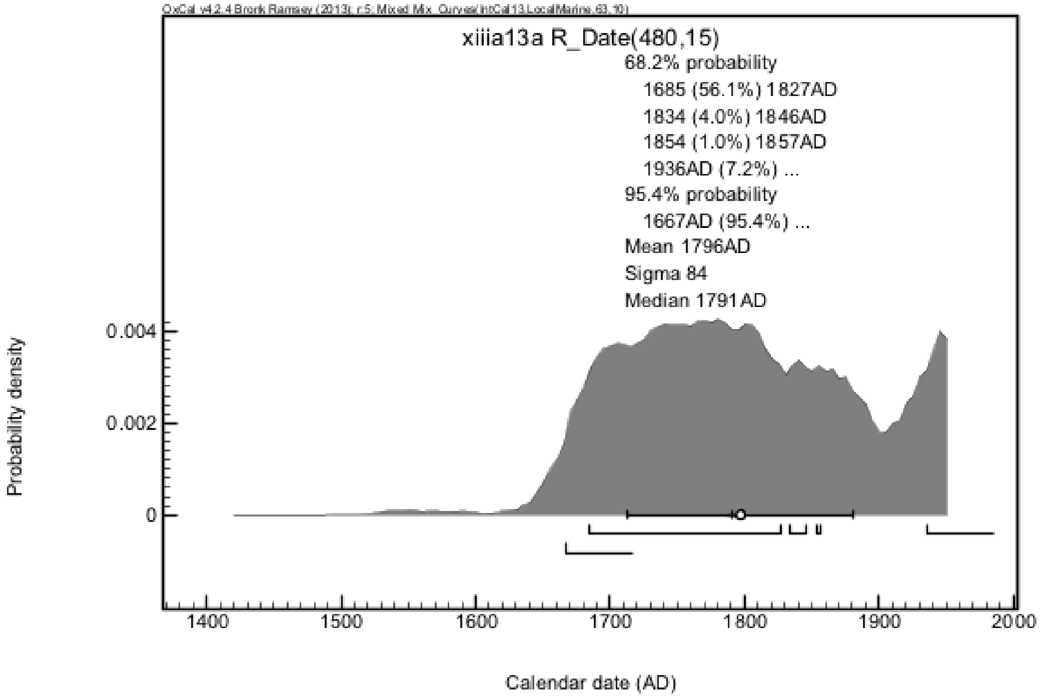

OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,77,10)
xiiia1 R_Date(540,15)
68.2% probability
1703 (61.8%) 1869AD
1937AD (6.4%) ...
95.4% probability
1678AD (95.4%) ...
Mean 1805AD
Sigma 83
Median 1803AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,66,10)
xiiia21 R_Date(640,15)
68.2% probability
1531 (68.2%) 1666AD
95.4% probability
1459 (92.7%) 1711AD
1739 (0.9%) 1754AD
1780 (1.8%) 1802AD
Mean 1603AD
Sigma 74
Median 1600AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,71,10)
xiiia22 R_Date(510,15)
68.2% probability
1700 (61.1%) 1867AD
1936AD (7.1%) ...
95.4% probability
1678AD (95.4%) ...
Mean 1804AD
Sigma 83
Median 1802AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,75,10)
xiiia3c R_Date(630,15)
68.2% probability
1585 (2.0%) 1594AD
1618 (66.2%) 1808AD
95.4% probability
1504 (95.4%) 1875AD
Mean 1689AD
Sigma 96
Median 1681AD
Probability density
0.004
0.002
0
1400
1600
1800
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,80,10)
xiiia8 R_Date(525,20)
68.2% probability
