An Isotopic Investigation of the Diet and Origins of 18th- and 19th-Century Individuals from Newfoundland and Louisbourg, Nova Scotia

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Abstract

The forced migration of French colonists from Placentia, Newfoundland, to what would become the Fortress of Louisbourg, Nova Scotia, following the Treaty of Utrecht connects the two sites historically. To investigate this link, isotopic analyses involving carbon ($\delta^{13}C_{VPDB}$), nitrogen ($\delta^{15}N_{AIR}$), and strontium ($^{87}Sr/^{86}Sr$) were conducted to evaluate the diet and geographic origins of individuals from archaeological sites in Newfoundland, including St. Paul's Anglican Cemetery in Harbour Grace, Foxtrap-2 in Foxtrap, and St. Luke's Anglican Cemetery in Placentia, as well as the Block 3 cemetery at the Fortress of Louisbourg. Isotopic analyses ($\delta^{13}C_{VPDB}$ and $\delta^{15}N_{AIR}$) were also conducted on faunal remains from Placentia and the Fortress of Louisbourg to establish local isotope baselines for comparison. While there was variability in human $\delta^{13}C$ and $\delta^{15}N$ values from all the sites, these data were interpreted to indicate a mixed C_3 terrestrial and marine diet. The $^{87}Sr/^{86}Sr$ data suggest most individuals could have originated in coastal regions of either Western Europe or North America. This research contributes to the growing isotopic data for the historic period in North America, especially the Atlantic Canadian region, and more specifically provides isotopic evidence of the historical connection between Placentia and the Fortress of Louisbourg.

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Glossary

% – per cent
~ – approximately
< – less than
> – greater than
± – plus or minus for standard deviation
°C – degrees Celsius
‰ – per mil (parts per thousand)
$^{87}Sr/^{86}Sr$ – ratio of strontium-87 to strontium-86
AIR – Ambient Inhalable Reservoir
Ar – argon
C – carbon
C:N – atomic carbon and nitrogen ratio
C_3 – photosynthetic pathway
C_4 – photosynthetic pathway
Ca – calcium
CAM – photosynthetic pathway Crassulacean Acid Metabolism
CO_2 – carbon dioxide
CV – column volume (~1ml)
CREAIT – Core Research Equipment and Instrument Training Network at Memorial University
DI H_2O – deionized water
HCl – hydrochloric Acid
HNO_3 – nitric Acid
IQR – interquartile range
Kr – Krypton
M – molar
MAAS – Memorial Applied Archaeological Sciences laboratory
MARC – Memorial Archaeology (laboratory sample number header)
MC-ICP-MS – multicollector inductively coupled plasma mass spectrometer
mg – milligrams
mL – milliliters
mm – millimeter
n – sample size
N – nitrogen
N_2 – Nitrogen gas
N_2-fixer – Nitrogen fixer
NH_4 – Ammonium

NIST – National Institute of Standards and Technology
NO_3 – Nitrate
Rb – rubidium
SE – standard error
Sr – strontium
TIMS – thermal-ionization mass spectrometer
VPDB – Vienna Pee Dee Belemnite
Wks – weeks
δ – delta notation
$\delta^{13}C_{col}$ – delta value of carbon compared to VPDB, specifically from bone collagen
$\delta^{13}C$ VPDB – delta value of carbon compared to VPDB
$\delta^{15}N$ AIR – delta value of nitrogen compared to AIR
$\delta^{15}N_{col}$ – delta value of nitrogen compared to AIR, specifically from bone collagen
μm - micrometer
σ – standard deviation

Chapter 1. Introduction

1.1 Introduction

The research that this thesis examines falls under bioarchaeology, a sub-discipline rooted in both archaeology and biological anthropology which examines human remains to understand past populations using a biocultural approach. Bioarchaeology is interdisciplinary in its methods, drawing from a variety of other disciplines for its methodologies. This thesis will draw on bioarcheology's interdisciplinary approach in the application of stable isotope analysis to study 18th- and 19th-century populations in Atlantic Canada.

Stable and radiogenic isotope analysis has become a common research tool in archaeological studies to reconstruct dietary patterns (carbon and nitrogen isotopes) and determine people's origins (strontium isotopes) (Anthony 1990; Katzenberg 2000; Bentley 2006). This method of analysis has become important due to its ability to directly analyze the diet and mobility of past populations (Vogel and van der Merwe 1977; Tauber 1981; Schoeninger et al. 1983; Price et al. 1994). Carbon and nitrogen isotopic analysis aids in the determination of differences between C_3 and C_4 diets (Vogel and van der Merwe 1977), marine and terrestrial diets (Schoeninger et al. 1983), and the trophic level of consumers (Richards et al. 2000). Examining strontium isotopes aids in the investigation of population origins and mobility (Bentley 2006).

1.2 Overview

Atlantic Canada played a significant role for fisheries and militaries in the 18th- and 19th-centuries due to an extensive supply of cod and access to important Atlantic trade routes (Pope 2004; Candow 2006). European settlement in Newfoundland began as a way to control access to fishing locations and as the industry grew, the French and English stationed their militaries and established fortified posts there to protect their fisheries (Johnston 2004; Candow 2006). The French colonial capital in Newfoundland was Placentia, selected for its defendable harbour and advantageous location as a trading and fishing port (Prowse 1896). Harbour Grace and Foxtrap, located on opposite shores of Conception Bay, were settlements founded by English fishermen (Pike 1996; Pitt and Pitt 2015a,b). Tensions existed between the English and French settlements in Newfoundland, exasperated by war in Europe, and resulted in armed conflict (Proulx 1979; Candow 2006; Cadigan 2009). The English gained control of Newfoundland with the Treaty of Utrecht in 1713, forcing the French to relocate to Île Royale, now known as Cape Breton Island (Donovan 1982; Johnston 2001,2004). Occupied for about 60 years, the Fortress of Louisbourg was the central location for both the French fishery and military (Carroll 2008) and was an area of conflict between the French and English. Besieged twice by the English (in 1745 and 1758), the Fortress fell to the English after the second siege and was abandoned in 1763 (Greer 1979; Johnston 2013).

1.3 Research Objectives and Significance

The main goal of this thesis is to investigate the archaeological and historical connections between Placentia, NL and Louisbourg, NS. This thesis focuses on the

isotopic examination of human and animal remains from several historic period archaeological sites located on the Avalon Peninsula of Newfoundland including: the St. Paul's Anglican Cemetery in Harbour Grace, Foxtrap-2 in Foxtrap, and St. Luke's Anglican Cemetery in Placentia, which were chosen for study because of the completeness of the collection and the chronological contextuality. It also examines skeletal remains from the Block 3 cemetery at the Fortress of Louisbourg, Nova Scotia. Several research questions were investigated as a part of this thesis, including:

1. What was the dietary composition of the individuals who were buried at the 18th- and 19th-century Newfoundland and Louisbourg sites?
2. What were the potential geographic origins of these individuals?
3. Did any significant dietary differences exist between the French and English populations at this time?

This work aims to help build a comparative isotopic database for the 18th- and 19th-century Atlantic Canada region utilizing isotopic analyses of individuals recovered from Newfoundland and Louisbourg. One of the goals of this research is to broaden our understanding of what the people living in Newfoundland and Louisbourg in the 1700s and 1800s were eating and where they might have come from.

There are several aspects of this thesis that are significant. This project adds to the isotopic dataset of the Canadian east coast. It adds to the information we know about the people who lived in Louisbourg, especially during the first years of occupation. Using stable isotopic analysis gives us a unique and direct method of exploring the diet and

potential origins of past people and allows us to look at individuals. This project is among the first to examine the isotopes of individuals within a historic context in North America, specifically civilians rather than a military population which is more commonly studied in bioarchaeological research (see Katzenberg 1991; Trimble and Macko 1994; Ubelaker and Owsley 2003; France et al. 2013; Vigneant et al. 2017).

1.4 Organization of thesis

Chapter 1 has provided a broad overview of the thesis and the objectives for this research. Chapter 2 details the historical background of the sites in Newfoundland and Louisbourg, focusing on the similarities and differences that exist within the written record pertaining to French and English diets, as well as in demography of the locations of sites that are examined within this thesis.

Chapter 3 provides an overview of what stable isotopic analysis is and how carbon, nitrogen, and strontium isotopes are used in this research, as well as the correct terminology and notation. This chapter also details how diet and origins can be reconstructed using stable isotopic analysis and the limitations that exist for each isotope system. Finally, this chapter describes the different skeletal tissues and how each is structured, as well as the process of diagenesis and how it can affect the skeleton.

Chapter 4 discusses the materials and methods employed within this thesis to examine the research questions. This chapter first discusses the sites that are examined within this thesis, which include the Block 3 cemetery in Louisbourg, NS, St. Paul's Anglican Cemetery in Harbour Grace, NL, Foxtrap-2 in Foxtrap, NL, and St. Luke's

Anglican Cemetery in Placentia, NL. Each section gives the burial number, sex of the individual, and bone and/or tooth analyzed. This chapter also details the Placentia and Louisbourg faunal material, including the individual species and the bone used in analysis. Previous isotopic work in the region is discussed as well as the details pertaining to the preparation and analysis of the bone samples for carbon and nitrogen isotopic analysis and tooth samples for strontium analysis. Limitations faced within this research are also addressed.

Chapter 5 presents the results of the isotopic analyses. Measures of human and faunal collagen preservation, including the collagen yield, carbon to nitrogen ratio (C:N), and carbon and nitrogen concentrations are described in this chapter. Statistics are presented, as well as visual representations of the data in scatterplots and boxplots.

Chapter 6 discusses on the results as well as a comparison to previously studied data. This chapter includes an examination of faunal diet reconstruction from the areas under study as well as a comparison to previously analyzed faunal data from the region. A human diet reconstruction is presented, with comparisons of the sites from Newfoundland and Louisbourg, as well as to sites previously examined from both the region and elsewhere. A discussion of potential origins for the humans from the sites in Newfoundland and Louisbourg is included. Individual life histories are also explored.

Chapter 7 summarizes the research in this thesis and discusses its relevance in the field. Ideas on future research that could take place are offered in this chapter as well.

Chapter 2. Background

Atlantic Canada has long been influenced by European contact, predominantly the French and the English, beginning in the sixteenth century. Research in this thesis focuses on two specific regions. The first is the Avalon Peninsula, Newfoundland, exploring the initial French occupation of Placentia and considering the later English influence in the region (including Harbour Grace and Foxtrap). The second region of focus is the French established Fortress of Louisbourg on Cape Breton Island (see Figure 2.1).

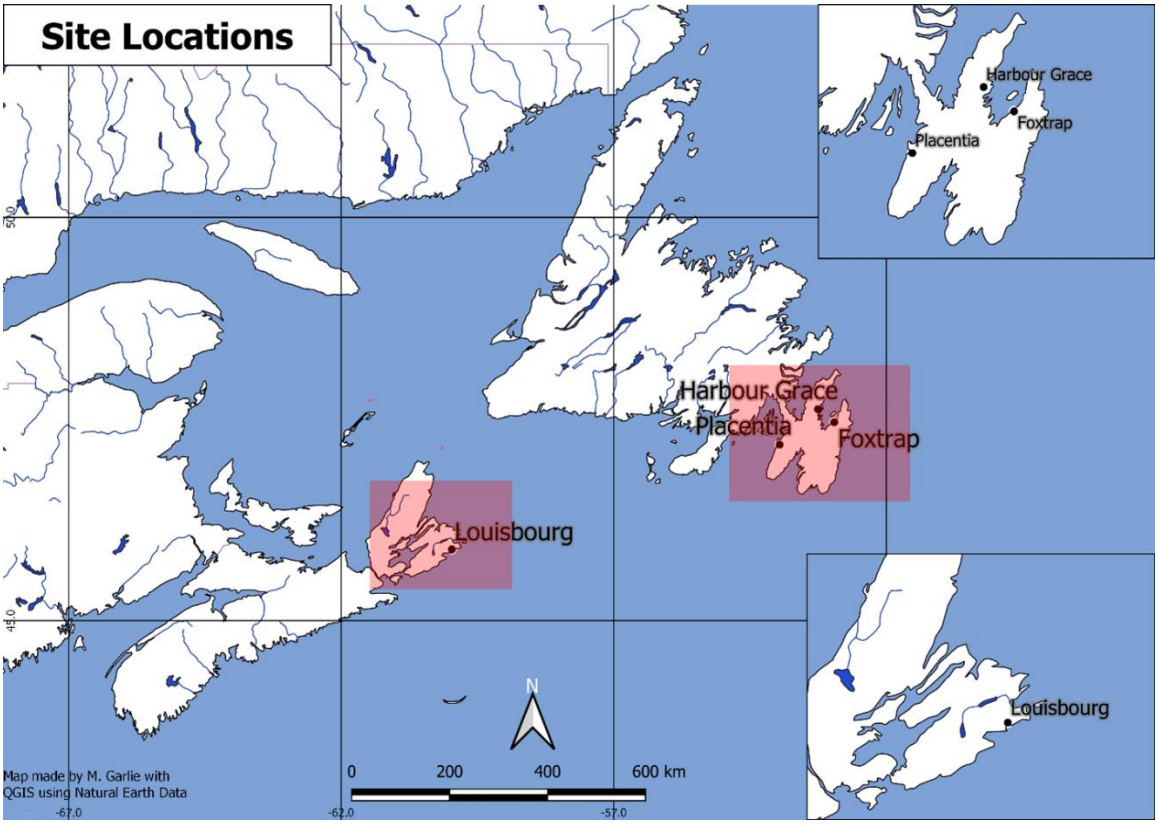

Figure 2.1. Map of site locations, including Placentia NL, Harbour Grace NL, Foxtrap NL, and Louisbourg NS.

Seventeenth- and eighteenth-century Atlantic Canada, especially Newfoundland, was a critical location for the fishing industry, as it had large expanses of cod stocks and shoreline on which to salt and dry fish (Rose 2008). In Europe, salt cod was an important commodity but because local fish stocks were depleted, this led to an increased demand for Newfoundland cod, especially in countries that depended on fish for a large part of their diet (e.g., Spain, France, Portugal) (Rose 2008). Though initially discouraged, settlement in Newfoundland began as a way to establish fisheries in locations with access to good cod stocks (Rose 2008).

While occupied by the French for a period of about 50 years (1662-1713), Placentia was established to assert France's authority over the Placentia Bay fishery and stake claim to the fishery in Newfoundland (Carroll 2008:57). Once acquired by the English after the Treaty of Utrecht in 1713, Placentia played a much smaller role in North America. However, the English did successfully establish a colonial government that saw the continuance of fishing, a rise in the Irish immigrant population, and the development of an influential merchant firm until 1811, when the British garrison was eventually abandoned (Carroll 2008:58-59). After being expelled from Newfoundland in the early 1700s, the French were left with only a small foothold in Atlantic Canada, which included Île St. Jean (present-day Prince Edward Island) and Île Royale (present-day Cape Breton Island) (Donovan 1982; Johnston 2004). The French eventually chose Louisbourg, located on Cape Breton Island, as their new seat of power.

The Fortress of Louisbourg was a place of conflict between the French and the English towards the end of its occupation period. The English besieged the Fortress in

1745 and again in 1758. This chapter will briefly discuss the history of colonial Newfoundland with a focus on the Avalon Peninsula, including the sites in Placentia, Harbour Grace, and Foxtrap, and the colonial history of Cape Breton Island focusing on the Fortress of Louisbourg, in order to understand the historical context in which bioarchaeological interpretations are made.

2.1 Placentia, Newfoundland

2.1.1 The French Occupation

During early European colonialism, the Placentia region had been given several names. Initially explored by Europeans at the beginning of the sixteenth century, the first recorded place name is *Insulae Cortrealis*, after the Portuguese explorers and mapmakers Gaspar and Miguel Cortreal (McCarthy 1973). By 1547 the name was changed to reflect the increased use of the area by Spanish fisherman and was called *Isle de Plaziencia*. Fishermen from several countries, including Portugal, Spain, and the Basque region, utilized this location both before and after becoming a French and then English colony (Carroll 2008; Landry 2018). During the French occupation, the region was known as Plaisance, which was later Anglicized to Placentia by the English in the 18th-century and remains as such into the contemporary period.

Both the French and the English were interested in the rich fishing grounds off Newfoundland, and by the 1600s, the English began to focus their fishing interests on the east coast of the Avalon Peninsula, while the French were establishing fishing locations along the southern shore, with a central location at the French colonial capital of

Placentia (Carroll 2008). Placentia's location offered several advantages, including a large, sheltered harbour, making it easy for French vessels to safely anchor, proximity to the fishing banks, and extensive beaches with cobbles suitable for drying fish (Landry 2018). Placentia was also strategically located in the Cabot Strait and was a main avenue of communication between France and its other North American colonies further inland down the St. Lawrence waterway, including Quebec City (Gaulton and Carter 1996).

In 1655, King Louis XIV appointed the first of several French Governors in Placentia in an attempt to place Newfoundland under French control (Carroll 2008). Placentia did not officially become a settled population until 1662 when 80 colonists arrived under Governor Thalour du Perron, including fifty settlers, thirty soldiers, and a chaplain (Landry 2008:17). By 1690, England and France were going to war in Europe, and Placentia became the base of operations in the fight against the English in Newfoundland (McCarthy 1973:64).

2.1.2 The English Occupation

With the signing of the Treaty of Utrecht in 1713, the island of Newfoundland was ceded to the English, and the French were required to either abandon the colony or become English subjects (McCarthy 1973; Carroll 2008:58). Despite this loss of land, the French did retain the right to fish and use the shore for migratory fishing on the Newfoundland coast from Cape Bonavista to Point Riche during the fishing season (Cadigan 2009:56). Once the English took control of Newfoundland, many military forces were moved to Placentia due to damage from earlier French attacks on the forts at St. John's (Gaulton and Carter 1996). The English fortified certain areas, including the

building of Fort Frederick beginning in 1721 by Governor Gledhill (Cromwell 2011). By 1740, the security of the fishery in Placentia, not the fear of military aggression, is what prompted improvements of Placentia's defenses, leading to the construction of the New Fort in 1743 (Cromwell 2011). In the spring of 1762, the French captured St. John's and Placentia became the capital of Newfoundland, leading to Fort Frederick, the New Fort and Fort Royal being utilized during this time (Cromwell 2011). This was short-lived due to St. John's being regained later the same year and soon the defenses of Placentia fell into total neglect and abandonment (Cromwell 2011). After the 18th-century, Placentia played a limited role for the English, resulting in a reduction of trade and eventual abandonment of the site (Gaulton and Carter 1996).

2.2 English sites on the Avalon Peninsula

While the Treaty of Utrecht gave the English full control of the island of Newfoundland, they had already been settling the island for decades. The English primarily settled along the northeast coast of the Avalon Peninsula, including locations like St. John's and Ferryland. Prowse (1896) writes that while the precise year that settlement began in Newfoundland is difficult to determine, it is clear that the people who were part of winter fishing crews were often the first permanent European settlers. By 1630, the English had displaced other Europeans along the east coast of the Avalon Peninsula and had begun to establish year-round settlements (Pocius 2015).