1719 (5.5%) 1735AD
1803AD (62.7%) ...
95.4% probability
1692AD (95.4%) ...
Mean 1823AD
Sigma 80
Median 1830AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,63,10)
xiiia13a R_Date(480,15)
68.2% probability
1685 (56.1%) 1827AD
1834 (4.0%) 1846AD
1854 (1.0%) 1857AD
1936AD (7.2%) ...
95.4% probability
1667AD (95.4%) ...
Mean 1796AD
Sigma 84
Median 1791AD
Probability density
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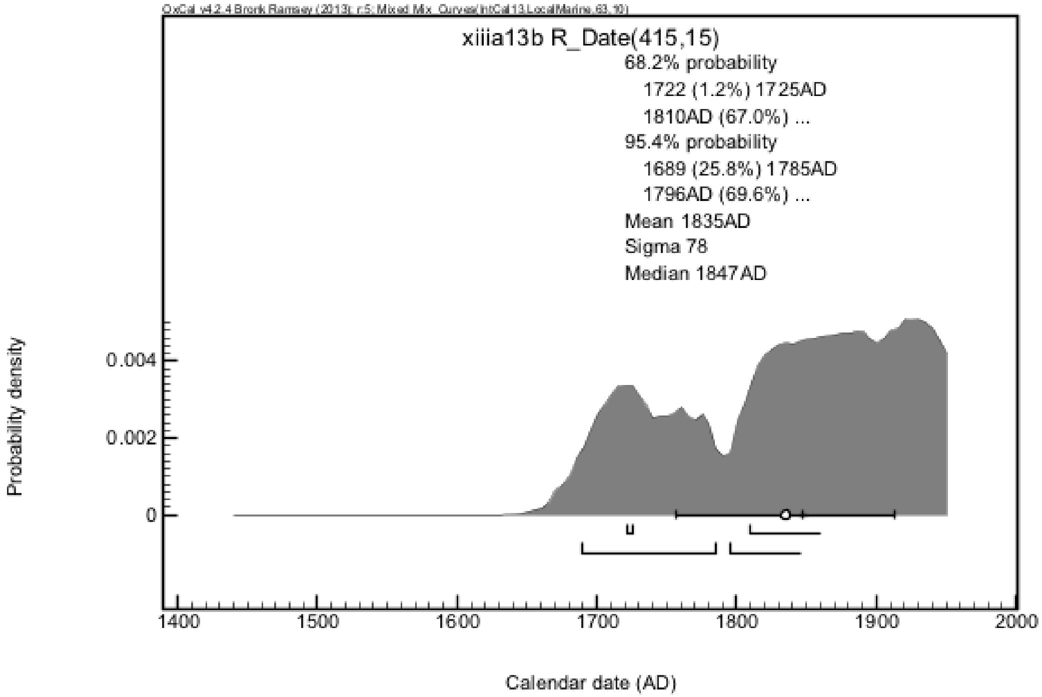
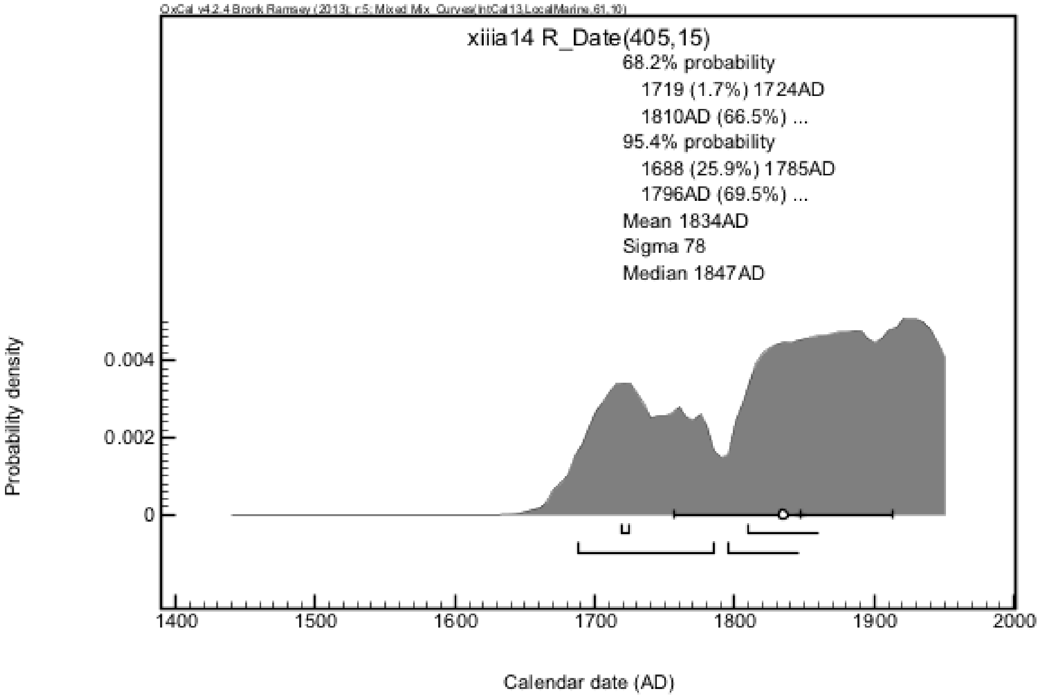
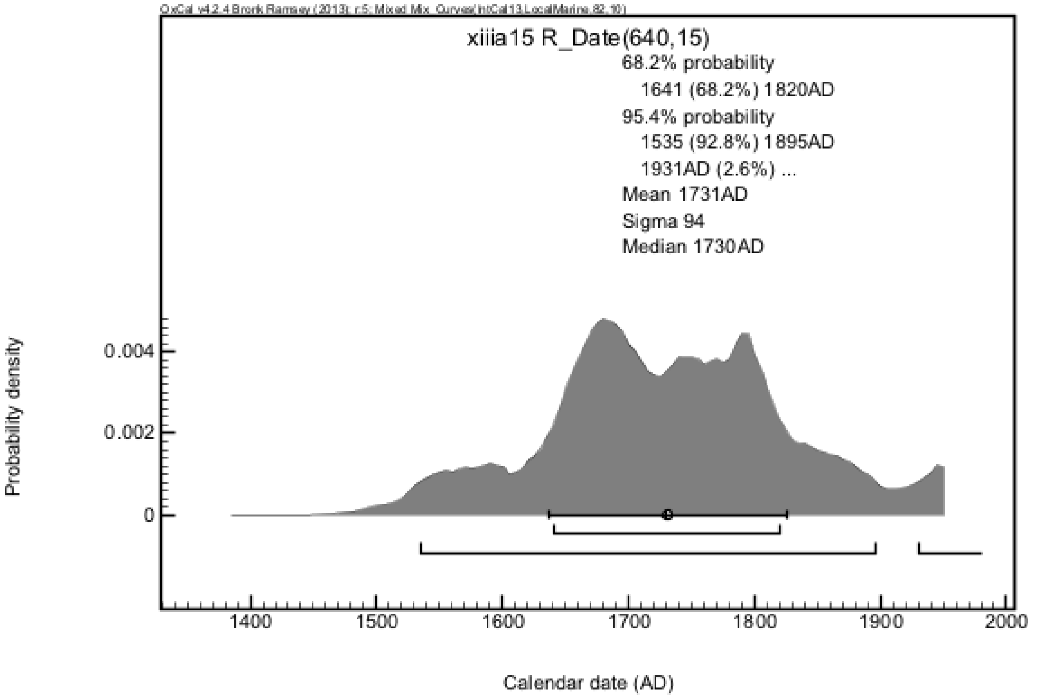
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,63,10)
xiiia13b R_Date(415,15)
68.2% probability
1722 (1.2%) 1725AD
1810AD (67.0%) ...
95.4% probability
1689 (25.8%) 1785AD
1796AD (69.6%) ...
Mean 1835AD
Sigma 78
Median 1847AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,61,10)
xiiia14 R_Date(405,15)
68.2% probability
1719 (1.7%) 1724AD
1810AD (66.5%) ...
95.4% probability
1688 (25.9%) 1785AD
1796AD (69.5%) ...
Mean 1834AD
Sigma 78
Median 1847AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)


OxCal v4.2.4 Bronk Ramsey (2013); r:5; Mixed Mix_Curves(IntCal13,LocalMarine,82,10)
xiiia15 R_Date(640,15)
68.2% probability
1641 (68.2%) 1820AD
95.4% probability
1535 (92.8%) 1895AD
1931AD (2.6%) ...
Mean 1731AD
Sigma 94
Median 1730AD
Probability density
0.004
0.002
0
1400
1500
1600
1700
1800
1900
2000
Calendar date (AD)

APPENDIX 4: REFERENCE MATERIALS

Table A.4.a Elemental and isotopic reference material known/accepted values. Standard deviation in parenthesis.

TERRA Lab ID	Standard ID	$\delta^{13}C_{VPDB}$(‰)	%C	$\delta^{15}N_{AIR}$(‰)	%N
C-5	CBM (CaCO3)*	.75(0.06)			
C-6	NBS-19 (CaCO3)	1.95[1]			
C-132	MUN-CO-1*	-21.02(0.1)[1]			
N-4	IAEA-N-2 $((NH_4)_2SO_4)$			20.32(0.09)	21.2
N-6	USGS-26 $((NH_4)_2SO_4)$			53.62(0.25)	21.2
G-7	EDTA #2	-40.38(0.01)[2]	41.10	-0.83(0.04)	9.59
G-30	D-Fructose	-10.53(0.11)	40.00		
G-32	Sulfanilamide		41.85		16.27
G-34	BBOT		72.53		6.51
G-40	B2155 (protein)	-27.03(0.13)[3]	46.5(0.78)[4]	5.97(0.08)[3]	13.32(0.40)[4]

*Denotes internal standard

**Fixed value, defines VPDB scale.

[1] Coplen et al. 2002; [2]Indiana University Certificate of Analysis; [3]Coplen et al. 2006; [4]Elemental Microanalysis Certificate of Analysis

Table A.4.b Mean $\delta^{13}C$ and $\delta^{15}N$ values for collagen standards by analytical run.