Harbour Grace, located on the western shore of Conception Bay, was used by fishermen for hundreds of years and was already a thriving seasonal fishing community by 1550 and continued to be so throughout the 1600s (Pike 1996). Settlement at Harbour

Grace officially began around 1618, most likely by former settlers of the Cupids colony (Pitt and Pitt 2015a). By the late 17th-century, England and France were at war in Europe, and by the early 18th-century, the French were making life difficult for the English by launching attacks on settlements (Pike 1996). The French captured Harbour Grace for a period of about four months in 1762 before the English recaptured it (Pike 1996). Harbour Grace had two separate fires, in 1832 and 1858, and after each had to rebuild lost businesses and homes; in the 1860s, there was a decline in the seal hunt and collapse of the fisheries, leaving fishermen reliant on the government (Pike 1996).

Foxtrap today is a part of Conception Bay South along with several other former settlements, including Topsail, Chamberlains, Manuels, Long Pond, Kelligrews, Upper Gullies, Lawrence Pond, and Seal Cove, and is located on the southeast shore of Conception Bay on the Avalon Peninsula (Pitt and Pitt 2015b). These settlements were founded by fishermen around 1800, and residents grew crops in the areas of land backing their fishing sites (Pitt and Pitt 2015b). New settlers arrived in the late 18th- and early 19th-centuries, and Foxtrap became more of a commercial town with its proximity to St. John's (Korneski 2013).

2.3 Demography of Newfoundland Sites

2.3.1 French Demography at Placentia

One of the interesting features of Newfoundland's population history is the slow growth of a permanent population living on the island (Pocius 2015). The demography of Placentia is a bit difficult to reconstruct completely due to a lack of parish records, but

Landry (2001b) was able to piece together some information based on census data and notarial documents. During the French occupation, a variety of residents lived in Placentia, including those in military and administration roles, seasonal fishermen, and permanent residents (Crompton 2012:86). The first census of the permanent population in Placentia in 1671 identified 74 individuals, with the population peaking around 265 individuals in 1710 (Landry 2008:139).

Despite being considered permanent residents, these *habitants* might not have spent every season in Newfoundland (Pope 1993, 2004). According to the 1699 census, out of 34 married *habitants*, 10 had wives living in France (L'Hermitte 20 September 1699a, 20 September 1699c in Crompton 2012). While family-based fishing establishments did exist, traditional nuclear families were not necessary for continual growth to occur in the colony (Landry 2001b). Placentia instead accessed a highly mobile labour force, called *engagés* or hired fishermen, which led to seasonal increases in the population (Landry 2007; Crompton 2012). General population censuses do not give an accurate count of how many fishing crews there were each season, but a few records from seasonal fishing ships give information on the size of these crews. For example, in 1704, 40 fishing ships were anchored in Placentia, with a total of 1,508 men (Anon. 1704 in Crompton 2012), which is high compared to 1705, where 23 seasonal ships recorded a total of only 721 men (Anon. 1705 in Crompton 2012) and 1712, where 24 ships recorded a total of 885 men (P. Costebelle 9a November 1712 in Crompton 2012).

The French military population in Placentia was not counted on the census, but records did exist. Typically, enlisted soldiers were posted to the colonies for a

minimum of six years, which often made them more permanent than many hired fishermen (Cassel 1988:118-119). As the number of women living within the colonies grew, it became common for officers to marry into the civilian population, establishing roots in the community. Between the years 1662 and 1690, there were likely fewer than 30 soldiers living in the colony (Mauclerc and Cartigny 9 November 1687 in Crompton 2012).

It can also be assumed that most of the population was male, including the soldiers, officers, administrative personnel, and "unattached male servants" (Crompton 2012; Pocius 2015:8). The demographics of Placentia were likely similar to that of Louisbourg when it was established, where women never made up more than 30% of the *habitant* population (Johnston 2001; Crompton 2012). In general, women made up a very small part of the colonial population, with most having arrived as young, single servants and who stayed on the island after marriage. Children also made up a very small proportion of the Placentia population (Johnston 2001).

There was a good deal of movement between France's North American colonies at the time, with populations fluctuating by the season and year, leading to changes in the demographic composition (Crompton 2012). Records indicate that the largest proportion of *habitants* in Placentia came from La Rochelle, on the coast of France, with smaller numbers coming from Ile de Ré nearby, and others coming from Saint-Malo in Brittany in northern France and Bayonne in the Basque country to the south (see Figure 2.2) (Landry 2008:142; Crompton 2012). There are also census records from 1698 for *habitants* from regions like Provence, Bayeux, and Jersey, and records indicate that by

the end of the 17-century, there were *habitants* who had been born in Quebec and eventually moved to Placentia (Thibodeau 1959-1960; Crompton 2012). While the majority of the citizens living in Placentia were originally from France, there were also those born in Quebec, the Basque region, and even a few English and Irish settlers who married French women (Brière 1990:67; Parat 9 July 1688:fol.90v-91,93v in Crompton 2012; Parat 22 September 1685 in Crompton 2012; Anon. December 8 1666 in Crompton 2012). It is difficult to ascertain the origins of all the soldiers who may have been posted in Placentia but lists of recruits and deserters suggest that many were recruited from the Poitou-Charentes region of France (see Figure 2.2) (Mezy 14 April 1697; Durand la Garenne and Subercase 25 October 1704 in Crompton 2012).

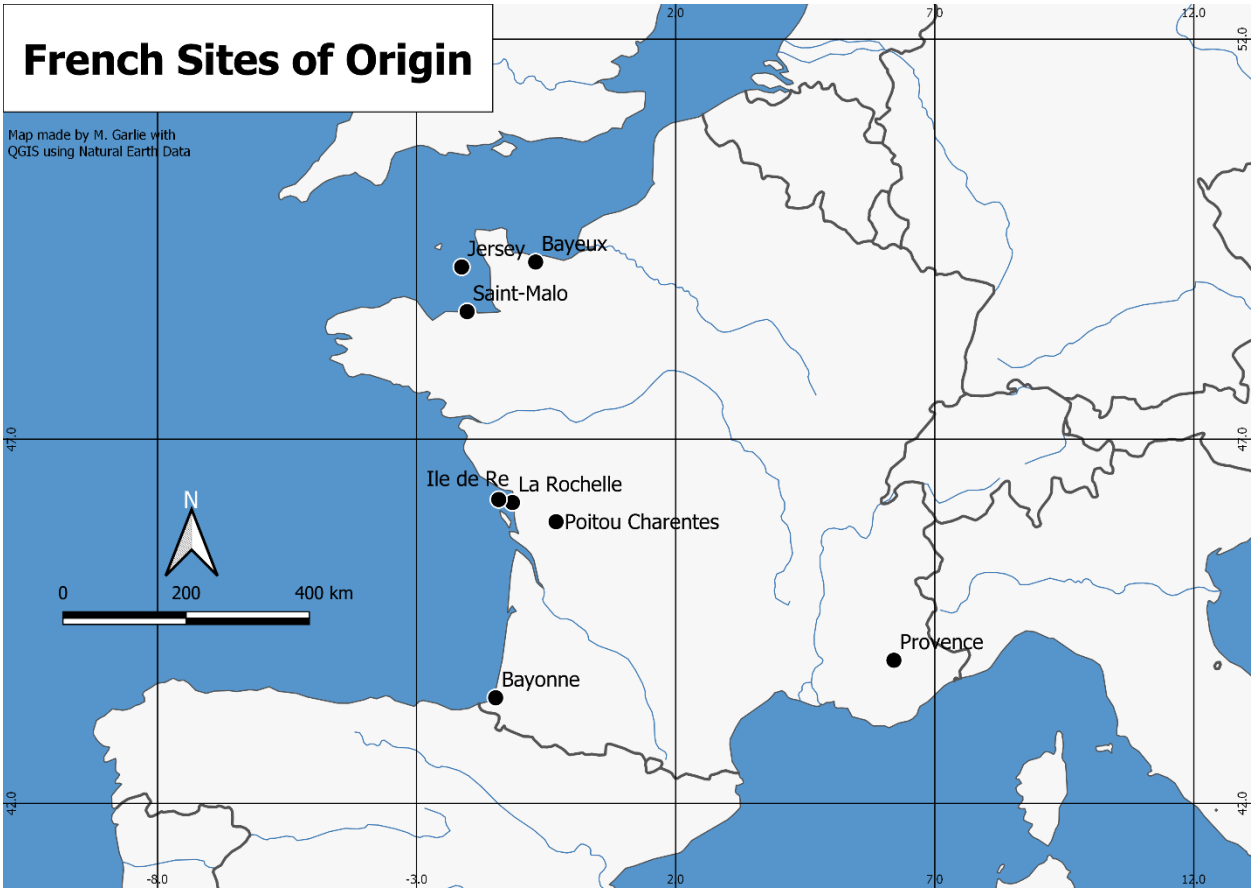

Figure 2.2. French Cities of Origin for the Citizens and Soldiers of Placentia.

The census recording Mi'kmaq and Abenaki individuals and/or families living in Placentia, as well as serving in the French military, provide evidence of the encounters between the French and local Indigenous populations (Williams 1987; Marshall 1996; Martijn 1996, 2003; Gerald Penney Associates 2008:9). However, there is little to no historical documentation of Black individuals living in the colony of Placentia and when present these documents provide limited information. For example, a "Georg le Negre" was purchased by Governor Pastour de Costebelle from a prominent merchant (Donovan 2004:27) and in 1677 Henri Brunet, a French trader who moved ships between Boston

and Placentia, referenced that a naturalized Englishman by the name of Thomas Picq purchased "carisse pour sa negresse," likely meaning he intended to clothe an individual of African descent in his household (Brunet September-December 1677:fol.104v in Crompton 2012). In summary, while Placentia was primarily a French colony, it was by no means a homogenous population.

2.3.2 English Demography at Placentia and Sites Along the Avalon Peninsula

With the English acquisition of Placentia in 1713, the fishing center eventually aided in the establishment of the Irish Catholic population on the island with the promise of work in the fisheries. The importance of the fishing industry increased the population, and because of the extensive fortifications built prior to English occupation, Placentia also became the military center of the island (Mannion 1986; Carroll 2008). While Placentia was the English seat of government for a short period in the early 1700s, the area was populated predominantly by Irish settlers, and eventually the English established St. John's as their primary political center, with Placentia considered little more than a "display of sovereignty" (Carroll 2008:63).

The English population increased in Placentia between 1720 and 1723, going from 167 inhabitants to 218 (Proulx 1979). There is no data for the mid-1720s, but by 1727 the population had fallen to only 28 inhabitants (Proulx 1979). This decrease seemed short-lived because according to later numbers of quintals of fish caught and the number of fishing boats belonging to inhabitants, the resident population in Placentia became more active within the fishing industry (Proulx 1979). While the inhabitant

population increased, it seems the English garrison decreased in size over the years, with 350 soldiers in 1713, 200 in 1717, and only 24 in 1732 (Proulx 1979).

In 1732, Newfoundland was overwhelmingly occupied by English Protestants; however, after 1720 Irish Catholics from southwest Ireland were also recruited to work in the fisheries (Mannion 2013). Edward Falkingham, the Governor of Newfoundland appointed in 1732, recorded 321 ships arriving in Newfoundland in 1732, carrying 2,944 men from England, as well as 23 fishing ships from Ireland carrying 372 men (Mannion 2013). In Placentia, there were over 700 men engaged in the fishery, and 80% came from the seasonal fishing ships, primarily from the ports of Bideford and Barnstaple in north Devon (Mannion 2013). Falkingham also recorded a count of the residential fishery, broken into categories that included masters, men servants, mistresses, women servants, and children (Mannion 2013). Mannion (2013) points out that the geography of the residential fishery was different from the migratory or seasonal fishery, with over 60% of residential fisheries located in harbours north of St. John's, while most migratory fisheries (85%) were concentrated on the Avalon peninsula between St. John's and Placentia.

During the 1740s, European tensions during the War of the Austrian Succession affected the fisheries in Newfoundland, and Placentia was hit hard. English fishermen deserted the colony causing many issues for the resident community. Residents were also forced to use their fish reserves and were further supplemented by goods smuggled in by New England merchants (Proulx 1979). Eventually the British government stepped in to help the fishing industry, resulting in an unprecedented increase in Placentia's population

(see Figure 2.3) (Proulx 1979). Population numbers usually increased in the summer when migratory fishing servants hired to work on fishing vessels arrived to work and subsequently decreased in the winter when seasonal fishermen returned to Europe.

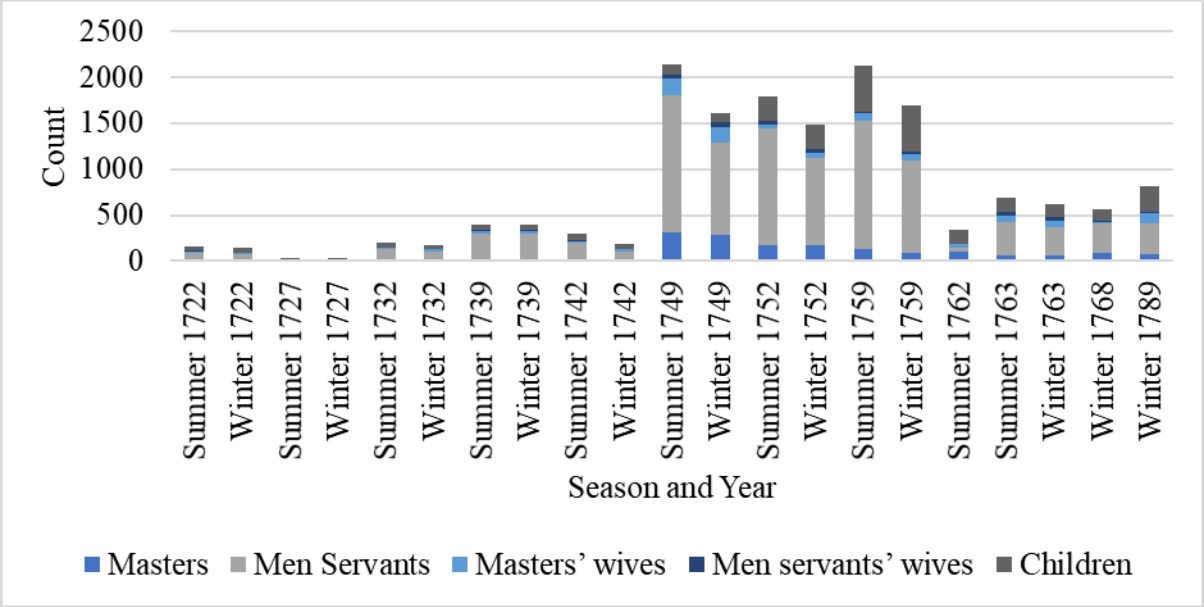

Figure 2.3. Summer and Winter Populations in Placentia for Select Years (from Proulx 1979).

Similar to when Placentia was occupied by the French, women did not make up a large part of the population when controlled by the English. Between 1722 and 1789, the percentage of women living in Placentia ranged between 5% and 19%. The percentage of children living in Placentia was generally greater than the percentage of women living there in most of the years, making up 5% to 44% of the population. The percentage of men living in Placentia was always significantly greater than that of women, with migratory fishing servants making up a large percentage of the population most years.

The population in other English colonies on the Avalon peninsula grew at different rates. The shift that brought English Newfoundland from a primarily migratory

fishing population to a more sedentary population was a complex process throughout the late 1600s and early 1700s (Handcock 1989). Conception Bay was a region where early permanent settlement took place, with a well-established population by the 1740s (Cadigan 1995). Much of this settlement was clustered between Carbonear and Habour Main, due to the area having better fishing and farming resources than other parts of Newfoundland, with better soil and timber (Cadiagn 1995). While most settlers in the area were Protestant English, strong Catholic communities existed in Harbour Grace, Carbonear, Brigus, and Harbour Main (Cadigan 1995). The 1675 census of Harbour Grace recorded a year-round English population of 36 individuals, but by January 1697 there were 100 men (Pike 1996). By 1715, men were hired over winter to build boats, resulting in hundreds being made and allowed for the economy to begin to diversify, with English firms building up businesses (Pike 1996). One hundred years later, Harbour Grace was a center for the cod fishery and seal hunt, as well as shipbuilding and oil production, and in 1825 there was an influx of Irish immigrants (Pike 1996).

The community of Foxtrap came to be around 1800 as people, mostly fishermen, from northern parts of Conception Bay around Port de Grave established themselves here to avoid overburdening the longer settled region (Korneski 2013). In 1845, which is the first year that Foxtrap appeared in the census, there were 88 inhabitants (Korneski 2013:104; Pitt and Pitt 2015b). In 1857 the census identified 143 inhabitants, and by 1891 the population had grown to 381 (Korneski 2013:105). Foxtrap is notable for the Battle of Foxtrap, where residents assaulted railroad surveyors for trying to bring the railroad through the community (Korneski 2013). With the influx of new settlers in the late 18th-

and early 19th-centuries, Foxtrap grew from a seasonally occupied fishing settlement to a commercial town, with local people growing crops and raising livestock in order to supply an expanding urban market, which came from being located in close proximity to St. John's (Korneski 2013:105).

2.4 Food in Newfoundland

2.4.1 The French

While Newfoundland was a huge exporter of dried cod in the 17th- and 18th-centuries, for several reasons, it also relied upon the import of goods for the survival of those living there. Among these is the fact that the climate, shallow soils, and short growing season did not allow for great cultivation or diversity in local food sources. Many records indicate that agriculture was near impossible on the island and note the sterility of the soil (Pope 2003a; Colbert 7 October 1669, 9 March 1671 in Crompton 2012); however, cartographic evidence suggests that inhabitants of Placentia engaged in some subsistence gardening (L'Hermitte 20 September 1699a,b,c in Crompton 2012). In 1708 Governor Costebelle wrote in a letter that the land behind Fort Louis was fertile and that he grew artichokes, asparagus, green peas, and pumpkins (P. Costebelle 28 October 1708:fol. 67 in Crompton 2012). Other vegetables that would have been grown in Newfoundland at this time included turnips, cabbages, and beans, though their importance was not in the amount produced but in how they aided in combating diseases such as scurvy (Mannion 2000). These types of vegetables were grown because they were simple to care for, preserved well, and were suitable for the soil and climate of the island (Higgins 2009). Bread, or biscuit, was a large part of the French diet in colonial North

America and was often served with soup for meals (Godbout 2008; Vigeant et al. 2016). Survey records indicate that many *habitant* properties had pens for livestock, with pigs, sheep, and chickens most often mentioned (Crompton 2012). The consumption of fish is assumed due to the French inhabitants being Catholic, which at the time meant abstaining from terrestrial meat consumption approximately 155 days out of a year (Vigeant et al. 2016).