Date of analysis m-d-y	Standard	n	$\delta^{13}C_{VPDB}$ (‰)	1σ	$\delta^{15}N_{AIR}$ (‰)	1σ
11-19-2014	Sulfanilamide	4	-28.94	.11	-3.54	.04
	EDTA #2	8	-40.38	.06	-.83	.12
	IAEA-N-2	6			20.32	.36
	D-Fructose	6	-10.53	.03		
	B-2155	3	-27.30	.13	6.01	.24
	BBOT	2	-27.07		-21.39	
03-08-2015	Sulfanilamide	6	-28.95	.02	-3.78	.22
	EDTA #2	7	-40.38	.04	-.83	
	USGS-26	5			53.62	.14
	D-Fructose	5	-10.53	.08		
	B-2155	4	-27.24	.08	5.7	.21
03-25-2015	Sulfanilamide	6	-29.08	.05	-3.72	.1
	EDTA #2	6	-40.38	.1	-.83	.06
	USGS-26	5			53.62	.53
	D-Fructose	6	-10.53	.06		
	B-2155	4	-27.23	.07	5.96	.12
04-28-2015	Sulfanilamide	6	-29.01	.18	-3.86	0.2
	EDTA #2	5	-40.38	.07	-.83	.05

	IAEA-N-2	5			20.32	.12
	D-Fructose	6	-10.53	.06		
	B-2155	4	-27.55	.45	5.96	.09
11-05-2015	Sulfanilamide	6	-28.98	.07	-3.92	.14
	EDTA #2	9	-40.38	.07	-.83	.06
	IAEA-N-2				20.32	.22
	D-Fructose	5	-10.53	.08		
	B-2155	4	-27.29	.18	6.17	.14
11-06-2015	Sulfanilamide	6	-29.07	.16	-3.4	.25
	EDTA #2	6	-40.38	.11	-.83	.08
	IAEA-N-2	6			20.32	.08
	D-Fructose	6	-10.53	.04		
	B-2155	4	-27.29	.18	6.17	.14
12-14-2015	Sulfanilamide	6	-29.18	.1	-3.62	.09
	EDTA #2	6	-40.38	.07	-.83	.1
	IAEA-N-2	5			20.32	.12
	D-Fructose	6	-10.53	.09		
	B-2155	4	-27.23	.05	5.9	.08
01-21-2016	Sulfanilamide	6	-29.19	.12	-3.58	.14
	EDTA #2	6	-40.38	.1	-.83	.06
	L-Valine	6	-9.42	.12	29.52	.07
	B-2155	4	-27.27	.15	5.8	.1

Table A.4.c Mean δ^{13}C values for carbonate standards run on 12-08-2015.

Standard	n	$\delta^{13}C_{VPDB}$(‰) all peaks	1σ	$\delta^{13}C_{VPDB}$(‰) all analyses	1σ
C-5(CBM)	5	.69	.04	.61	.08
C-6 (NBS -19)	5	1.98	.05	1.95*	.05
C-132 (MUN-CO-1)	5	-21.01	.04	-21.02	.01

*Fixed value, defines VPDB scale

APPENDIX 5: STATISTICAL ANALYSES

Summary Statistics:

Table A.5.1 Port au Choix-3 summary statistics (all burials: n=103)

	Statistic	**Standard error**
δ^{13}C values		
Mean	-14.24	0.07
Standard deviation	0.71	
Median	-14.20	
Standard error	0.07	
Kurtosis	1.51	
Skewness	-0.92	
Range	4.10	
Interquartile Range	0.70	
Minimum	-16.80	
Maximum	-12.70	
δ^{15}N values		
Mean	20.44	0.14
Standard deviation	1.40	
Median	20.40	
Sample variance	1.96	
Kurtosis	0.60	
Skewness	0.07	
Range	7.60	
Interquartile range	1.50	
Minimum	16.60	
Maximum	24.20	

Table A.5.2 Port au Choix-3 Locus I summary statistics (n = 10)

	Statistic	**Standard error**
δ^{13}C		
Mean	-13.91	0.08
Standard deviation	0.25	
Median	-13.92	
Sample variance	0.06	
Kurtosis	-0.65	
Skewness	-0.36	
Range	0.75	
Interquartile range		
Minimum	-14.36	
Maximum	-13.61	
δ^{15}N		
Mean	20.13	0.19

Standard deviation	0.61
Median	20.01
Sample variance	0.37
Kurtosis	1.02
Skewness	0.85
Range	2.09
Interquartile range	
Minimum	19.30
Maximum	21.39

Table A.5.3 Port au Choix-3 Locus II summary statistics (n = 81)

	Statistic	**Standard error**
δ^{13}C		
Mean	-14.3	0.84
Median	-14.2	
Standard deviation	0.76	
Variance	0.57	
Kurtosis	1.13	0.53
Skewness	-1.92	0.50
Range	4.1	
Interquartile range	0.75	
Minimum	-16.8	
Maximum	-12.7	
δ^{15}N		
Mean	20.6	0.16
Median	20.5	
Standard deviation	1.5	
Variance	2.2	
Kurtosis	0.546	0.529
Skewness	-0.143	0.267
Range	7.6	
Interquartile range	1.6	
Minimum	16.6	
Maximum	24.2	

Table A.5.4 Port au Choix-3 Locus V (n = 8)

	Statistic	**Standard error**
δ^{13}C		
Mean	-14.07	0.14
Standard deviation	0.39	
Median	-14.02	
Sample variance	0.15	
Kurtosis	0.22	
Skewness	0.09	

Range	1.25	
Interquartile range		
Minimum	-14.65	
Maximum	-13.40	
δ^{15}N		
Mean	20.08	0.36
Standard deviation	1.03	
Median	20.14	
Sample variance	1.06	
Kurtosis	1.26	
Skewness	0.91	
Range	3.21	
Interquartile range		
Minimum	18.89	
Maximum	22.10	

Table A.5.5 Port au Choix-3 Harp's Burials (n = 3)

	Statistic	**Standard error**
δ^{13}C		
Mean	-15.03	0.51
Standard deviation	0.89	
Median	-14.87	
Sample variance	0.78	
Kurtosis	-	
Skewness	-0.77	
Range	1.75	
Interquartile range		
Minimum	-15.98	
Maximum	-14.23	
δ^{15}N		
Mean	18.90	0.55
Standard deviation	0.96	
Median	18.80	
Sample variance	0.92	
Kurtosis		
Skewness	0.50	
Range	1.91	
Interquartile range		
Minimum	17.99	
Maximum	19.90	

Table A.5.6 Port au Choix-3 Adult Females (n = 24)

	Statistic	**Standard error**
$\delta^{13}C$		
Mean	-13.9 (-13.9)	
Median	-14.1	
Standard deviation	0.50 (0.46)	
Variance	0.245 (0.218)	
Kurtosis	0.331	0.918
Skewness	0.792 (1.107)	0.472 (0.524)
Range	2.0 (1.8)	
Interquartile range	0.68	
Minimum	-14.7	
Maximum	-12.7	
$\delta^{15}N$		
Mean	20.2 (20.3)	
Median	20.2	
Standard deviation	0.844 (0.662)	
Variance	0.712 (0.438)	
Kurtosis	-0.49	0.918
Skewness	0.504 (-0.65)	0.472 (0.524)
Range	3.4 (2.4)	
Interquartile range	1.48	
Minimum	18.8	
Maximum	22.2	

Table A.5.7 Port au Choix-3 adult males, n=25

	Statistic	**Standard error**
$\delta^{13}C$		
Mean	-14.4 (-14.4)	
Median	-14.2	
Standard deviation	0.75 (0.73)	
Variance	0.567 (0.534)	
Kurtosis	0.255	0.902
Skewness	-0.981 (-1.098)	0.464 (0.434)
Range	2.8 (2.8)	
Interquartile range	0.7	
Minimum	-16.1	
Maximum	-13.3	
$\delta^{15}N$		
Mean	19.6 (19.8)	
Median	20.0	
Standard deviation	1.34 (1.39)	

Variance	1.79 (1.93)	
Kurtosis	-0.15	0.902
Skewness	-1.02 (-0.747)	0.464 (0.434)
Range	4.5 (5.60)	
Interquartile range	1.85	
Minimum	16.6	
Maximum	21.1	