2.4.2 The English

Planters, as the English settlers were known, on the island also kept some livestock that generally included cattle, pigs, and sheep, though the long winters and small grassland led to issues with keeping such livestock alive (Mannion 2000). John Mason, the second Governor of Cupids, wrote of the food that was grown in Newfoundland, which included wheat, rye, barley, oats, garden vegetables, peas, beans, and cauliflower, as well as the many different fish that could be caught (Prowse 1896). Supplemental hunting was something that English Commodore John Graydon claimed yielded "deer [likely caribou], bear, and beaver…otter and seal," though hunting and trapping were confined to the edges of settlement (Mannion 2000). During this time, it was highly probable that the chief sustenance of planters, servants, and migratory fishermen was fish. The "allowance for victuals" by Captain William Poole for someone hired for an English fishing season included 120 pounds of salt meat, 300 pounds of bread, one and three-quarters bushels of peas, three hogsheads of beer, and fish for seven months (PRO, CO 1/44 1677 in Mannion 2000:8).

Items imported to the island included pork, beef, butter, oil, cheese, bread, flour, oatmeal, peas, hops, malt, beer, wines, brandy, rum, molasses, sugar, and tobacco (Mannion 2000:8). With roots in traditional English foodways, the Newfoundland diet included beef, bread, flour, pork, peas, and fish, as well as liquor at night (Mannion 2000). Fresh foods and uncooked grains were uncommon, as were small animals and poultry, lamb, mutton, veal, or goat, and milk in various forms, fruit, or vegetables, all of which did not transport well (Mannion 2000).

2.5 Louisbourg, Nova Scotia

Louisbourg was founded in 1713 on Île Royale (what is today Cape Breton Island) following the expulsion of the French from Placentia, Newfoundland. Louisbourg was intended to be a primary stronghold in the North Atlantic to support French interests, but also held proximity to good fishing grounds, making it a good location as the seat of the French cod fishery (Johnston 1991). McLennan (1918:2) wrote that "[t]he value of Cape Breton, as a naval base to protect Canada and French commerce in the Western Ocean, is so obvious that it need not be more than mentioned." Previously known as English Harbour (Havre à l'Anglois), Louisbourg had been an occasional base for European fishermen who had never permanently settled there (Johnston 1991). For the first three decades of its existence, Louisbourg enjoyed relative peace and prosperity; however, there were occasional shortages in food and supplies and the hardships associated with an inconsistent supply chain (Johnston 2007:13). The fishery, based on cod, employed hundreds, and established trade links throughout the Atlantic, including with France and the Caribbean. After 30 years of occupation, the colony was besieged in

1745 by New Englanders, who occupied the site for four years before the French retook possession in 1749 (Balcom 1995). This second French occupation was considerably shorter, as the English took control again in 1758, and though the French did not lose final possession until 1763, the fortifications at the Fortress had already been demolished (Balcom 1995).

2.5.1 Louisbourg Demography

The first inhabitants of Louisbourg included the settlers and fishermen expelled from Placentia in 1713, with approximately 149 permanent residents, a number that increased over time (see Table 2.5) (Johnston 2001).

The population at the Fortress eventually grew to include a garrison of French, Swiss, and German soldiers, royal and civil officials, servants, merchants, tradesmen, fishermen, shore-workers, sailors, proprietors, innkeepers, artisans, labourers, and many others (Johnston 1995b, 1995c, 2001). Some of these were permanent inhabitants, while others were seasonal workers (McLennan 1918; Johnston 1995c, 2001). Among the resident population, adult males outnumbered females, sometimes as much as 10:1 (Johnston 1995a, 1996). This imbalance meant that Louisbourg women married at a younger age than men, with the average age of marriage for women at 20 years, and for men at 29 years (Johnston 1995a). In 1720 children made up approximately 22.4% of the Louisbourg population and as much as 45.4% by 1737 (McNeill 1985; Johnston 2001).

Table 2.1. Louisbourg Civilian and Military Population (from Johnston 2001).

Year	Population
1713	149
1720	950
1724	1,243
1734	1,668
1737	2,006
1752	3,940

Documents, such as census reports and parish records, are helpful in understanding the origins and demography of the Louisbourg population. The first Louisbourg census to include 'Place of Birth' was in 1724, and it recorded that the permanent civilian population included 813 individuals, though only lists 113 by name and origin (Johnston 1995a). A large proportion of the population originated in France, compared to a smaller proportion that originated in New France; the fewest number of individuals came from other countries including Switzerland, Belgium, and Germany (Johnston 1995a,b, 2001). However, these numbers account for only those males and females who were heads of households and no other members, including wives, children, fishermen, soldiers, and servants were included with this census (Johnston 1995b). In general, over 50% of brides in Louisbourg originated from New France, whereas grooms were more likely to have variable regions of origin (Johnston 1995a, 2001). Most fishermen who resided in Louisbourg came from France originally, including the regions of Normandy, Brittany, and parts of the Basque country, but some were from Placentia or other areas of New France, or even other countries (Johnston 1995b, 1995c). The majority of soldiers in Louisbourg were recruited from France, with only a few recorded

exceptions (Johnston 1995b, 1995c). A group of Swiss and German soldiers, who belonged to the Karrer Regiment, also resided in Louisbourg, eventually making up one-quarter of the total garrison population by 1741 (Johnston 1995b, 2001).

There are instances of a few Protestants of English, Irish, or Scottish origin that converted to Catholicism while living in Louisbourg that can be found in parish records (Johnston 1995a). There are also several Black individuals documented in Louisbourg, both enslaved (n=210) and freed (n=6) (Donovan 1995; Johnston 1995a). Most enslaved peoples performed domestic services, with women performing a wide range of duties in the house, such as looking after children, cleaning, washing clothes, and cooking, and men usually performing outdoor jobs, such as caring for gardens and animals, cutting firewood, and carrying water (Donovan 1995). Several governors of Louisbourg owned slaves, including Pastour de Costebelle, who brought the first enslaved individual, Georges, to Louisbourg when he moved from Placentia (Donovan 1995). Similar to Placentia, the Fortress of Louisbourg was not inhabited solely by people of French origins but also included groups of colonial-born French, non-French Europeans, Indigenous, and Black peoples (Ellerbrok 2014).

2.5.2 Louisbourg Food

Louisbourg's main export was dried fish (Johnston 2007:15). Since the fishing grounds were so valuable, the offshore resources quickly surpassed the importance of its onshore resources (McNeill 1985). Save from small-scale agriculture in remote locations, agriculture on Cape Breton Island was much smaller compared to other New World colonies (Clark 1980). Household vegetable gardens and occasional hunting and

freshwater fishing supplemented the diets that were based primarily on local bread and cod (Downey 1965; McNeill 1985; O'Neill 1995; Lane Jonah and Véchambre 2012). It is believed that cod, being a reliable and nutritious food that could be easily preserved, was a stapIe in diets at the Fortress of Louisbourg (Downey 1965; McNeill 1985; Balcom 1995). While fish were caught to sell, they were also caught for consumption in Louisbourg and catches included: "dogfish, skates/rays, herring, salmon, trout…mackerel, swordfish, lamprey, sturgeon, eel, shad, smelt, gaspereaux, tomcod, haddock, chub, horned pout, "petits barbillons", flounder and halibut" (Cumbaa 1976:4) suggesting that not only were marine fish consumed but freshwater fish as well.

By 1716 the French harvested many foodstuffs from gardens, including: "wheat, beans, … and peas, cabbages, dock, chicory, celery, artichokes, lettuce, and other salads; in the woods, strawberries, raspberries, blueberries and small fruit called cranberries" (Vigneras 1959:426; Donovan 2006:22). Several animals were imported to Louisbourg. Pigs and chickens were used as meat, while sheep were kept for their wool (Lachance 2000). Cows were used for milk, and on occasion meat, but were used frequently as draft animals alongside horses (Lachance 2000).

Trade was an important industry at the Fortress of Louisbourg, both between colonies and between continents (McNeill 1985; Moore 1995). Imports were relied upon for almost all Louisbourg's goods, including most of its food supply that could not be produced locally (McLennan 1918; Clark 1980; Moore 1995). Food items imported from Europe included salt, grain, flour, wine, brandy, and salted meat (Varkey 2002), flour and dried vegetables from Canada (Moore 1995; Varkey 2002), and sugar, coffee, molasses,

and rum from the French West Indies (Vernon 1903; Clark 1980; Varkey 2002). Though trade with non-French colonies was discouraged, it still occurred at the Fortress (Chard 1995; Varkey 2002). This meant that Louisbourg trade included a large amount of Acadian and New England goods, including fish, flour, bread, oats, wheat, peas, and meat from Acadia (Clark 1980; Moore 1995), as well as livestock with approximately 600-700 cattle and 2000 sheep imported annually (Clark 1980; Moore 1995; Rawlyk 1999). Goods from New England included livestock, meat, eggs, butter, cheese, flour, corn, wheat, rice, produce, and cider (McLennan 1918; Clark 1980; Chard 1995). Despite this, the supply of food to the Fortress of Louisbourg was a constant concern, especially in the winter months (McLennan 1918). During the winter, the inhabitants of Louisbourg relied on food items that did not spoil, such as flour, salt, fish, hogs lard, and biscuit, resulting in a nutrient low diet which caused many residents to suffer from scurvy (McLennan 1918; McNeill 1985).

2.6 Conclusion

French and English colonies in Atlantic Canada had a long and complex history in both military and trade, especially regarding the fishing industry. First named by Portuguese explorers, Placentia was a popular location for fishermen from several countries, including Portugal, Spain, the Basque region, as well as later influence from France and England. As the French capital in New France, several fortifications were built in Placentia during the period of French occupation between 1662 and 1713. While Placentia had a large transient population of military and fishermen, the permanent population increased slowly. Men made up much of the population, with only few

women and children contributing to overall population. Due to its challenging climate, a lot of foodstuffs were imported to Placentia, though small personal gardens were able to produce some vegetables. Livestock was kept, but it is likely that the fishery was a main source of food.

The English settled much of the Avalon Peninsula and eventually occupied Placentia as well. During the 18th-century, most English fisheries switched from migratory to resident, bringing a more permanent English population to the island. Harbour Grace and Foxtrap were English settlements tightly involved with the fishery. Their diet was reported as following that of traditional English foodways, which included primarily beef, bread, flour, pork, peas, fish, and liquor (Mannion 2000).

Founded in 1713 following the expulsion of the French from Newfoundland, Louisbourg was to become the stronghold of New France in the Atlantic world. The French occupied Louisbourg from 1713 to 1745, and again from 1749 to 1758. Like Placentia, the majority of Louisbourg inhabitants were male, with population numbers fluctuating seasonally. Louisbourg had a diverse population, including French, German, Swiss, Black, and Indigenous peoples. Like Placentia, Louisbourg relied on trade for foodstuffs, though were also able to grow some items in local gardens. The French diet is recorded as consisting of fish, bread, poultry, pork, and garden vegetables (Balcom 1995; Lachance 2000; Donovan 2006; Lane Jonah and Véchambre 2012).

Chapter 3. Stable Isotopes: Dietary Patterns and Origins

Human and faunal skeletons contain extensive information that can aid in the understanding of various aspects about the past. The food and drink that an individual consumes often leaves traces in the body that can be detected using isotopic analyses, operating under the caveat that you are *what* and *where* you eat (DeNiro and Epstein 1976; Budd et al. 2004; Fry 2006). Through the use of isotopic analyses of elements such as carbon (C), nitrogen (N), and strontium (Sr), researchers can assess both the diet and potential geographic origins of an individual. This chapter will explore the theory and methods associated with isotopic analyses in archaeological contexts.

the use of stable isotopes within the discipline of archaeology is a method of analysis that is now well established, having been employed for over forty years (Katzenberg 2000). The first application of stable carbon isotope analysis was in the 1970s to understand the spread of maize as a food source in North America (Vogel and van der Merwe 1977; van der Merwe and Vogel 1978), and is often used alongside stable nitrogen isotopes, which identify trophic levels within a sample (Schoeninger and DeNiro 1984; Ambrose and DeNiro 1987). Strontium isotopes, however, are often applied when reconstructing migration and the movement of people in the archaeological past (Ericson 1985; Schwarcz et al. 1991; Sealy et al. 1995; Evans et al. 2012).

3.1 Skeletal Tissues

3.1.1 Bone Collagen

The skeleton fulfils many import functions, including protection, support, storage of minerals, facilitation of movement, and blood production (White and Folkens 2000; Christensen et al. 2014). Bone consists of two main components: hydroxyapatite, the inorganic, mineral fraction of bone, and collagen, the organic fraction (Veis 1984). Collagen has 18 amino acids from dietary protein, as well as dietary lipids and carbohydrates, though to a lesser extent (Ambrose and Norr 1993; Tieszen and Fagre 1993). These amino acids form a collagen triple helix consisting of chains that form fibrils of collagen, usually around 1,000 amino acids long (Miller 1976; Ramachandran and Ramakrishnan 1976). The triple helix stabilizes itself with hydrogen bonds which are formed between nitrogen, oxygen, and hydrogen, as well as by the presence of the amino acids hydroxyproline and proline (Ramachandran and Ramakrishnan 1976; Collins et al. 1995; Harris 2016).

The skeletal system has three types of bone cells that are important to both bone growth and maintenance: osteoblasts, osteocytes, and osteoclasts. Osteoblasts are the cells responsible for bone formation and once they have completed their life cycle, they become osteocytes which are responsible for communication between the active osteoblast and osteoclasts cells. Osteoclasts cells are responsible for bone resorption and work in tandem with the osteoblast cells as bone is continually remodeled over the life course (White and Folkens 2000; Currey 2002). While bone growth terminates at the end of the adolescent growth spurt (Branca et al. 1992; Lewis 2007; Rauchenzauner et al.

2007), bone remodeling occurs throughout adulthood to maintain the skeleton (Datta et al. 2008). While the turnover of bone is essential to skeletal metabolism, the turnover rate of bone, including collagen, is generally slower than other animal tissues (e.g., fat) (Tieszen et al. 1983). Different skeletal elements do show variability in their rate of bone collagen turnover. For example, the collagen turnover in ribs ranges between 5 and 10 years (Richards and Hedges 1999), whereas femoral collagen turnover is much slower, occurring approximately every 10 years or more (Hedges et al. 2007).

3.1.2 Hydroxyapatite

The enamel of teeth is made up of hydroxyapatite mineral crystals which are packed densely together (Hillson 2005:146–148). Hydroxyapatite [$Ca(PO_4)_6(OH)_2$] contains calcium, phosphate, and hydroxyl ions (Capo et al. 1998:198). Enamel is denser and harder than bone mineral and tooth dentine, which are both susceptible to factors within the burial environment (i.e., diagenesis), which is discussed in further detail in the next section (Budd et al. 2000). Because of enamel's resistance to diagenetic changes, and the fact that it does not turn over once developed, this tissue is commonly sampled for archaeological research (Budd et al. 2000). Generally, molars are sampled (Evans et al. 2012), as each molar represents a distinct period of childhood development (see Table 3.1) (Gustafson and Koch 1974; Anderson et al. 1976; Scheuer and Black 2000:151–161). Second and third molars are preferred, as they generally represent the isotope signal post–weaning (approximately 3 years of age) (Hillson 1996; Slovak and Paytan 2011). While a newborn infant would have an isotopic composition identical to that of its mother (Katzenberg et al. 1996), a breast-feeding child's only source of dietary nitrogen is via

the mother's milk, and their $\delta^{15}N$ would be enriched by 2-3‰ compared to the mother's diet (Steele and Daniel 1978; Fogel et al. 1989). A pattern can be seen of increasing $\delta^{15}N$ values during the first months of life, with a maximum value reached at the onset of weaning followed by a gradual decline as weaning continues (Schurr 1998).

Table 3.1. Age of enamel mineralization and eruption of permanent premolars and molars (Wheeler 1965; Ubelaker 1978; Scheuer and Black 2000:151–161).

Tooth	Age of mineralization onset	Crown completed	Age of eruption
3rd Premolar	1.5-2 years	5-6 years	10-12 years
4th Premolar	2-2.5 years	6-7 years	10-12 years
1st Molar	At birth	2.5-3 years	6-7 years
2nd Molar	2.5–3 years	7-8 years	11-13 years
3rd Molar	7-10 years	12-16 years	17-21 years

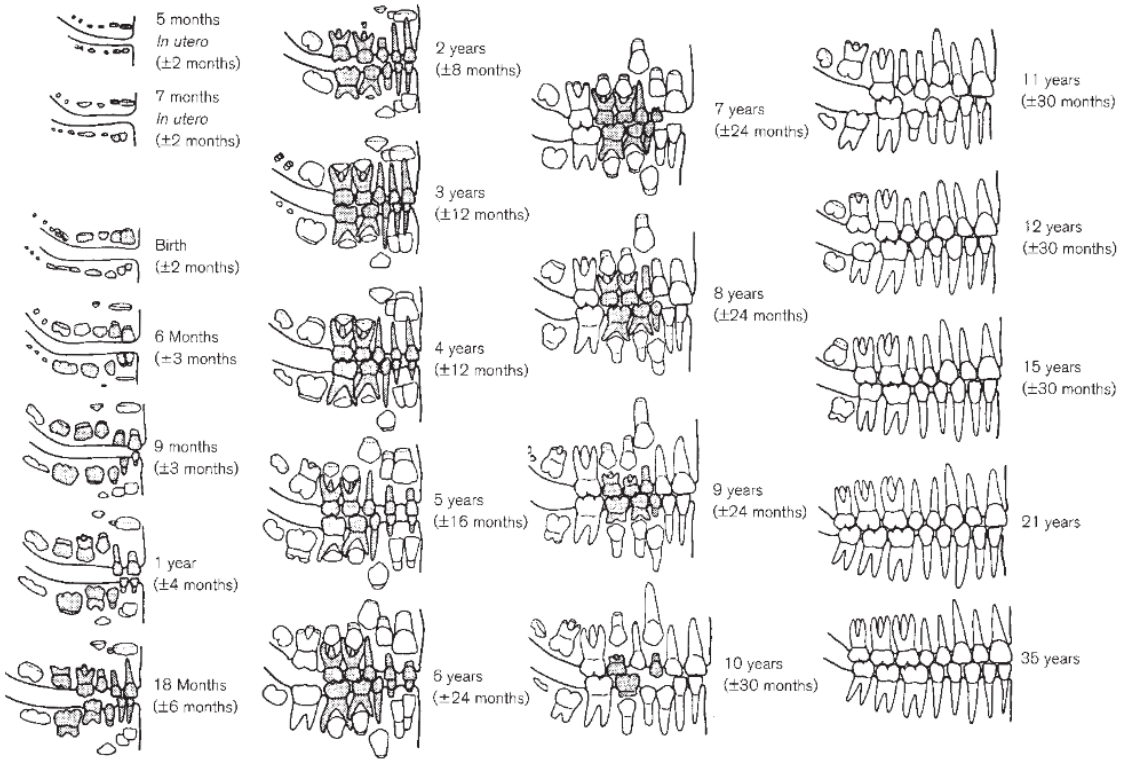

Fig. 3.1. Chart of the development of the teeth from 5 months *in utero* to 35 years of age. From WEA (1980) after Ubelaker (1978).