Table A.5.8 Port au Choix-3 Locus II Cluster A, n=15

δ^{13}C	**Statistic**	**Standard error**
Mean	-14.2	0.79
Median	-14.2	
Standard deviation	0.31	
Variance	0.09	
Kurtosis	-0.41	1.121
Skewness	0.197	0.580
Range	1.10	
Interquartile range	0.50	
Minimum	-14.7	
Maximum	-13.6	
δ^{15}N		
Mean	20.3	0.344
Median	20.3	
Standard deviation	1.33	
Variance	1.78	
Kurtosis	-0.593	1.121
Skewness	0.486	0.580
Range	4.5	
Interquartile range	1.9	
Minimum	18.3	
Maximum	22.8	

Table A.5.9 Port au Choix-3 Locus II Cluster B

δ^{13}C	**Statistic**	**Standard error**
Mean	-14.3	0.18
Median	-14.2	
Standard deviation	0.91	
Variance	0.819	
Kurtosis	1.279	0.902
Skewness	-0.983	0.464
Range	3.8	
Interquartile range	0.9	

Minimum	-16.8	
Maximum	-13.0	
δ^{15}N		
Mean	20.8	0.33
Median	20.5	
Standard deviation	1.64	
Variance	2.70	
Kurtosis	1.518	0.902
Skewness	-0.250	0.464
Range	7.6	
Interquartile range	1.6	
Minimum	16.6	
Maximum	24.2	

Table A.5.10 Port au Choix-3 Locus II Cluster C

δ^{13}C	**Statistic**	**Standard error**
Mean	-14.2	0.12
Median	-14.2	
Standard deviation	0.78	
Variance	0.612	
Kurtosis	-0.192	0.724
Skewness	-0.438	0.369
Range	3.4	
Interquartile range	1.1	
Minimum	-16.1	
Maximum	-12.7	
δ^{15}N		
Mean	20.6	0.23
Median	20.6	
Standard deviation	1.45	
Variance	2.11	
Kurtosis	0.384	0.724
Skewness	-0.316	0.369
Range	7.0	
Interquartile range	1.7	
Minimum	16.9	
Maximum	23.9	

Table A.5.11 Recent Indian/Beothuk bone collagen results (n = 30) summary statistics

	Statistic	**Standard error**
δ^{13}C		
Mean	-14.73	0.10
Standard deviation	0.55	
Median	-14.60	
Sample variance	0.31	
Kurtosis	3.21	
Skewness	-0.35	
Range	2.80	
Interquartile range	0.80	
Minimum	-16.60	
Maximum	-13.80	
δ^{15}N		
Mean	16.64	0.23
Standard deviation	1.27	
Median	16.65	
Sample variance	1.62	
Kurtosis	3.16	
Skewness	0.28	
Range	7.3	
Interquartile range	1.30	
Minimum	13.20	
Maximum	20.5	

Table A.5.12 Recent Indian Beothuk carbonate results (n = 10) summary statistics

	Statistic	**Standard error**
δ^{13}C		
Mean	-11.71	0.21
Standard deviation	0.67	
Median	-11.61	
Sample variance	0.44	
Kurtosis	4.62	
Skewness	-1.94	
Range	2.37	
Interquartile range		
Minimum	-13.38	
Maximum	-11.01	

Shapiro-Wilk Tests for Normality

Table A.5.13 Port au Choix 3 Locus II, Clusters $\delta^{13}C$

Cluster	**Statistic**	**df**	**Sig.**
A	0.960	15	0.692
B	0.916	25	0.041
C	0.974	41	0.458

Table A.5.14 Port au Choix-3 Locus II, Cluster $\delta^{15}N$

Cluster	**Statistic**	**df**	**Sig.**
A	0.952	15	0.554
B	0.933	25	0.103
C	0.976	41	0.523

Table A.5.15 Port au Choix-3 adult males

Isotope	**Statistic**	**df**	**Sig.**
$\delta^{13}C$	0.89	25	0.01
$\delta^{15}N$	0.87	25	0.00

Table A.5.16 Port au Choix-3 adult females

Isotope	**Statistic**	**df**	**Sig.**
$\delta^{13}C$	0.94	24	0.13
$\delta^{15}N$	0.97	24	0.57

Levene's Test for Equal Variance

Table A.5.17 Port au Choix-3 $\delta^{13}C$ Locus II adults

Levene's statistic	**df1**	**df2**	**Sig.**
2.46	2	53	0.10

Table A.5.18 Port au Choix-3 adult males and females

Isotope	**Levene's statistic**	**df 1**	**df 2**	**Sig.**
$\delta^{13}C$	2.786	2	49	0.101
$\delta^{15}N$	6.700	2	49	0.013

Kruskal Wallis Test

Table A.5.19 Port au Choix-3 δ^{15}N clusters, adults only

Cluster	N	Mean rank
A	15	23.04
B	25	32.84
C	41	27.82
Total	81	

Kruskal Wallis Test Statistics

	Nitrogen
Chi-square	2.75
Df	2
Asymptotic sig.	0.25

One-way ANOVA

Table A.5.20 Port au Choix-3 δ^{13}C cluster, adults only

	Sum of squares	Df	Mean square	F	Sig.
Between groups	0.07	2	0.04	0.08	0.93
Within groups	21.05	46	0.46		
Total	21.12	48			

Welch's T Test

Table A.5.21 Port au Choix-3 Adult males and females with Anderson data (Jelma data)

Isotope	Sig. (2-tailed)	*T* statistic	Mean difference	St. error difference
δ^{13}C	0.02	-2.41	-0.44	0.18
δ^{15}N	0.05	-2.00	-0.61	0.31

Cluster Analysis

Table A.5.22 K-means analysis of marine fauna

Cluster	**δ^{13}C**	**δ^{15}N**	**Site**	**Species**
1	-8.4	10.0	Boyd’s Cove	Canada goose
1	-9.6	12.0	Boyd’s Cove	Eider
1	-9.9	11.8	Boyd’s Cove	Marten
1	-8.9	16.2	Boyd’s Cove	Otter
1	-10.7	14.4	Boyd’s Cove	Sculpin
1	-10.4	14.6	Boyd’s Cove	Sea raven
1	-10.4	15.3	Boyd’s Cove	Cormorant
1	-11.7	12.5	Boyd’s Cove	Cormorant
1	-9.7	15.7	Boyd’s Cove	Otter
1	-11.5	18.4	Beaches	Otter
1	-10.7	18.7	Beaches	Otter
1	-12.1	17.9	Beaches	Otter
1	-12.5	17.1	Beaches	Harp seal
1	-12.9	10.8	Peat Garden North	Tuna
1	-10.7	15.5	Crow Head Cave	Scoter
1	-10.6	15.6	Crow Head Cave	Scoter
1	-10.7	14.6	Crow Head Cave	Sculpin
1	-12.7	13.6	Crow Head Cave	Sculpin
Mean				
St.dev				
2	-15.1	13.8	Boyd’s Cove	Guillemot
2	-13.9	19.8	Boyd’s Cove	Polar bear
2	-13.6	16.2	Boyd’s Cove	Bearded seal
2	-17.9	15.1	Boyd’s Cove	Murre
2	-14.7	16.8	Boyd’s Cove	Harbour seal
2	-14.3	13.1	Boyd’s Cove	Bird
2	-16.5	14.6	Beaches	Fox
2	-15.2	15.6	Beaches	Harbour seal
2	-12.7	19.8	Beaches	Harp seal
2	-15.3	16.4	Parke’s Beach	Seal
2	-15.4	14.2	Port au Port	Seal
2	17.0	11.5	Peat Garden North	Gull
2	-15.0	14.4	Peat Garden North	Harp seal
2	-13.7	16.0	Peat Garden North	Seal
2	-14.5	15.4	Peat Garden	Seal

2	-15.4	16.0	North Peat Garden	Harp seal
2	-15.1	14.7	North Peat Garden	Harp seal
2	-16.2	14.8	North Crow Head Cave	Dovekie
2	-17.2	14.3	Crow Head Cave	Dovekie
2	-16.3	13.5	Crow Head Cave	Dovekie
2	-17.1	15.4	Crow Head Cave	Dovekie
2	-17.5	15.8	Crow Head Cave	Dovekie
2	-17.4	15.2	Crow Head Cave	Dovekie
2	-17.1	14.3	Crow Head Cave	Dovekie
2	-16.4	14.3	Crow Head Cave	Dovekie
2	-17.0	14.6	Crow Head Cave	Dovekie
2	-16.8	15.6	Crow Head Cave	Dovekie
2	-15.9	16.9	Crow Head Cave	Murre
2	-16.4	18.0	Crow Head Cave	Murre
2	-16.2	17.6	Crow Head Cave	Murre
2	-16.8	17.7	Crow Head Cave	Murre
2	-15.6	17.6	Crow Head Cave	Murre
2	-15.4	14.3	Crow Head Cave	Puffin
2	-15.6	13.8	Crow Head Cave	Puffin
2	-16.1	11.8	Crow Head Cave	Great auk
2	-15.9	13.2	Crow Head Cave	Great auk
2	-15.8	14.8	Crow Head Cave	Great auk
2	-13.9	16.7	Crow Head Cave	Cod
2	-14.4	14.2	Crow Head Cave	Cod
2	-16.1	14.9	Crow Head Cave	Cod
2	-16.4	12.1	Crow Head Cave	Cunner
2	-15.1	13.5	Crow Head Cave	Cunner
2	-14.5	13.5	Crow Head Cave	Redfish
2	-13.1	16.2	Crow Head Cave	Sculpin
2	-15.0	15.9	Crow Head Cave	Seal
2	-13.7	16.4	Crow Head Cave	Seal
2	-14.4	13.4	Crow Head Cave	Seal
2	-15.7	16.0	Crow Head Cave	Harp seal
2	-14.1	19.3	Crow Head Cave	Polar bear
Mean				
St.dev				