3.2 What are Isotopes? Terminology and Notation

Isotopes are atoms of an element that contain the same number of protons but a different number of neutrons within the nucleus (Soddy 1922; Katzenberg 2000; Hoefs 2015). Isotopes can be classified as either stable or unstable. Stable isotopes do not lose neutrons over time, whereas unstable, or radioactive, isotopes do (Katzenberg 2000; Hoefs 2015). The accepted convention for reporting stable light isotope ratio measurements uses the delta (δ) notation in units of per mil (‰) (Hoefs 2015). The equation to calculate the delta value of an isotopic ratio is shown below.

$$\delta \text{ in } ‰ = \frac{R\,(Sample) - R(Standard)}{R(Standard)}\ x\ 1000$$

Standards are materials with known isotopic ratios, and there exist internationally accepted standards as well as internal standards specific to individual laboratories (Katzenberg 2000). Standards are used to measure samples which have unknown isotopic ratios, allowing for isotopic results to be calibrated and comparable to measurements from other labs (Mariotti et al. 1981). A positive delta value indicates that a sample has more heavy isotopes than the standard, otherwise noted as isotopically heavier, whereas a negative delta value indicates the sample has less of the heavy isotope than the standard or is isotopically lighter (Sulzman 2007). Different standards are used for different isotopes. For example, the standard for carbon is Vienna Pee Dee Belemnite (VPDB), which is a calcite containing a cretaceous fossil (Belemnite) from the Pee Dee formation in South Carolina (Craig 1954, 1957; van der Merwe 1982; Coplen et al. 2006). The standard for nitrogen is Ambient Inhalable Reservoir, or AIR (Junc and Svex 1958). The

standards used for strontium analysis in this research are NIST SRM987, which is strontium carbonate (Avanzinelli et al. 2005) and NIST SRM 1400, which is bone ash (Galler et al. 2007).

3.3 Reconstructing Diet

3.3.1 Carbon Isotopes

Carbon exists with three isotopes ^{12}C, ^{13}C, and ^{14}C, and a natural abundance of 99%, 1%, and <0.1%, respectively. ^{12}C and ^{13}C are stable isotopes and ^{14}C is unstable or radioactive. Fractionation is the change that takes place in isotopic ratios between materials because of the different rates that isotopes undergo chemical reactions, such as the enrichment or depletion between ^{13}C and ^{12}C (Van der Merwe 1982). In plants, fractionation occurs when CO_2 is incorporated into a plant's tissues during photosynthesis (Park and Epstein 1960). Three types of photosynthesis exist and include C_3, C_4, and CAM pathways (Van der Merwe 1982). The most common pathway is in C_3 plants, which typically occur in temperate areas, and include wheat, barely, and rice. In contrast, C_4 plants grow in hotter, drier areas, and include grasses, corn, maize, sugar cane, and sorghum (Bender 1968; van der Merwe 1982; DeNiro 1987; Ambrose and Norr 1993). C_3 plants can have $\delta^{13}C$ values ranging from –22‰ to –38‰, as this pathway produces low $\delta^{13}C$ values (Smith and Epstein 1971; DeNiro and Epstein 1978; van der Merwe 1982; Balasse et al. 2006). In contrast, the C_4 pathway produces higher $\delta^{13}C$ values, ranging from –16‰ to –9‰ (DeNiro and Epstein 1978:183; van der Merwe 1982). There also exists CAM plants, or the Crassulacean Acid Metabolism photosynthetic pathway, which can switch between C_3 and C_4 pathways depending on

conditions in the environment (van der Merwe 1982). Plants source carbon differently depending on the environment in which they occur (i.e., marine or terrestrial). Terrestrial plants use atmospheric carbon during photosynthesis (Schwarcz et al. 1991), whereas marine plants acquire carbon from dissolved CO_2, bicarbonates, and carbonates in the ocean resulting in a greater variation of $\delta^{13}C$ values (–31 to –7‰) (van der Merwe 1982).

Organisms within ecosystems contain a variety of $\delta^{13}C$ values due to fractionation, which is influenced by an animal's metabolism and trophic level. For example, in a terrestrial ecosystem, plants are first consumed by herbivores, which are in turn consumed by carnivores. Each step in an ecosystem causes a trophic shift with heavier isotopes absorbed preferentially over lighter isotopes, meaning that a consumer's cellular tissue is isotopically heavier than the consumer's diet (DeNiro and Epstein 1978). The trophic shift in carbon between levels of the food chain is relatively small, with several studies suggesting a 0‰ – 2‰ increase in $\delta^{13}C$ values (DeNiro and Epstein 1978, 1981; Bender et al. 1981; Macko et al. 1982; Bocherens and Drucker 2003).

3.3.2 Nitrogen Isotopes

Nitrogen accounts for approximately 78% of the elemental content of atmospheric gas (Hoefs 2009). In order to be absorbed into plant or animal matter, nitrogen must be incorporated into organic compounds (Hoefs 2009:54–57). Nitrogen is most abundant as ^{14}N, at >99.6%, but is also present in small amounts of the heavier ^{15}N, at about 0.3% (Rosman and Taylor 1998). The nitrogen isotope ratio is used to monitor trophic levels within a sample (Coltrain et al. 2016). Calculation of $\delta^{15}N$ values uses the same equation as $\delta^{13}C$, but with ^{15}N compared to ^{14}N, reported against the standard of AIR.

Plants can be divided into two groups, N_2–fixing plants and non–N_2–fixing plants. N_2 fixing plants, like legumes, have a symbiotic relationship with bacteria that live in roots and use atmospheric N_2 and nitrate (NO_3) and ammonium (NH_4) ions in soil as nitrogen sources; in contrast, non–N_2–fixing plants, like terrestrial ferns, do not have the ability to fix N_2 and must rely on soil nitrogen from decomposed organic matter (Virginia and Delwiche 1982; DeNiro 1987; Katzenberg 2000). Because soil nitrate and ammonium have more positive $\delta^{15}N$ values than atmospheric N_2, N_2–fixing plants will have lower $\delta^{15}N$ values than non–N_2–fixing plants (DeNiro 1987). Cyanobacteria (blue–green algae) directly fix atmospheric N_2 in the ocean, making their $\delta^{15}N$ values average around 0‰, while marine plants cannot fix N_2 and use dissolved nitrate and ammonium, which have values associated with local conditions in the ocean (DeNiro 1987). Marine plants typically have higher $\delta^{15}N$ values than terrestrial plants because of the uptake of seawater–bound nitrogen, which allows for the distinction between marine and terrestrial plants (Miyake and Wada 1967; Schoeninger and DeNiro 1984).

Fixation as a term is used for the processes that converts unreactive atmospheric N_2 into reactive nitrogen. In the roots of plants, microorganisms that break down organic materials process N_2 via fixation with the result of having $\delta^{15}N$ values of about 0‰ (Katzenberg 2000; Hoefs 2009). As nitrogen moves up through the trophic levels, there is an increase in the $\delta^{15}N$ values between 3–5‰ with each step up the food web due to enrichment of the heavier isotope, in this case ^{15}N, though O'Connell and colleagues (2012) have suggested an increase of 6‰ to be a more accurate estimate (DeNiro and Epstein 1981; Minagawa and Wada 1984; Schoeninger and DeNiro 1984). Because of

this trophic shift, along with more steps in the marine food chain, marine foods often have higher nitrogen isotope values than terrestrial foods (Schoeninger and DeNiro 1984). For example, Schoeninger and DeNiro (1984) found that marine animal collagen δ^{15}N values average 14.8±2.5‰ (n=61, 1σ), whereas terrestrial animal collagen averaged 5.9±2.2‰ (n=27, 1σ) with only a 1‰ overlap between the ranges and almost a 9‰ difference between the means of marine and terrestrial animals.

3.4 Reconstructing Origins

3.4.1 Strontium Isotopes

Strontium isotope ratios have the potential to give archaeologists information on the geographic origins of humans and animals, as well as to track movements during their lifetimes. Strontium isotopes are found in bedrock and become integrated into the biosphere through plant intake and can therefore be used to identify the place of food origin. Strontium has four naturally occurring stable isotopes: ^{88}Sr, ^{87}Sr, ^{86}Sr, and ^{84}Sr, with abundances of approximately 82.53%, 7.04%, 9.87%, and 0.56%, respectively (Kendall et al. 1995; Hoefs 2015). Only ^{87}Sr is radiogenic and forms through the β–decay of rubidium (^{87}Rb), which has a half–life of 4.88×10^{10} years (Faure 1986; Kendall et al. 1995). Therefore, there are two sources of ^{87}Sr in any material: that which is formed during primordial nucleo-synthesis along with the other three strontium isotopes and that which is formed by the radioactive decay of ^{87}Rb (Kendall et al. 1995). In strontium isotope analyses, ^{86}Sr is most commonly compared to ^{87}Sr, and this ratio provides a measure of the relative proportion of radiogenic to stable strontium (Kendall et al. 1995). Recently, other strontium isotopes are starting to be explored, such as $\delta^{88/86}$Sr (Knudson

et al. 2010; Oeser and von Blanckenburg 2020). Because the atomic radius of strontium is similar to that of calcium, it will substitute for calcium in minerals, and $^{87}Sr/^{86}Sr$ in minerals and rocks range from about 0.7 to greater than 4.0 (Faure 1986; Kendall et al. 1995). Unlike the other isotopes this project examines (i.e., $\delta^{13}C$ and $\delta^{15}N$), strontium is expressed solely as a direct ratio of ^{87}Sr to ^{86}Sr abundance, in the form of $^{87}Sr/^{86}Sr$.

A natural difference exists in strontium isotope ratios ($^{87}Sr/^{86}Sr$) within rocks because of the original abundance of ^{87}Rb and ^{86}Sr and the age since formation. Older rocks, and those with higher Rb content, will typically have higher $^{87}Sr/^{86}Sr$ (e.g., > 0.710) than younger rocks or those with less Rb (e.g., < 0.704) (Bentley 2006: 141). Strontium found within soil comes not only from bedrock, but also groundwater, wind–blown dust, glacier movement, and precipitation (Graustein 1989; Miller et al. 1993:438; Sillen et al. 1998). The mixing that occurs with all these sources contributes to the overall strontium isotope ratios of soil that are available for uptake by plants and animals and these ratios are referred to as bioavailable strontium (Åberg 1995:315–316). The ratios of strontium in river water depends on a variety of things, including weathering of local bedrock and minerals in the water. Global seawater is homogeneous with a current $^{87}Sr/^{86}Sr$ of 0.7092, though it has become more radiogenic over time (DePaolo and Ingram 1985; Hess et al. 1986). Coastal terrestrial regions can be affected by sea spray because strontium can be redeposited from the ocean into the soil there (Whipkey et al. 2000:45).

Unlike $\delta^{13}C$ and $\delta^{15}N$, strontium isotopes do not undergo significant fractionation during their incorporation into plants and animals (Graustein 1989:503–505; Åberg

1995:315–321; Capo et al. 1998:215), meaning they are passed relatively unaltered through trophic levels in the food chain (Montgomery 2002:35). Most stores of strontium are found within the hydroxyapatite of bones and teeth, as strontium replaces calcium within this inorganic skeletal component (Parker and Toots 1970:929). Most strontium that humans incorporate into the hydroxyapatite comes from plant material in their diets; however, it is important to note that concentrations of strontium can vary across different parts of a plant (Elias et al 1982:2567; Montgomery 2002:35–36). Herbivores take up strontium from the plants that they consume, whereas carnivores take up strontium from consuming herbivores (Montgomery 2010). The strontium ratios in bone represent later life strontium ingestion as the human skeleton consistently remodels during the life course (Bentley 2006), whereas strontium values from tooth enamel reflect early life strontium ingestion as this dental tissue does not remodel once formed in childhood (Hillson 2005).

Because strontium sources differ, looking only at the underlying geology is not sufficient to identify geographic origins. This has led researchers to create bioavailable strontium maps, often focused on a specific region (see Evans and Tatham 2004; Evans et al. 2010; Bataille and Bowen 2012; Laffoon et al. 2012; Bataille and Bowen 2012; Willmes et al. 2018) or attempt to model $^{87}Sr/^{86}Sr$ on a larger (global) scale (Bataille et al. 2020). These regional baselines can be used to determine local versus non–local individuals within a population and suggest potential origins (Schroeder et al. 2009; Montgomery 2010; Evans et al. 2012). One factor that complicates analysis is that seawater across the globe has relatively consistent $^{87}Sr/^{86}Sr$ and will effectively override

any other sources of strontium being incorporated into the skeleton. Therefore, if an individual grew up near the coast, their isotopic values will be close to 0.7092 regardless of the surrounding geology (Montgomery et al. 2014). It is worth noting that the level of variation that exists in biological systems can render specificity to the analytically measurable six decimal place resolution for $^{87}Sr/^{86}Sr$ (i.e., 0.000001) relatively insignificant. Within spatially close living animals or humans, the level of biological $^{87}Sr/^{86}Sr$ variation is expected to occur at two orders of magnitude higher (i.e., 0.0001).

3.5 Diagenesis

Mineralized tissues, like bone and teeth, exist in a closed system *in vivo*, meaning that cellular and metabolic processes are not highly affected by the outside environment (Kendall et al. 2018). After death, the skeleton becomes exposed to the surrounding environment, and thus is affected by physical, chemical, and biological alterations, known as diagenesis (Kendall et al. 2018). There is a difference in diagenetic alteration potential between bone and dental tissues. Enamel is more resistant to diagenesis than bone due to its high density, low porosity, and low organic component, making the measured isotopic values of elements (e.g., strontium) within it more likely to reflect biogenic values (Lee-Thorp and van der Merwe 1991; Koch et al. 1997; Kohn et al. 1999; Lee-Thorp 2002; Hoppe et al. 2003). Alternatively, bone and dentine have high porosity and a high organic component, making them more susceptible to diagenesis (Lee-Thorp and van der Merwe 1991; Koch et al. 1997; Kohn et al. 1999; Lee-Thorp 2002; Hoppe et al. 2003). This study employs the analysis of bone collagen, which can be assessed for potential diagenesis with quality assurance (QA) checks (%C, %N, atomic C:N, and

collagen yield [DeNiro 1985; van Klinken 1999; Szpak et al. 2017]), whereas it is more difficult to assess potential diagenetic change in bone mineral due to a lack of established QA measures. The methods for the preparation of tooth enamel and bone collagen for carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and strontium isotope analysis are discussed in more detail in Chapter 4 (Materials and Methods).

Chapter 4. Materials and Methods

4.1 Sites

4.1.1 St. Paul's, Newfoundland

St. Paul's Anglican Church (CkAh–6) in Harbour Grace was originally the site of two wooden churches (1764), which were affected by the harsh Newfoundland climate over several decades and arson in 1816 (Ford 1935). To make a permanent fixture for the community, the church was rebuilt with stone in 1820, and was home to two churchyard cemeteries where the early colonists of Conception Bay were interred (Ford 1935; Pike 2013). In 1991, the Provincial Archaeology Office was contacted by the Royal Canadian Mounted Police (RCMP) because human remains were found while a trench was being dug next to the church meant for a new structural foundation, and a salvage excavation was completed (Pike 2013). Nineteen individuals were recovered, eight of which were from the backhoe created back–dirt pile (Pike 2013). Each individual sampled from St. Paul's had a burial number associated with them but were also assigned a Memorial Applied Archaeological Sciences (MAAS) Laboratory MARC (internal sample number) for each of the three isotope analyses completed (i.e., carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and strontium ($^{87}Sr/^{86}Sr$), see Appendix 1, Tables A.1 and A.3). Two samplings took place, and from the first sampling, four teeth were sampled for strontium and nine bone samples were taken for carbon and nitrogen isotope analysis. More bone and tooth samples were taken recently for additional data, which included nine bone samples for carbon and nitrogen and five tooth samples for strontium isotope analyses (Table 4.4). Permission to

conduct destructive analysis on these samples was provided by St. Paul's Anglican Church and the remains have been repatriated and reburied.

Table 4.1. Bones and teeth sampled from the St. Paul's Anglican Cemetery assemblage.

Individual	Sex	Age	Bone	Tooth
NP 250/F3	Male	30-45	left humerus	M2
NP 251/F4	Male	38-50	right clavicle	LLPM4
NP 254/F7	Female	20-30	left humerus	LLM1
			right rib frag.	LLM3
10	Indeterminate	12-18 months	right humerus	–
11	Female	50+	right humerus	–
NP 258/F13	Male	35-50	left humerus	URM2
NP 262/F21	Indeterminate	12 - 14	right femur	M1; M2
NP 263A/F22	Female	25-35	right humerus	–
NP 253/F6	Indeterminate	Fetus (24-28 wks)	fetal skull frags	–
NP 255/F9	Indeterminate	Fetus (32-36 wks)	fetal neurocranial frags	–
NP 259/F15	Indeterminate	9-12 months	left femur	–
NP 260/F16	Indeterminate	Late Fetal/Perinate (40 wks)	right femur	–
NP261/F19	Indeterminate	Late Fetal/Perinate (40 wks)	right femur	–
NP 264/Ind. 1	Indeterminate	50+ years	left ramus	LLM1
NP 264/Ind. 2	Indeterminate	Young Adult	right ramus	–
NP 264/Ind. 3	Indeterminate	Young Adult	lower left mandible	–
NP 264/non-adult	Indeterminate	1-3 months	ribs	–

*Tooth Key: L or U= mandibular or maxillary; L or R= left or right; M or PM= molar or premolar, tooth number.

4.1.2 Foxtrap, Newfoundland

The site of Foxtrap–2 (CjAf–10) is located on Delaney's Road in Foxtrap, NL. Based on maps from the early 1900s, the land surrounding the site was owned by the

Taylor family and used as a farm until it was sold in 1998 to its current owners. As a result of archaeological excavation of the Foxtrap–2 site in 2016 and 2017 a total of 31 burials were recorded, including 8 adults, 13 non-adults, and 3 individuals of indeterminate age (Grimes et al. 2018). Because of poor preservation, only 18 burials contained identifiable skeletal elements, and of those, most adult burials consisted of incomplete long bones and cranial elements, whereas non-adult remains consisted of cranial bone fragments and isolated teeth (Grimes et al. 2018). For this study, 13 bones and nine teeth were sampled for isotope analyses. Fragmented long bones were targeted for sampling (n=6); however, in certain cases this was not possible due to lack of preservation and cranial bones were selected (n=7). All teeth were second molars, except for one, which was either a second or a third molar (Table 4.2). Each individual sampled from Foxtrap had a burial number associated with them but were also assigned a MARC number for each of the three isotope analyses completed (i.e., carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and strontium ($^{87}Sr/^{86}Sr$), see Appendix 1, Tables A.1 and A.3). Permission for destructive analysis was granted through the Provincial Archaeology Office and the Department of Justice and the remains are currently housed at Memorial University.

Table 4.2. Bones and teeth sampled from the Foxtrap–2 assemblage.

Individual	Sex	Age	Bone	Tooth
4	Indeterminate	>9 years	unknown long bone	LRM2
7	Indeterminate	adult	unknown long bone	ULM2
8	Indeterminate	non-adult	skull fragment	–
9	Indeterminate	adult	frontal bone	URM2/3
10	Indeterminate	adult	maxilla	ULM2
11	Possible Male	adult	left clavicle	LLM2

Individual	Sex	Age	Bone	Tooth
12	Possible Female	adult	right humerus	LRM2
13	Indeterminate	adult	maxilla	URM2
14	Possible Male	adult	right ulna/ radius	URM2
20	Indeterminate	9years ± 24 months	right cranium	–
23	Indeterminate	non-adult	petrous portion	–
26	Indeterminate	5-11 years	right temporal	–
30	Indeterminate	adult	left humerus	LRM2

*Tooth Key: L or U= mandibular or maxillary; L or R= left or right; M or PM= molar or premolar, tooth number.

4.1.3 St. Luke's, Newfoundland

The Placentia skeletal sample included four individuals from St. Luke's Cemetery (ChAl–17) in Placentia, NL. St. Luke's Cemetery which is in St. Luke's Anglican Churchyard, was used first in the late 16th century as a burial ground and includes internments from Basque, French Catholic, and English historic periods (Newfoundland and Labrador Heritage Foundation 2020). Archaeological excavations in 1971 discovered burials approximately two feet beneath the surface of unmarked head/footstones (Mounier 1971). The context in which these burials were found was more consistent with the remains being French and associated with the French church built in 1689 by the Récollet friars (Mounier 1971; Taylor-Hood 1999). Preservation for most individuals was poor due to the location beneath the water–table and resulted in minimal recovery of skeletal elements (Mounier 1971). Bone samples were taken from four individuals for carbon and nitrogen isotope analysis and teeth samples from six individuals for strontium isotope analysis (Table 4.5). Each individual sampled from St. Luke's had a burial number associated with them but were also assigned a MARC number for each of the three isotope analyses completed (i.e., carbon (δ^{13}C), nitrogen (δ^{15}N), and strontium

($^{87}Sr/^{86}Sr$), see Appendix 1, Tables A.1 and A.3). Permission for destructive analysis was granted through the Provincial Archaeology Office and The Rooms and the remains are currently housed at Memorial University.

Table 4.3. Bones and teeth sampled from St. Luke's Anglican Cemetery assemblage.

Individual	Sex	Age	Bone	Tooth
62A	Indeterminate	Indeterminate	?	URM2
62B	Indeterminate	Indeterminate	?	–
62C	Indeterminate	Indeterminate	?	–
63	Indeterminate	Indeterminate	–	URM1
			–	URM2
			–	URM3
66A	Indeterminate	Indeterminate	–	LRM1
			–	LRM2
			–	LRM3
67	Indeterminate	Indeterminate	–	LRM1
			?	URM1
			–	URM3

*Tooth Key: L or U= mandibular or maxillary; L or R= left or right; M or PM= molar or premolar, tooth number.

4.1.4 Block 3, Louisbourg, NS

Block 3 was Louisbourg's first cemetery and was used for the first decade of the settlement (1713–1723) (Johnston 2004). The Block 3 cemetery was located next to the building that housed the convent of the Récollect on the sloping lot along the waterfront (Johnston 1984) (Figure 4.1). De–sanctified in AD 1723, several burials were exhumed and reburied in the new parish cemetery in Block 34 the same year (Johnston 1984, 2004). However, many burials remained in Block 3 and were further disturbed as the lot passed through the ownership of Cressonet dit Beausejour (1725–1726) and LaGrange (1724–1726) (Harris 1974; Johnston 2004; Scott et al. 2020). During archaeological excavations that were a part of the reconstruction of the Fortress as a National Historic

Site of Canada in the late 20th century, 26 individuals from the Block 3 cemetery were exhumed (Harris 1974).

Figure 4.1. Map showing where Block 3 is in relation to the rest of the Fortress of Louisbourg. Map created using a Google Earth (n.d.) image of the Fortress of Louisbourg with a map by Fry (1971) of historical lot division overlaid.

Each individual sampled from Block 3 had a burial number associated with them but were also assigned a MARC number for each of the three isotope analyses completed (i.e., carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), and strontium ($^{87}Sr/^{86}Sr$), see Appendix 1, Tables A.1 and A.3). Twenty-five bones were sampled for carbon and nitrogen isotope analysis, with ribs or long bones targeted for sampling and one sample came from a cranial bone. Nineteen teeth were sampled for strontium isotope analysis. Tooth samples were taken from premolars and molars (Table 4.4). Permission for destructive analysis was granted through Parks Canada and the remains are currently housed at the University of New Brunswick

Table 4.4. Bones and teeth sampled from the Fortress of Louisbourg Block 3 assemblage.

Individual	Sex	Age	Bone	Tooth
1	Male	35-40	rib	LLM2(3?)
2	Male	20-25	rib	URM2
3	Possible Male	18-21	rib - left 2nd	ULM2
4	Male	18-25	rib	URPM4
5	Indeterminate	<40	right radius	–
6	Indeterminate	<30-35	left fibula	–
7	Male	30-35	rib	LLPM4
8	Possible Female	35-45	rib	LLM2
9	Male	25-40	rib	ULPM4
10	Male	30-34	rib	LLM2
11	Indeterminate	<40	rib	–
12	Male	20-40	rib	LLM2
13	Indeterminate	16-19	rib	ULM2
14	Indeterminate	18-23	-	–
15	Possible Female	25-30	rib	ULM2
16	Male	25-39	rib	ULM2
17	Male	30-39	left radius	LRM2
18	Male	<45	rib - left 2nd	LRM2
19	Male	17-18	rib	URPM4
20	Male	20-35	rib	URM2
21	Female	20-40	long bone - meta-carpal or -tarsal	–
22	Male	20-40	right radius	–
23	Male	30-45	right radius	ULM2
24	Male	20-40	left radius	–
25	Possible Male	20-40	rib	URPM3
44	Male	27-35	cranial - frontal sinus	LLPM4

*Tooth Key: L or U= mandibular or maxillary; L or R= left or right; M or PM= molar or premolar, tooth number.

4.1.6 Placentia Faunal Material

Faunal material from Placentia was chosen from boxes housed at the Rooms, the provincial museum and archives, in St. John's, NL, with permissions from the museum. Access and sampling were facilitated by Lori Temple. This included nine fish, three cow, three seal, three bird, three fox, a fox or cat, a likely cat, a rat, two squirrels, three pigs, a

sheep, and two sheep or goat bones (Table 4.7). Along with previously analyzed faunal bones from other parts of Newfoundland (Guiry et al. 2012a), these data were used to help create a faunal baseline for the island of Newfoundland.

Table 4.5. Placentia faunal material sampled.

Animal	MARC	Bone
Fish	5299	Pre-maxilla
Fish	5300	Pre-maxilla
Fish	5301	Pre-maxilla
Fish	5307	Pre-maxilla
Fish	5308	Pre-maxilla
Fish	5310	Pre-maxilla
Fish	5312	Pre-maxilla
Fish	5313	Pre-maxilla
Fish	5314	Pre-maxilla
Cow	5316	Femur
Cow	5318	Long bone
Cow	5319	Humerus
Seal	5325	Rib
Seal	5326	Carpal/metacarpal
Seal	5327	Phalange
Bird	5332	Ulna
Bird	5334	Ulna
Bird	5341	Ulna
Fox	5349	Humerus
Fox/Cat	5353	Femur (juvenile)
Fox	5354	Radius
Rat	5355	Jaw
Squirrel	5356	Tibia
Squirrel	5357	Tibia
Fox	5363	Humerus
Likely Cat	5364	Metatarsal
Pig	5368	Mandible
Pig	5369	Mandible
Pig	5370	Mandible
Sheep/Goat	5376	Humerus
Sheep/Goat	5377	Humerus
Sheep	5378	Humerus

4.1.5 Louisbourg Faunal Material

A small amount of faunal material from the Fortress of Louisbourg was sampled for stable carbon and nitrogen isotope analysis, facilitated by Dr. Scott and Parks Canada, including five pigs, two cow, one sheep/goat, a fish, a canine, and a bird bone (Table 4.6). These data will be used in conjunction with previous obtained data from Ellerbrok's (2014) MA thesis to help create a baseline for the Fortress of Louisbourg.

Table 4.6. Louisbourg faunal material sampled.

Animal	MARC	Bone
Pig	5231	Cervical Vertebra
Pig	5232	Astragalus
Pig	5233	Metatarsal epiphysis
Pig	5234	Phalanx
Pig	5235	Metatarsal
Cow	5236	Astragalus
Cow	5290	Phalanx
Sheep/Goat	5291	Humerus
Fish	5292	Premaxilla
Canine	5293	Root of tooth
Bird	5294	Humerus

4.2 Description of Previous Isotopic Work

This thesis includes a comparative analysis of previous isotopic work (St. Paul's human - Munkittrick et al. 2019; St. Luke's human carbon and nitrogen - Harris unpublished; Louisbourg human and faunal - Ellerbrok 2014; Guiry et al. 2012). The methodological approach remains relatively consistent across the different samples from these previous works as they were all completed at the MAAS lab.

Previous stable carbon and nitrogen isotope analyses that were conducted on St. Paul's (Munkittrick et al. 2019; Pike unpublished) and St. Luke's (Harris unpublished) are also used as comparative material in this analysis; however, new strontium isotope information was included from each of the two sites. From St. Paul's, enamel samples were taken from the individuals for strontium isotope analysis by J. Munkittrick, and bone collagen samples were taken by Kelly-Anne Pike (Munkittrick 2015). From this first sampling of the St. Paul's individuals, four teeth were sampled for strontium and nine bone samples were taken for carbon and nitrogen isotope analysis. More bone and tooth samples were taken by the author and J. Munkittrick for additional data for this thesis, including nine bone samples for carbon and nitrogen and five tooth samples for carbonate, oxygen, and strontium isotope analyses. The St. Luke's isotope data was obtained in a batch of samples run previously (Harris unpublished), but the data were not analyzed or used in research.

The Louisbourg human and faunal work was completed by Ellerbrok (2014). The human samples come from the Ste. Marie mass burial at Louisbourg and contained 48 individuals, including 45 adults and three non–adults. One individual was recovered outside the root cellar and was believed to be a reinterment but was still included in the Ellerbrok study. In Ellerbrok's (2014) study, long bones and ribs were preferentially sampled. Ellerbrok chose to sample for bone collagen twice to observe any variability of isotopic values within the same bone or between different bones from the same individual. For dentition, first and second molars were selected. A total number of 44

individuals were sampled by Ellerbrok, 29 had bone and dental samples, 11 had only bone samples, and four only had dental samples.

A total number of 109 faunal specimens were also collected from Louisbourg by Ellerbrok, which included 58 specimens excavated from the Ste. Marie site and 51 specimens that were excavated from Blocks 3 and 4 within the Fortress walls (Ellerbrok 2014). Of the 109 faunal samples, 84 bone and 30 tooth samples were collected, some of them as duplicates. The faunal remains excavated from French–only occupation layers were chosen by Ellerbrok over layers that included New England or British occupation periods in an attempt to exclude domestic fauna that might have been brought in by non–French occupants of the Fortress (Ellerbrok 2014).

Faunal data from Guiry et al. (2012a) was also used as a comparative dataset. This included 145 faunal specimens from two Newfoundland sites, Dos de Cheval (EfAx-09) and Ferryland (CgAf-02). Dos De Cheval was a French fishery site, with faunal materials coming from temporal contexts between the late 17th- and late 19th-centuries. Ferryland was an English colony and the faunal materials came from middens that date from the mid to late 17th-century.

4.3 Collagen Preparation and Analysis (Carbon and Nitrogen)

For this thesis, a total of 65 samples were analyzed from 64 individuals (St. Paul's individual 7 had two separate bones sampled, a humerus and a rib). Seven duplicates were also analyzed. A total number of 31 faunal samples were analyzed, as well as nine duplicates, though only six duplicates were not lost or rejected. Bone collagen analysis

was competed following a modified version of the Longin method (1971) by Richards and Hedges (1999). Age and sex estimation of individuals sampled was performed by different researchers, with all following the standards set by Buikstra and Ubelaker (1994), as well as Brickley and McKinley (2004). Unfortunately, in several cases, the human remains recovered were badly damaged or suffered from poor preservation.

4.3.1 Preparation

Sample preparation and pretreatments took place at the Memorial Applied Archaeological Sciences (MAAS) laboratory, Department of Archaeology, Memorial University under the supervision of Dr. V. Grimes. Approximately 200–300mg of cortical bone was cut from each bone sample using a Jobmate rotary tool, then the surfaces of the samples were cleaned with air abrasion using aluminum oxide powder. Samples were then weighed (~200–300mg) and placed into clean 15mL glass test tubes with screw caps, and the laboratory sample number (MARC#) written on each. Chilled (4°C) 0.5M HCl was added to the test tubes, filled to about two-thirds, covered, and placed on the lab bench to demineralize at room temperature (~20°C). The acid was changed every other day until the bone was spongy as determined by probing with the tip of a Pasteur pipette. The demineralization process could take anywhere from a few days to a few weeks depending on the preservation of the bone. Once demineralization was complete, the samples were rinsed in deionized water (DI H_2O, 18.3 MΩ) three times to ensure the acid was completely gone and then refrigerated (4°C) in DI H_2O until the remaining samples were completely demineralized. Once all samples were demineralized, they were rinsed with DI H_2O again before being acidified by adding two

drops of 0.5 M HCl to obtain a solution pH of 3 (Brown 1999). The sample tubes were then placed into the heating block (set to 70°C) with the screw tops tightly on and left for 48 hours to gelatinize the collagen. Once gelatinized, the samples were then filtered with Ezee filter separators (9ml, 60–90 μm pore size, Elkay Laboratory Products, Basingstoke, UK) into a labelled plain glass tube and covered with a piece of parafilm. The tubes were then placed into a –20°C freezer with the rack tipped so that the tubes were at an acute, almost horizontal angle to increase surface area for freezing. After 24 hours the samples were moved to a –60°C freezer. Prior to freeze-drying (lyophilization), the parafilm was perforated; after 48 hours in the freeze-dryer, collagen samples were weighed into 2ml centrifuge tubes.

4.3.2 Analysis

The measurement of bone collagen for both carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes were completed at the Stable Isotope Laboratory of the TERRA CREAIT network at Memorial University. Small amounts (~1mg) of the collagen samples were weighed into tin capsules (7 x 7mm ultralight, Elemental Microanalysis, UK) with a proportion of samples analyzed as duplicates (~10% in most cases, as is the standard in the lab). Samples were flash combusted at 1800°C in a Carlo Erba NA 1500 Series elemental analyzer, and the gases that result from this combustion were passed through a reduction reactor at 650°C to reduce NO_2. The resulting gases CO_2 and N_2 are then separated on a 3m stainless steel Poropak QS 50/80 chromatographic column and carried by helium to a Thermo Electron ConFloIII interface. The gasses are directly carried to a Thermo Scientific Delta V Plus isotope ratio mass spectrometer, where gasses are ionized

and then sent through a magnetic field before the strength of the voltage is recorded by the Faraday cups. Four pulses of reference gases are injected after each sample, and samples were interspersed with reference materials. Stable carbon and nitrogen isotope ratios were calibrated relative to the VPDB and AIR scales using EDTA#2 (δ^{13}C –40.38 ± 0.011‰, δ^{15}N –0.83 ± 0.041‰), USGS62 (δ^{13}C –14.79 ± 0.044‰, δ^{15}N 20.17 ± 0.064‰), G–9 (internal standard, L–Glutamic acid, δ^{13}C –26.74 ± 0.06‰, δ^{15}N –2.77 ± 0.18 ‰), and B1255 (δ^{13}C –27.03 ± 0.133‰, δ^{15}N 5.97 ± 0.083‰). The approach used in Szpak et al. (2017) was used to calculate precision, accuracy, and sample measurement uncertainty. Precision was determined to be 0.2 and 0.7 for δ^{13}C and δ^{15}N, respectively, based on the summed standard deviations of all repeated measurements during the relevant analytical sessions. The high nitrogen uncertainty was likely due to propagated error. Accuracy was determined to be 0.228 and 0.052 (rounded to 0.2 and 0.1, respectively) for δ^{13}C and δ^{15}N, based on the difference between observed and known δ values of the check standards.

4.3.3 Collagen Preservation

The preservation of collagen is vital to accurate interpretation of isotope data. There are several methods to assess the quality of collagen samples. One such method is to calculate the collagen yield of each sample (van Klinken 1999). Fresh and modern bone contains approximately 22% collagen, which degrades slowly during the time it is buried, and generally, 1% is the cutoff point where samples are no longer considered suitable for analysis (van Klinken 1999). Calculating the collagen yield, which is the

mass of the original bone sample compared to the amount of resulting collagen, is calculated using the following equation (van Klinken 1999):

%yield = (Final mass/Initial mass) x 100

Another method of assessing the quality of collagen samples is the calculation of the C/N atomic ratio for each sample (DeNiro 1985). Acceptable ratios between carbon and nitrogen atoms in collagen falls between 2.9 and 3.6 (DeNiro 1985), with a mean of 3.2 (Ambrose 1990). Any value outside of this range potentially indicates that carbon and nitrogen within the collagen could be diagenetically altered (DeNiro 1985). In addition to this, the %C and %N used to make the C:N atomic values were assessed, though they are a qualitative measure in themselves. These collagen preservation assessments were conducted on all samples analyzed for this research.

4.4 Strontium Preparation and Analysis

4.4.1 Strontium Preparation

Strontium isotope analysis followed the solution method described in Madgwick et al. (2017), which has been modified from Deniel and Pin (2001) and Copeland et al. (2008) and includes several steps. Sample preparation, including cutting and cleaning enamel samples, took place in the MAAS Lab. A stainless-steel cut wheel was used to remove approximately 20 mg of enamel from the tooth crown after the outer surface was abraded with a stainless-steel dental burr to remove potential contaminates. This was also used to remove all adhering dentine from the enamel because dentine is more prone to diagenesis. Samples were then placed in labelled 2ml centrifuge tubes, ultrasonicated

three times in DI H_2O (18.3 MΩ) for five minutes each, rinsed once with acetone, and allowed to dry. Dental tools were cleaned between each sample using ultrasonification in DI H_2O for three–five minutes, rinsed with DI and dipped into 2M HNO_3, then rinsed with DI H_2O, and allowed to dry.