Table A.5.22 Summary of K-means cluster analysis of Port au Choix-3 adult carbon and nitrogen isotope data.

Diet cluster	**δ^{13}C(‰)**	**δ^{15}N(‰)**	**NP**	**Locus**	**Burial cluster**	**Sex**
1	-14.2	21.1	29	II	B	M
1	-13.3	21.1	32	II	C	M
1	-13.6	20.7	47A	II	C	M
1	-13.2	21.0	16A	II	B	F
1	-13.6	21.1	21	II	A	F
1	-13.0	21.0	18B	II	B	F
1	-13.5	20.4	25	II	B	F?
1	-14.1	21.6	28A	II	B	F
1	-14.2	22.2	37C	II	C	F
1	-12.7	21.0	49A	II	C	F
1	-13.6	20.6	60D	I	-	F
1	-13.8	20.6	24B	II	B	?
1	-14.2	21.1	28B	II	B	?
1	-13.4	20.6	285	V	-	?
mean	**-13.6**	**21.0**				
st.dev	**0.5**	**0.5**				
2	-15.2	17.5	5	II	B	M
2	-15.9	16.6	31	II	B	M
2	-15.5	17.5	40A	II	C	M
2	-16.1	16.9	35A	II	C	M
mean	**-15.7**	**17.1**				
st.dev	**0.4**	**0.5**				
3	-14.7	20.2	44B	II	C	M
3	-14.0	20.0	1A	II	A	M
3	-14.4	21.0	8A	II	A	M
3	-14.3	20.4	15	II	B	M
3	-14.1	20.1	18A	II	B	M
3	-14.7	21.0	19	II	B	M
3	-13.5	20.2	27A	II	B	M
3	-14.0	20.5	30	II	B	M
3	-14.1	20.0	30C	II	B	M
3	-13.9	20.0	34	II	C	M
3	-13.9	20.0	46A	II	C	M?
3	-14.0	20.6	60A	I	-	M
3	-14.6	19.7	1B	II	A	F?
3	-14.2	20.4	4	II	A	F?
3	-13.9	20.4	6	II	A	F
3	-14.0	20.3	7	II	A	F?

3	-14.2	20.0	37B	II	C	F
3	-13.6	20.2	52	II	C	F
3	-14.1	19.8	60B	I	-	F
3	-13.6	20.1	60C	I	-	F
3	-14.1	20.0	61A	I	-	F
3	-14.5	20.3	162A	V	-	F
3	-14.9	20.5	23	II	B	?
3	-14.9	20.9	37D	II	C	?
3	-14.6	20.8	37E	II	C	?
3	-14.4	20.9	43B	II	C	?
3	-14.4	20.4	46B/C	II	C	?
3	-13.8	19.9	60E	I	-	?
3	-14.2	19.9	275A	V	-	?
3	-14.0	20.0	286	V	-	?
mean	**-14.2**	**20.3**				
st.dev	**0.4**	**0.4**				
4	-14.5	18.3	12	II	A	M
4	-14.2	18.9	14A	II	A	M
4	-14.6	19.4	47B	II	C	M
4	-14.7	19.2	3	II	A	F?
4	-14.2	19.3	9	II	A	F?
4	-14.3	19.2	10A	II	A	F
4	-14.3	18.8	44A	II	C	F
4	-14.4	19.5	61B	I	-	F
4	-13.7	19.4	50A	II	C	F
4	-14.4	19.4	51	II	C	?
4	-14.0	18.9	162C	V	-	?
mean	**-14.3**	**19.1**				
st.dev	**0.3**	**0.4**				
5	-15.9	19.5	22D	II	B	M
5	-14.9	18.0	276	V	-	?
5	-16.0	18.8	277	HB*	-	?
mean	**-15.6**	**18.8**				
st.dev	**0.6**	**0.8**				

* Denotes Harp’s Burial