The following steps were completed in the Radiogenic Isotope Laboratory in the Department of Earth Sciences at Memorial University. Column fabrication and resin prep followed Charlier et al. (2006). Columns were made with standard 1ml pipette tips and a medium porosity (70µm) polyethelene frit (Bel–Art Products, New Jersey, USA), which was added to each column. Strontium spec resin (Eichrom Technologies) and was rinsed in consecutive washes of 8M HNO_3, 6M HCl, and DI water to remove trace organic compounds and any traces of strontium. Samples, including the procedural quality control standard NIST SRM 1400, were weighed and digested. The NIST SRM 987 was previously dissolved and is the solution used to check for analytical precision and accuracy. Samples were weighed in 3 mL Savillex perfluoroalkoxy (PFA) vials and the weight recorded. Sample digestion occurs in a HEPA filtered clean box. 2 ml of single–distilled 8M HNO_3 was added to each vial. Vials were placed on the hot plate and heated to ~100°C for approximately 1 hour or until each sample was completely digested. Once digested, samples were removed from heat and allowed to cool before 0.5ml was removed into clean, labeled 2ml microcentrifuge tubes for future determinations of strontium concentration of each sample.

All Sr-extraction columns went through a set of water and acid washes, including two column volumes (CVs; approximately equal to 1ml volume of the pipet tip) of DI

H_2O, 1 CV of HCl, and 1 CV of HNO_3 before the Sr-Spec resin was loaded (~250µl), with all washes being collected in 10 ml polyethelene (PE) beakers. Then each column containing the Sr-Spec resin was rinsed with 3 CVs of 6M HCl, 3 CVs of DI H_2O, and 3 CVs of 8M HNO_3 (Horwitz et al. 1991, 1992; De Muynk et al. 2009), all added dropwise. It is important that acid and water rinses are added carefully as to minimize disturbance of the resin. Once the resin was cleaned and primed, then the sample in 8M HNO_3 was added. The 10 ml PE beaker was removed from beneath the column, and the sample (~1ml) was draw from the digestion vial. The now empty vial was placed beneath the column and the sample was loaded slowly into the column and directly on the Sr–spec resin bed. When all the sample had dripped through and into the original sample vial, it was then reloaded, this time catching the solution that passes through into the 10 ml PE waste beaker. Loading and reloading the sample helps to maximize strontium recovery on the Sr-Spec resin. After this, the sample was rinsed with 3CVs of 8M HNO_3, allowing each to drip through into the 10 ml PE waste beaker before adding another CV. During the Sr elution step, a labelled 2 ml microcentrifuge tube was placed under the column and the column was raised so that just the tip rested inside the 2 ml tube. The sample was eluted from the Sr-Spec resin with 2ml of DI H_2O, administered dropwise onto the center of the resin bed. The last step before the sample can be analyzed was to acidify the sample by adding 75µl of 8M HNO_3, resulting in a 0.3 M HNO_3 solution containing the sample strontium.

4.4.2 Strontium Analysis

This project employed a Multi-Collector Inductively-Coupled Plasma-Mass-Spectrometry (MC-ICP-MS) for strontium isotope analysis. Samples were brought to the CREAIT Micro Analysis Facility (MAF), where they were analyzed on a Thermo Scientific Neptune MC-ICP-MS. Argon (Ar), an inert gas, was added and the sample was introduced into the plasma ion source where the ions are produced, accelerated, and focused (Houk et al. 1980; Wilschefski and Baxter 2019). The ion beam was separated in the analyzer via an electro–magnetic field into beams with ions separated according to their mass and charge, with heaviest ions deflected the least, and then these beams were concurrently measured by a series of faraday collectors, calculating the isotope ratio based on the different voltages of the ion beams (Copeland et al. 2008; Munkittrick 2015:127; Bower 2017). Krypton (Kr) was monitored to correct for the contribution of Kr in the Ar gas. Rubidium (Rb) was monitored to correct for possible ^{87}Rb in the solutions. The faraday cup configuration allowed for the simultaneous measurement of ^{82}Kr, ^{83}Kr, ^{84}Sr, ^{85}Rb, ^{86}Sr, ^{87}Sr, and ^{88}Sr. All data were corrected for first on–peak blank intensities, then mass bias corrected using the exponential law and a normalization ratio of 8.375209 for ^{88}Sr/^{86}Sr (Madgwick et al. 2019). Residual krypton (Kr) and rubidium (^{87}Rb) interferences were monitored and corrected using ^{82}Kr and ^{83}Kr (^{83}Kr/^{84}Kr= 0.20175 and ^{83}Kr/^{86}Kr= 0.66474; without normalization) and ^{85}Rb (^{85}Rb/^{87}Rb= 2.5926), respectively (Madgwick et al. 2019). The NIST SRM 987 was measured over three runs and gave an average ^{87}Sr/^{86}Sr value of 0.710287 ± 0.000013 (n=35, 1σ). All sample data were corrected with a value that was the difference of the measured SRM 987 from the

published value of $^{87}Sr/^{86}Sr$= 0.710248 (Avanzinelli et al. 2005), which resulted in an average correction of $^{87}Sr/^{86}Sr = 0.000039 \pm 0.000008$. The bone ash strontium concentration standard NIST SRM 1400 was measured as a total procedure isotope monitoring check over three analytical runs and gave an average $^{87}Sr/^{86}Sr$ value of 0.713152 ± 0.000021 (n=12, 1σ), which is similar to the published value of 0.71315 ± 0.00008 (Galler et al. 2007). The measured SRM 1400 $^{87}Sr/^{86}Sr$ values were corrected by the SRM 987 standard and gave an average $^{87}Sr/^{86}Sr$ value of 0.713142 ± 0.000023, which again falls within the error range for reported $^{87}Sr/^{86}Sr$ values in SRM 1400 (Galler et al. 2007).

4.5 Statistical Analyses

All isotope data ($\delta^{13}C$, $\delta^{15}N$, and $^{87}Sr/^{86}Sr$) were plotted and statistically analyzed using the R 3.6.0 software and Microsoft 365 Excel version 2011. Isotope data were first examined using descriptive statistics, including calculations of mean, median, standard deviation, and variance. The Shapiro–Wilk normality test was used to determine normality of each dataset, using the W statistic, though datasets with very small samples (<30) were assumed to have non–normal distributions.

Further statistical analyses were completed with both Wilcoxon rank sum tests and Kruskal–Wallis tests. Post–hoc tests, including the Dunn (1964) Kruskal–Wallis multiple comparison with p–values adjusted with the Benjamini–Hochberg method, were completed on several sets of data to determine the possible significant differences in

isotopic values that may exist between sites. The presentation of the isotope results and the statistical analyses conducted on them are discussed in Chapter 5.

4.6 Limitations

Limitations for this research included sample size and potential diagenesis. This study dealt with small sample sizes by using non-parametric statistical tests. Regarding the faunal baseline, while a minimum of three specimens were taken for each animal type, not all samples made it through the isotope analysis process. Of those that did, many failed the bone collagen quality assurance measures and had to be excluded. Stable isotope analysis itself has limitations as a methodology, including that it is restricted in making broad generalizations concerning estimations of the dietary protein sources. Depending on the bone that is sampled, stable carbon and nitrogen isotope analysis of bone collagen only represents a period of time focused on the last 10-30 years of life. As for strontium isotope analysis, the method chosen only reflects the chemical signature left from childhood. This project also faced the limitation of poor sample preservation. Skeletal elements are often not well preserved in the acidic soils of Newfoundland and Nova Scotia, leaving little bone tissue for isotope analysis, therefore in many cases, the same skeletal element could not be sampled across multiple individuals. Instead, the best-preserved skeletal element had to be sampled and differences in the period of life that was represented in these samples was unavoidable.

Chapter 5. Results

This chapter discusses the results of the isotopic analyses on both human and faunal skeletal material from the four 18th- and 19th-century sites in Newfoundland and the Fortress of Louisbourg in Nova Scotia. Stable carbon and nitrogen isotope (δ^{13}C and δ^{15}N) analysis were conducted on human and faunal bone collagen (n=98). Radiogenic strontium isotope (^{87}Sr/^{86}Sr) analysis was conducted on human tooth enamel (n=43). Statistical tests are presented below for each site/group examined, as well as comparisons between these data groups.

5.1 Human Collagen Preservation

For the purpose of this thesis, an acceptable yield of collagen is above 1%, and the acceptable atomic carbon and nitrogen ratio (C:N) is between 2.9 and 3.6 (DeNiro 1985). The acceptable concentrations of carbon and nitrogen (weight %C and %N) are between 15–47% and 5.5–17.3%, respectively (Ambrose 1990; Schwarcz and Schoeninger 1991; van Klinken 1999). The δ^{13}C‰ VPDB, δ^{15}N‰ AIR, collagen yield (%), weight %C and %N, and the C:N atomic ratios are reported in Table 5.1, as well as in more detail in Table A.1, Appendix 1.

Table 5.1. Results from the human bone collagen carbon and nitrogen isotope analysis from the four archaeological sites. (*) indicates a value that has been averaged between duplicate measurements.

Site	Individual	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	F3	1648	17.7	–17.31	14.05	43.2	15.6	3.2
St. Paul's Anglican Church, Harbour Grace, NL	F4	1649	17.5	–16.73	16.45	43.9	15.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	F7	1645	12.5	–17.40	12.51	43.5	15.1	3.4
St. Paul's Anglican Church, Harbour Grace, NL		1646	12.6	–17.17	12.56	41.3	14.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	F10	1647	13.4	–17.32	20.14	43.9	15.1	3.4
St. Paul's Anglican Church, Harbour Grace, NL	F11	1644	8.5	–15.59	16.01	38.7	14.0	3.2
St. Paul's Anglican Church, Harbour Grace, NL	F13	1643	6.0	–15.98	16.82	44.0	16.1	3.2
St. Paul's Anglican Church, Harbour Grace, NL	F21	1651	4.9	–18.02	13.75	38.4	13.2	3.4
St. Paul's Anglican Church, Harbour Grace, NL	F22	1650	7.2	–17.06	15.06	39.8	14.5	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP 253/ F6	4928	13.4	–17.48	15.77	42.2	15.6	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP 255/F9	4929	17.1	–17.34	17.65	43.5	16.1	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP 259/ F15	4930	21.6	–17.22	15.18	***49.9***	16.3	3.6

Site	Individual	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	NP 260/ F16	4931	21.3	–16.74	16.00	44.4	16.2	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP 261/ F19	4932	16.2	–17.28	14.73	44.0	16.2	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP 264/ Ind. 1	4933	16.7	–19.28	11.36	42.7	15.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP264/ Ind. 2	4934	14.0	–16.38	16.93	42.7	16.0	3.1
St. Paul's Anglican Church, Harbour Grace, NL	NP 264/ Ind. 3	4935	18.9	–16.95	18.43	44.7	16.16	3.2
St. Paul's Anglican Church, Harbour Grace, NL	NP264/ non-adult	4936	22.9	–17.19	14.79	42.7	15.5	3.2
Foxtrap–2, Foxtrap, NL	4*	5162*	6.8	–17.74	16.82	42.2	15.0	3.3
Foxtrap–2, Foxtrap, NL	7	5163	3.5	–17.17	18.34	41.4	14.7	3.3
Foxtrap–2, Foxtrap, NL	8	5164	13.1	–16.98	16.32	43.7	16.1	3.2
Foxtrap–2, Foxtrap, NL	9	5165	5.8	–17.29	14.79	41.5	14.6	3.3
Foxtrap–2, Foxtrap, NL	10*	5166*	5.5	–17.32	17.71	42.4	15.5	3.2
Foxtrap–2, Foxtrap, NL	11	5167	3.5	–17.11	17.55	40.6	14.8	3.2
Foxtrap–2, Foxtrap, NL	12	5168	14.6	–16.30	17.41	44.5	16.4	3.2
Foxtrap–2, Foxtrap, NL	13	5169	3.0	–17.16	14.20	42.1	15.2	3.2
Foxtrap–2, Foxtrap, NL	14*	5170*	2.9	–17.48	16.02	43.0	15.6	3.2
Foxtrap–2, Foxtrap, NL	20	5171	2.4	–18.39	14.36	41.1	14.7	3.3
Foxtrap–2, Foxtrap, NL	23	5172	12.3	–17.66	18.06	44.1	16.1	3.2
Foxtrap–2, Foxtrap, NL	26	5173	7.4	–17.26	15.34	42.1	15.6	3.1
Foxtrap–2, Foxtrap, NL	30*	5174*	4.7	–17.83	16.20	41.9	14.5	3.4
St. Luke's Anglican Cemetery, Placentia, NL	62A	2834	2.2	–19.00	13.63	42.3	14.9	3.3
St. Luke's Anglican Cemetery, Placentia, NL	67	3312	9.6	–18.10	12.70	43.2	15.6	3.2
St. Luke's Anglican Cemetery, Placentia, NL	62 B	2848	NA	–18.20	14.30	44.8	14.8	3.5
St. Luke's Anglican Cemetery, Placentia, NL	62 C	2849	9.8	–16.86	13.79	43.3	15.0	3.4

Site	Individual	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	1	4772	4.3	–18.16	12.24	44.1	15.3	3.4
Block 3, Louisbourg, NS	2*	4773*	5.8	–18.80	12.04	43.8	15.7	3.4
Block 3, Louisbourg, NS	3	4774	3.8	–18.57	11.15	43.4	14.9	3.4
Block 3, Louisbourg, NS	4	4775	1.2	–19.22	11.01	43.7	15.1	3.4
Block 3, Louisbourg, NS	5	4776	8.3	–16.33	13.36	44.3	15.6	3.3
Block 3, Louisbourg, NS	6	4777	5.9	–11.59	11.05	44.7	15.9	3.3
Block 3, Louisbourg, NS	7	4778	1.7	–19.37	11.16	43.5	15.5	3.3
Block 3, Louisbourg, NS	8	4779	2.6	–19.09	11.09	42.9	15.3	3.3
Block 3, Louisbourg, NS	9	4780	1.6	–19.11	9.30	43.1	15.5	3.2
Block 3, Louisbourg, NS	10	4781	9.8	–17.86	14.01	44.7	16.0	3.3
Block 3, Louisbourg, NS	11	4782	5.4	–19.79	11.79	44.0	15.7	3.3
Block 3, Louisbourg, NS	12	4783	2.1	–21.56	5.21	43.6	15.4	3.3
Block 3, Louisbourg, NS	13	4784	2.8	–18.23	12.57	42.3	14.7	3.4
Block 3, Louisbourg, NS	14	–	–	–	–	–	–	–
Block 3, Louisbourg, NS	15	4785	***0.5***	–18.07	12.45	41.5	14.5	3.3
Block 3, Louisbourg, NS	16*	4786*	6.4	–19.52	12.57	44.2	15.8	3.4
Block 3, Louisbourg, NS	17	4787	3.9	–18.38	10.88	44.2	15.8	3.3
Block 3, Louisbourg, NS	18	4788	11.6	–15.09	11.71	41.5	14.6	3.3
Block 3, Louisbourg, NS	19	4789	1.2	–14.97	18.64	41.5	14.6	3.3
Block 3, Louisbourg, NS	20	4790	2.5	–19.50	8.76	41.1	14.7	3.3

Site	Individual	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	21	4791	7.6	–19.87	11.81	44.6	15.7	3.3
Block 3, Louisbourg, NS	22	4792	3.7	–18.85	11.68	44.1	15.4	3.3
Block 3, Louisbourg, NS	23*	4793*	10.5	–17.95	14.87	44.8	16.1	3.2
Block 3, Louisbourg, NS	24	4794	8.6	–19.23	10.54	44.0	15.7	3.3
Block 3, Louisbourg, NS	25	4795	17.2	–16.05	16.94	44.5	15.9	3.3
Block 3, Louisbourg, NS	BURIAL (44?)	4796	3.9	–20.01	4.58	44.1	15.6	3.3

An asterisk (*) indicates a sample that is duplicate and the number is the mean of values. Bold and italicized numbers mark those values that fall out of the acceptable range.

5.1.1 St. Luke's Collagen Preservation

Four individuals from St. Luke's Anglican Cemetery were previously sampled for carbon and nitrogen isotope analysis (Harris and Grimes, unpublished). The C:N ranged from 3.2–3.5, with a mean of 3.4. The collagen yields and C:N were acceptable, as were the carbon and nitrogen concentrations, meaning these samples could be used for further analysis.

5.1.2 St. Paul's Collagen Preservation

Nine individuals were sampled from the St. Paul's Churchyard collection in addition to the eight individuals previously sampled by Pike in 2013, but not reported. In the nine newly sampled individuals, acceptable yields of collagen were obtained, ranging from 5.4% to 22.9%, with a mean of 17.1%. The C:N ranged from 3.1–3.6, with a mean of 3.2. One individual had a carbon concentration (weight %) that fell outside the

accepted range (Burial NP259/F15) with a value of 49.2%. This individual was excluded from further data interpretation. When assessing the eight individuals (nine samples) previously run by Pike, all samples yielded acceptable amounts of collagen, ranging from 4.9% to 17.7%, with a mean of 11.1%. The C:N ranged from 3.2 to 3.4, with a mean of 3.3. A total of 17 individuals from the St. Paul's Churchyard were assessed.

5.1.3 Foxtrap Collagen Preservation

Thirteen individuals were sampled from Foxtrap-2 (MARC# 5162 to 5174). The collagen yield ranged from 2.4% to 14.6%, with a mean yield of 6.6%. The % weight of carbon and nitrogen fell within the acceptable limits for all samples. The C:N ranged from 3.1 to 3.3, with a mean of 3.2.

5.1.4 Block 3 Collagen Preservation

Block 3 had a total of 25 individuals sampled (MARC# 4865–4896). All samples yielded acceptable amounts of collagen, except MARC 4785 (Burial 15) with a yield of 0.5%. This sample was still used in analysis and data interpretations because its C:N was within the acceptable range. The collagen yield for the Block 3 individuals ranged from 0.5% to 17.2%, with a mean of 5.3%. The C:N ranged from 3.2 to 3.4, with a mean of 3.3.

5.2 Human δ^{13}C and δ^{15}N Results

5.2.1 Newfoundland δ^{13}C and δ^{15}N Collagen Results

The mean δ^{13}C and δ^{15}N values for the St. Luke's samples (n=4) were –18.0 ± 0.9‰ and 13.6 ± 0.7‰, with ranges of 2.1‰ and 1.6‰, respectively. The St. Luke's δ^{13}C

values ranged from –19.0‰ to –16.9‰ (Burials 62A and 62C) and the δ^{15}N values ranged from 12.7‰ to –14.3‰ (Burials 67 and 62B). The mean δ^{13}C and δ^{15}N values for the St. Paul's samples (n=17) were –17.1 ± 0.8‰ and 15.5 ± 2.3‰ with ranges of 3.7‰ and 8.8‰, respectively. The St. Paul's δ^{13}C values ranged from –19.3‰ to –15.6‰ (Burials NP264/Ind. 1 and 11) and the δ^{15}N values ranged from 11.4‰ to 20.1‰ (Burials NP264/Ind. 1 and 10). The mean δ^{13}C and δ^{15}N values for the Foxtrap–2 samples (n=13) were –17.4 ± 0.5‰ and 16.6 ± 1.5‰, with ranges of 2.1‰ and 4.1‰, respectively. The Foxtrap-2 δ^{13}C values ranged from –18.4‰ to –16.3‰ (Burials 20 and 12) and the δ^{15}N values ranged from 14.2‰ to 18.3‰ (Burials 13 and 7). Figure 5.1 is a scatterplot showing the spread of the Newfoundland human δ^{13}C and δ^{15}N values.

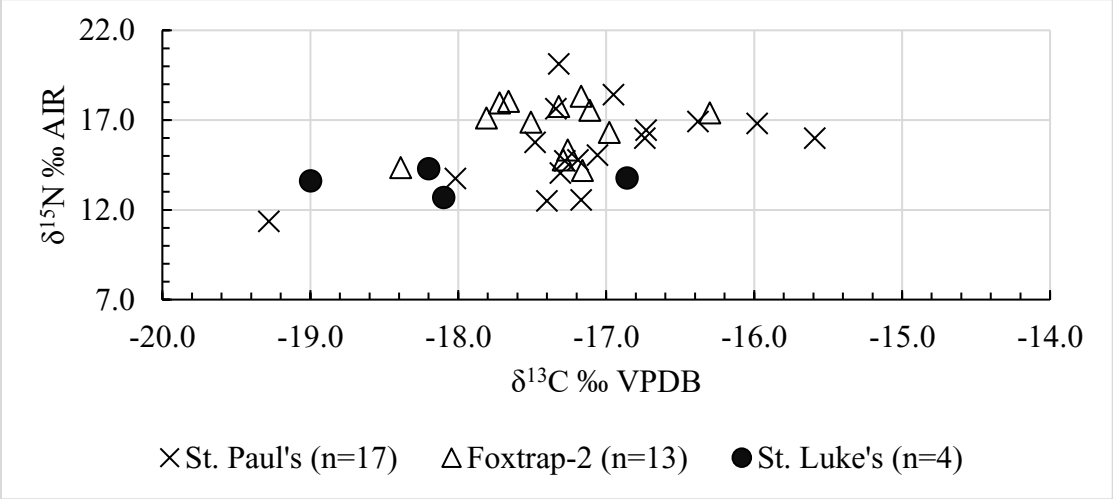

Figure 5.1. Scatterplot of δ^{13}C and δ^{15}N values for individuals from the Newfoundland sites.

Shapiro-Wilk normality tests were performed to determine the normality for each site, though it should be noted that sample sizes were small for several sites (see Table 5.3). While the tests suggested normal distribution, non-parametric tests were chosen for the data sets due to their small sample sizes and likelihood of non-normality because of

this (e.g., St. Luke's had a sample of four). A Kruskal-Wallis rank sum test was used to compare the Newfoundland sites for both $\delta^{13}C$ (Kruskal-Wallis chi-squared = 3.74, df = 2, p-value = 0.154) and $\delta^{15}N$ (Kruskal-Wallis chi-squared = 8.42, df = 2, p-value = 0.015) values. For $\delta^{13}C$ values, there were no significant differences between the Newfoundland sites, meaning that the data from all three sites are relatively similar. However, a significant difference was identified for $\delta^{15}N$ data between the three sites. Because a difference was identified, a post-hoc test was run to determine the specific differences between these three sites. A Dunn (1964) Kruskal-Wallis multiple comparison test was run, with p-values adjusted using the Benjamini-Hochberg method (see Table 5.3). A statistically significant difference was identified between Foxtrap-2 and St. Luke's with an adjusted p-value of 0.015, which shows that these two sites have the most significant difference between $\delta^{15}N$ values, with higher nitrogen values found at Foxtrap-2. This difference is discussed further in chapter 6.3.1.

Table 5.2. Shapiro-Wilk tests for normality in the human samples.

		$\delta^{13}C$		$\delta^{15}N$	
Site	**df**	**W Statistic**	**p-value**	**W Statistic**	**p-value**
Block 3	24	0.853	0.002	0.909	0.020
St. Paul's	17	0.897	0.050	0.989	0.997
Foxtrap-2	12	0.951	0.620	0.883	0.080
St. Luke's	3	0.944	0.680	0.949	0.710

Table 5.3. Newfoundland site differences with the Dunn (1964) Kruskal–Wallis multiple comparison test with p–values adjusted using the Benjamini–Hochberg method. Statistically significant differences at a 95% confidence interval are bolded and italicized.

Sites Compared	δ13C adjusted p-value	δ15N adjusted p-value
Foxtrap-2 – St. Luke's	0.358	***0.015***
Foxtrap-2 – St. Paul's	0.319	0.090
St. Luke's – St. Paul's	0.183	0.116

5.2.2 Louisbourg $\delta^{13}C$ and $\delta^{15}N$ Collagen Results

The mean $\delta^{13}C$ and $\delta^{15}N$ values for the Block 3 individuals (n=25) were –18.2 ± 2.1‰ and 11.7 ± 2.9‰, with ranges of 10.0‰ and 14.1‰, respectively. The $\delta^{13}C$ ranged from –21.6‰ to –11.6‰ (Burials 12 and 6) and $\delta^{15}N$ from 4.6‰ to 18.6‰ (Burials 44 and 19) (see Figure 5.2). Shapiro–Wilk normality tests were also run for $\delta^{13}C$ and $\delta^{15}N$ values, which showed that Block 3 was not normally distributed and should be examined with non-parametric tests (see Table 5.2).

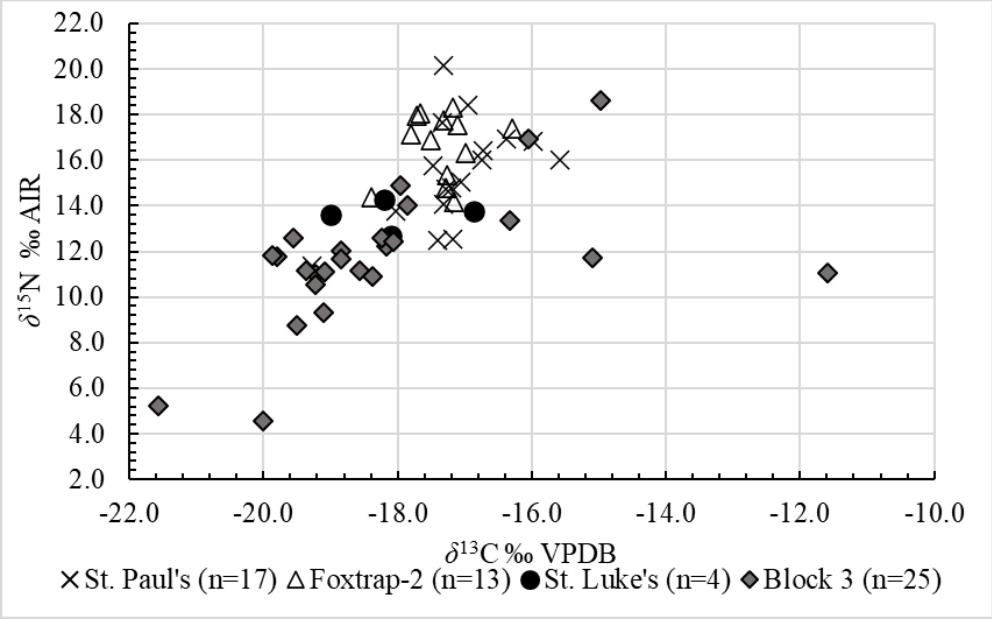

Figure 5.2. Scatterplot of $\delta^{13}C$ and $\delta^{15}N$ values for individuals from the Newfoundland and Louisbourg sites.

Overall, these four sites have more variable medians and interquartile ranges (IQR) for their $\delta^{15}N$ values than their $\delta^{13}C$ values (Figures 5.2 and 5.3). A Kruskal-Wallis rank sum test was used to compare both $\delta^{13}C$ and $\delta^{15}N$ values across all four sites. The results of this analysis identified statistically significant differences in both the $\delta^{13}C$ (Kruskal-Wallis chi-squared = 13.79, df = 3, p-value = 0.003) and $\delta^{15}N$ (Kruskal-Wallis

chi-squared = 29.47, df = 3, p-value = <0.001) data. Based on this significant result, a post-hoc test was completed, and the Dunn (1964) Kruskal–Wallis multiple comparison test was chosen, with p–values adjusted using the Benjamini–Hochberg method (see Table 5.3). As can be seen in the table below (Table 5.3), there are significant differences between the Block 3 and St. Paul's sites for both $\delta^{13}C$ and $\delta^{15}N$, as well as the Block 3 and Foxtrap-2 sites for $\delta^{15}N$ values. This test was run a second time for nitrogen values, after a Kruskal-Wallis rank sum test showed that there was still statistical significance (Kruskal-Wallis chi-squared = 29.15, df = 3, p-value = <0.001) after removing non-adults that might have high nitrogen values due to breastfeeding or weaning, which removed three St. Paul's individuals (MARC numbers 1647, 4928, and 4929). The adjusted p-value changed to 0.041 for the Block3 and Foxtrap-2 comparison and it changed to 0.005 for the Block 3 and St. Paul's comparison, which can still be considered significant.

Table 5.4. Site differences with the Dunn (1964) Kruskal–Wallis multiple comparison test with p–values adjusted using the Benjamini–Hochberg method. Statistically significant differences at a 95% confidence interval are bolded and italicized.

Sites Compared	δ13C adjusted p-value	δ15N adjusted p-value
Block 3- Foxtrap-2	0.032	***<0.001***
Block 3- St. Luke's	0.614	0.297
Foxtrap-2- St. Luke's	0.439	0.125
Block 3- St. Paul's	***0.004***	***<0.001***
Foxtrap-2- St. Paul's	0.710	0.318
St. Luke's- St. Paul's	0.301	0.275

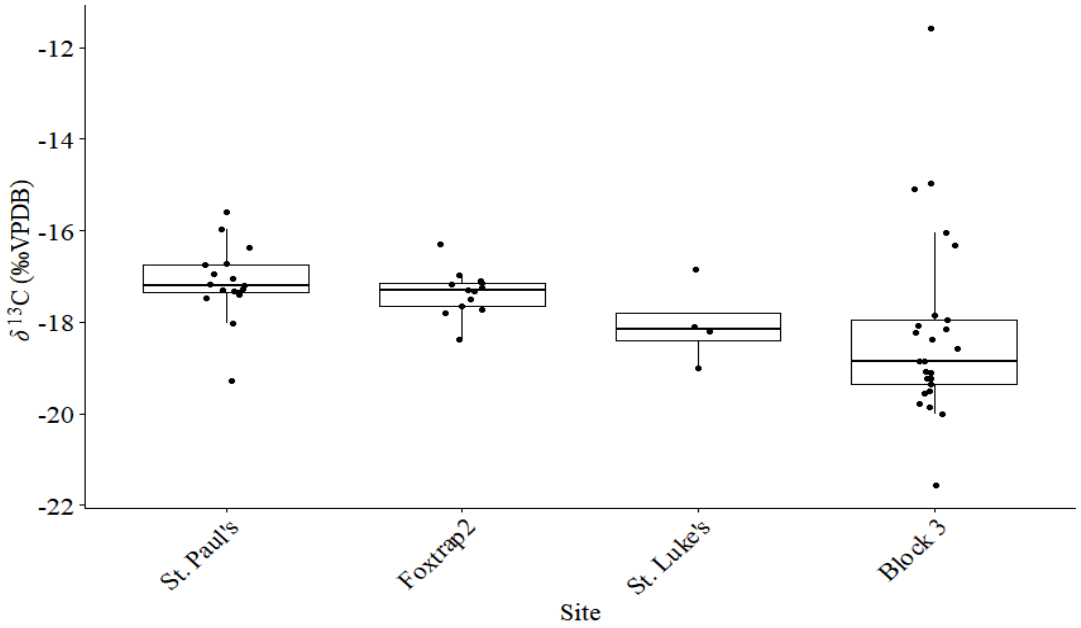

Figure 5.3. Boxplot illustrating the spread of $\delta^{13}C$ values for individuals from the Newfoundland and Louisbourg sites. Central tendency line indicates the median of the data, the box represents the Interquartile Range (IQR), and the whiskers indicates the 25th and 75th percentiles of the data.

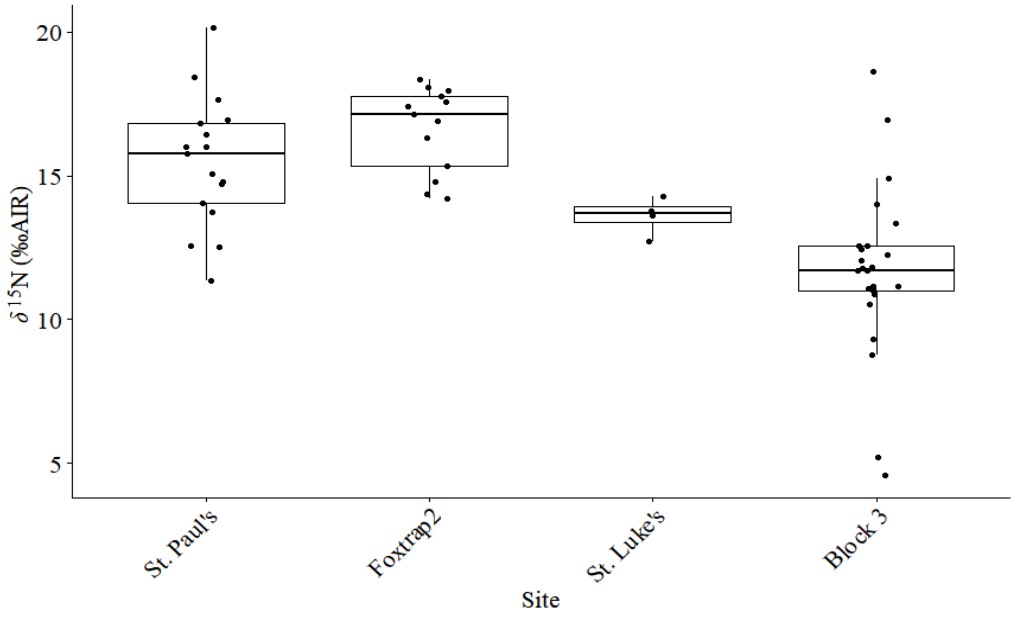

Figure 5.4. Boxplot illustrating the spread of $\delta^{15}N$ values for individuals from the Newfoundland and Louisbourg sites. Central tendency line indicates the median of the data, the box represents the Interquartile Range (IQR), and the whiskers indicates the 25th and 75th percentiles of the data.

5.3 Faunal Collagen Preservation

5.3.1 Placentia Faunal Collagen Preservation

From the site of Fort Louis, Placentia, 82 bones samples were initially taken for carbon and nitrogen isotope analysis; however, due to COVID–19 restrictions and limited laboratory access, only a representative subset (n=34) were fully prepared and analyzed. Of these 34 samples, 32 yielded enough collagen to be analyzed for $\delta^{13}C$ and $\delta^{15}N$. Of these, with 5 samples lost during the analytical session (i.e., misdrops in the EA autosampler), the collagen yield for the remaining 27 samples ranged from 0.9% to 19.3%, with a mean of 11.9%. The carbon and nitrogen concentrations fell within the acceptable ranges for all samples. Seventeen samples fell outside the accepted C:N range and were omitted from the remainder of this study, likely due to poor preservation which led to contamination of the bone sample (see Table 5.4, bold and italicized numbers). This left 10 samples, plus four duplicates, that fell within acceptable C:N ratio range of 2.9 and 3.6.

5.3.2 Fortress of Louisbourg Faunal Collagen Preservation

Eleven faunal bones from the Fortress of Louisbourg were sampled, with two duplicates. The collagen yield ranged from 3% to 19.2%, with a mean of 10%. Out of the 13 total samples analyzed, all but one (MARC 5232, a cow; C:N = 3.8) had an acceptable C:N, ranging from 3.1 to 3.5 with a mean of 3.1. The carbon and nitrogen concentrations fell within the acceptable ranges for all samples (see Table 5.4).

Table 5.5. Results of bone collagen faunal samples (n=47) for carbon and nitrogen isotope analysis from Placentia, Newfoundland and the Fortress of Louisbourg, Nova Scotia.

Site	Animal	MARC	Yield (%)	$\delta^{13}C‰$ VPDB	$\delta^{15}N‰$ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Fish	5299	0.8	–14.66	14.47	36.5	13.6	3.1	
Placentia, NL	Fish	5300	0.5	–	–	–	–	1.5	*
Placentia, NL	Fish	5301	1.0	–	–	–	–	1.9	*
Placentia, NL	Fish	5307	1.0	–14.84	14.88	34.6	12.4	3.3	
Placentia, NL	Fish	5308	1.5	–14.83	12.36	35.8	13.4	3.1	
Placentia, NL	Fish (b)	5308B	"	–16.61	13.79	36.6	12.4	3.4	
Placentia, NL	Fish	5310	0.5	–	–	–	–	–	*
Placentia, NL	Fish	5312	0.5	–	–	–	–	–	*
Placentia, NL	Fish	5313	0.5	–	–	–	–	–	*
Placentia, NL	Fish	5314	1.4	–15.05	12.67	30.3	11.3	3.1	
Placentia, NL	Fish (b)	5314B	"	–15.15	15.97	31.6	11.6	3.2	
Placentia, NL	Cow	5316	11.1	–18.56	2.44	45.1	14.1	***3.7***	*
Placentia, NL	Cow	5318	13.0	–21.55	6.04	43.5	13.3	***3.8***	*
Placentia, NL	Cow	5319	8.7	–18.02	1.49	44.3	14.3	3.6	
Placentia, NL	Cow (b)	5319B	"	–18.1	2.84	42.8	13.8	3.6	
Placentia, NL	Seal	5325	12.3	–22.03	7.26	41.3	13	***3.7***	*
Placentia, NL	Seal	5326	8.9	–11.86	16.58	42.7	13.4	***3.7***	*
Placentia, NL	Seal	5327	3.8	–13.15	18.6	33.1	11.7	3.3	
Placentia, NL	Bird	5332	18.5	–19.61	3.04	43.4	13.4	***3.8***	*
Placentia, NL	Bird	5334	9.6	–14.52	15.84	42	14	3.5	
Placentia, NL	Bird	5341	14.1	–15.12	17.28	44.4	12.6	***4.1***	*
Placentia, NL	Fox	5349	11.1	–19.7	6.15	42.7	13.2	***3.8***	*
Placentia, NL	Fox/cat	5353	19.2	–16.83	12.33	43	12.9	***3.9***	*
Placentia, NL	Fox	5354	17.0	–12.66	17.15	40.5	12.9	***3.7***	*
Placentia, NL	Rat	5355	18.9	–16.41	12.61	42.7	12.7	***3.9***	*
Placentia, NL	Rat (b)	5355B	"	–16.49	10.97	43.7	13.4	***3.8***	*
Placentia, NL	Squirrel	5356	19.3	–16.51	13.64	44.4	13.1	***3.9***	*
Placentia, NL	Squirrel	5357	14.4	–16.13	12.44	42.5	12.9	***3.9***	*
Placentia, NL	Fox?	5363	16.0	–14.5	14.81	42.5	13	***3.8***	*
Placentia, NL	Cat	5364	14.9	–14.25	18.05	42.3	13.9	3.5	
Placentia, NL	Cat (b)	5364B	"	–14.13	18.09	44.1	14.3	3.6	
Placentia, NL	Pig	5368	6.0	–12.67	8.41	42.6	13.8	3.6	
Placentia, NL	Pig	5369	17.6	–20.99	5.51	44.7	14.2	***3.7***	*
Placentia, NL	Pig (b)	5369B	"	–21.12	5.14	44.3	14.2	***3.7***	*

Site	Animal	MARC	Yield (%)	$\delta^{13}C‰$ VPDB	$\delta^{15}N‰$ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Pig	5370	17.5	–19.74	3.23	44.1	12.8	***4***	*
Placentia, NL	Sheep/ Goat	5376	17.3	–19.75	4.68	43.9	13.8	***3.7***	*
Placentia, NL	Sheep/ Goat	5377	13.3	–21.47	7.37	43.5	14.3	3.5	
Placentia, NL	Sheep	5378	13.2	–20.2	4.06	44.3	14	***3.7***	*
Placentia, NL	Sheep (b)	5378B	"	–20.22	6.9	44.2	13.5	***3.8***	*
Louisbourg, NS	Fish	5231	3.0	–14.93	12.06	40.8	15.3	3.1	
Louisbourg, NS	Cow	5232	13.0	–19.62	4.08	42.7	13.1	***3.8***	*
Louisbourg, NS	Cow (b)	5232B	"	–19.7	6.11	42.5	14.2	3.5	
Louisbourg, NS	Pig	5233	17.0	–13.54	7.32	42.8	15.9	3.1	
Louisbourg, NS	Sheep/Goat	5234	6.4	–20.54	6.01	42.5	15.9	3.1	
Louisbourg, NS	Canine	5235	13.3	–14.83	20.17	42.9	16.1	3.1	
Louisbourg, NS	Bird	5236	6.3	–20.16	9.35	42.3	15.7	3.1	
Louisbourg, NS	Pig	5290	19.2	–19.93	6.69	43.5	15.9	3.2	
Louisbourg, NS	Pig	5291	7.3	–20.29	6.8	42.5	16.2	3.1	
Louisbourg, NS	Pig	5292	12.4	–21.04	5.17	41.7	15.9	3.1	
Louisbourg, NS	Pig (b)	5292B	"	–21.06	5.67	41.6	15.8	3.1	
Louisbourg, NS	Pig	5293	8.0	–21.47	9.06	41.9	15.6	3.1	
Louisbourg, NS	Cow	5294	3.5	–17.83	6.49	40.7	15.2	3.1	

**Italicized numbers mark those values that fall out of the acceptable range.*

5.4 Faunal $\delta^{13}C$ and $\delta^{15}N$ Collagen Results

Table 5.5 shows the descriptive statistics for both the Fortress of Louisbourg and Placentia faunal specimens, examining the mean, standard deviation, and range for each ecological grouping. Figures 5.4 and 5.5 are boxplots comparing the Placentia and Louisbourg $\delta^{13}C$ and $\delta^{15}N$ values, respectively, along with the median and interquartile range (IQR) for each ecological grouping.

Table 5.6. Descriptive statistics of faunal $\delta^{13}C$ and $\delta^{15}N$ values (n=26) for Placentia and Louisbourg based on ecological grouping.

			$\delta^{13}C$ ‰ VPDB			$\delta^{15}N$ ‰ AIR		
Site	**Ecological Group**	**n**	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**
Placentia	Domestic Carnivore	2	–14.2	0.1	0.1	18.1	0.0	0
	Domestic Herbivore	3	–19.2	2.0	3.5	3.9	3.1	5.9
	Domestic Omnivore*	1	–12.7	–	–	8.4	–	–
	Marine	7	–14.9	1.0	3.4	14.7	2.1	6.2
	Wild Omnivore (Bird)*	1	–14.5	–	–	15.8	1.6	2.3
Louisbourg	Domestic Carnivore*	1	–14.8	–	–	20.2	–	–
	Domestic Herbivore	3	–19.4	1.4	2.7	9.7	0.3	0.5
	Domestic Omnivore	6	–19.6	3.0	8.0	6.8	1.4	3.9
	Marine*	1	–14.9	–	–	12.1	–	–
	Wild Omnivore (Bird)*	1	–20.2	–	–	9.4	–	–

**Any ecological group marked with an asterisk has only one specimen and the value therefore represents that one individual.*

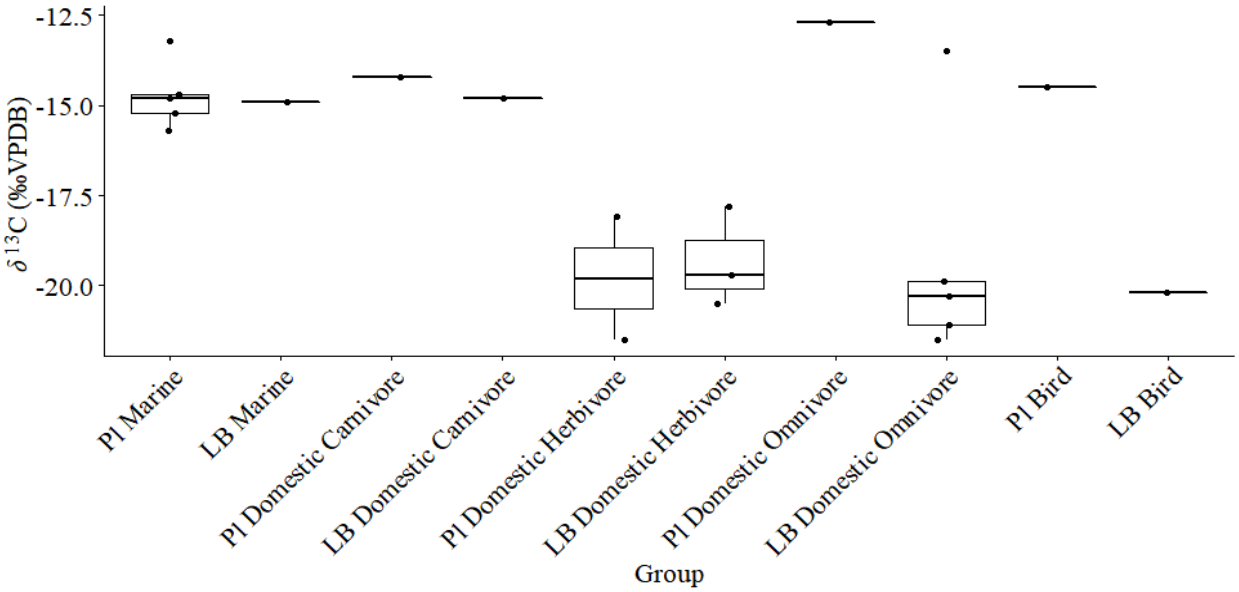

Figure 5.5. Boxplot for δ^{13}C (‰ VPDB) values for Placentia (Pl) and Louisbourg (LB) fauna. Central tendency line indicates the median of the data, the box represents the Interquartile Range (IQR), and the whiskers indicate the 25th and 75th percentiles of the data.

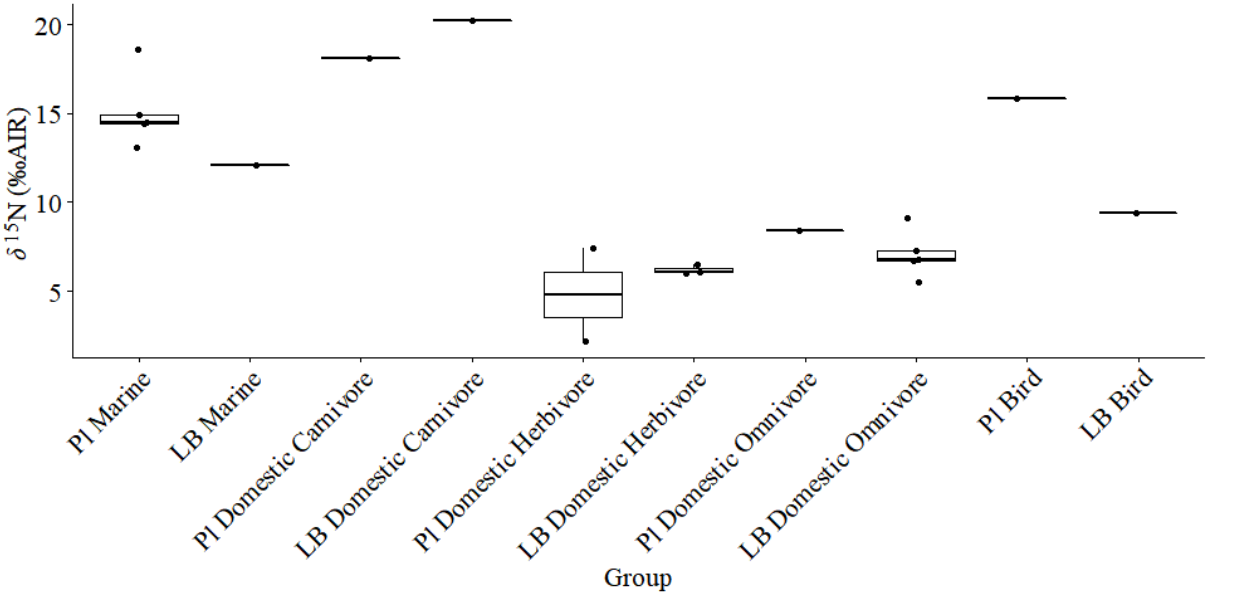

Figure 5.6. Boxplot for δ^{15}N (‰ AIR) values for Placentia (Pl) and Louisbourg (LB) fauna. Central tendency line indicates the median of the data, the box represents the Interquartile Range (IQR), and the whiskers indicate the 25th and 75th percentiles of the data.

5.5 $^{87}Sr/^{86}Sr$ Results

5.5.1 Bioapatite Preservation

While bioapatite samples for $^{87}Sr/^{86}Sr$ analysis were not directly examined for sample integrity, based on the sample preparation methods used (see Chapter 4.4.1), the potential for poor sample integrity was minimized.

5.5.2 Human $^{87}Sr/^{86}Sr$ Results

The mean $^{87}Sr/^{86}Sr$ value for the St. Paul's samples (n=9) was 0.7097 ± 0.0002, with a range from 0.7095 to 0.7101. The mean $^{87}Sr/^{86}Sr$ value for the Foxtrap–2 samples (n=9) was 0.7095 ± 0.0002 with a range from 0.7094 to 0.7101. The mean $^{87}Sr/^{86}Sr$ value for the St. Luke's samples (n=6) was 0.7100 ± 0.0003, with a range from 0.7097 to 0.7103. The mean $^{87}Sr/^{86}Sr$ value for the Block 3 individuals (n=19) was 0.7102 ± 0.0018, with a range from 0.7078 to 0.7155. The corrected $^{87}Sr/^{86}Sr$ values are shown in Table 5.6, as well as a boxplot of these data with the median and IQR represented in Figure 5.6. A more detailed table can be found in the Appendix (see Table A.3, Appendix 1).

Table 5.7. Results of the corrected $^{87}Sr/^{86}Sr$ human enamel samples (n=43) for the four archaeological sites.

Site Name	Source	Individual	Tooth	MARC	Corrected $^{87}Sr/^{86}Sr$
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	3	LRM2	4390	0.710069
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	7	LLM2	4391	0.709586
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	21	ULM2	4392	0.709490
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	22	LRM2	4393	0.709597

Site Name	Source	Individual	Tooth	MARC	Corrected $^{87}Sr/^{86}Sr$
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	251/F4	ULPM4	5219	0.710035
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	254/F7	LLM1	5220	0.709515
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick		LLM3	5221	0.709592
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	258/F13	URM2	5222	0.709868
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	NP 264/ Ind. 1	LLM1	5223	0.709581
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	4	LRM2	5178	0.709384
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	7	ULM2	5179	0.709379
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	9	URM2/3	5180	0.710102
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	10	ULM2	5181	0.709465
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	11	LLM2	5182	0.709417
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	12	LRM2	5183	0.709531
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	13	URM2	5184	0.709473
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	14	URM2	5185	0.709460
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	30	LRM2	5186	0.709686
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	62A	URM2	4675	0.710228
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	63	URM1	4676	0.710377*
	Run by Munkittrick		URM2	4677	0.710083
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	66A	LRM1	4679	0.709692
	Run by Munkittrick		LRM2	4680	0.710336
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	67	URM1	4683	0.709858

Site Name	Source	Individual	Tooth	MARC	Corrected $^{87}Sr/^{86}Sr$
Block 3, Louisbourg, NS	Garlie/ Munkittrick	1	LLM2 (3?)	4695	0.708940
Block 3, Louisbourg, NS	Garlie/ Munkittrick	2	URM2	4696	0.708791
Block 3, Louisbourg, NS	Garlie/ Munkittrick	3	ULM2	4697	0.708386
Block 3, Louisbourg, NS	Garlie/ Munkittrick	4	URPM4	4698	0.709667
Block 3, Louisbourg, NS	Garlie/ Munkittrick	7	LLPM4	4699	0.715502
Block 3, Louisbourg, NS	Garlie/ Munkittrick	8	LLM2	4700	0.709651
Block 3, Louisbourg, NS	Garlie/ Munkittrick	9	ULPM4	4701	0.709671
Block 3, Louisbourg, NS	Garlie/ Munkittrick	10	LLM2	4702	0.711993
Block 3, Louisbourg, NS	Garlie/ Munkittrick	12	LLM2	4703	0.713396
Block 3, Louisbourg, NS	Garlie/ Munkittrick	13	ULM2	4704	0.709323
Block 3, Louisbourg, NS	Garlie/ Munkittrick	15	ULM2	4705	0.710432
Block 3, Louisbourg, NS	Garlie/ Munkittrick	16	ULM2	4706	0.711222
Block 3, Louisbourg, NS	Garlie/ Munkittrick	17	LRM2	4707	0.708946
Block 3, Louisbourg, NS	Garlie/ Munkittrick	18	LRM2	4708	0.709487
Block 3, Louisbourg, NS	Garlie/ Munkittrick	19	URPM4	4709	0.710441
Block 3, Louisbourg, NS	Garlie/ Munkittrick	20	URM2	4710	0.707815
Block 3, Louisbourg, NS	Garlie/ Munkittrick	23	ULM2	4711	0.709775
Block 3, Louisbourg, NS	Garlie/ Munkittrick	25	URPM3	4712	0.709610
Block 3, Louisbourg, NS	Garlie/ Munkittrick	44	LLPM4	4713	0.710309

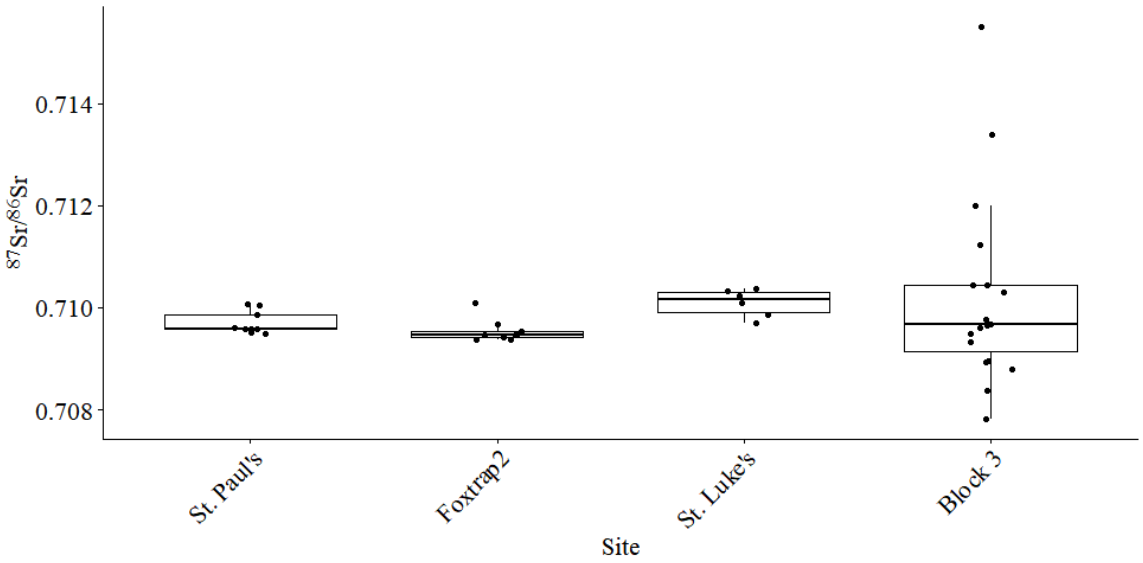

Figure 5.7. Human $^{87}Sr/^{86}Sr$ results by site. Central tendency line indicates the median of the data, the box represents the Interquartile Range (IQR), and the whiskers indicate the 25th and 75th percentiles of the data.

5.5.3 Fortress of Louisbourg Faunal $^{87}Sr/^{86}Sr$

The human $^{87}Sr/^{86}Sr$ data analyzed for this study will be compared to the faunal baseline from Ellerbrok (2014) which will be discussed in detail in Chapter 6. Table 5.7 shows the comparative Ellerbrok (2014) data, including the mean, standard deviation, and ranges calculated for each ecological grouping. Together, these faunal specimens (n=35) have a mean $^{87}Sr/^{86}Sr$ value of 0.7107 ± 0.0015 with a range of 0.0060 (Ellerbrok 2014).

Table 5.8. Ecological groupings of faunal species used as a baseline for human strontium values (from Ellerbrok 2014).

Ecological Group	**n**	**Mean ± 1 σ SD**	**Range**
Domestic Herbivore	14	0.7109 ± 0.0017	0.7093 to 0.7147
Domestic Omnivore	4	0.7107 ± 0.0013	0.7095 to 0.7125
Wild Herbivore	8	0.7108 ± 0.0019	0.7091 to 0.7137
Wild Omnivore	7	0.7101 ± 0.0009	0.7087 to 0.7112

5.6 Conclusions

This chapter presented the isotopic data from the three Newfoundland archaeological sites (St. Paul's Anglican Cemetery, Foxtrap-2, and St. Luke's Anglican Cemetery), as well as the Block 3 cemetery site from the Fortress of Louisbourg in Nova Scotia. It also presented comparative faunal data from Placentia and Louisbourg. Preservation of bone collagen was assessed for all samples, and those that did not meet the acceptable levels were not included in final data analysis. The interpretation of the results presented in this chapter are further examined in Chapter 6.

Chapter 6. Discussion

This chapter offers a discussion of the data presented in Chapter 5 beginning with an analysis of new and previously studied faunal dietary isotopic data to examine the diets of the people who lived in Newfoundland and Louisbourg. This chapter will also discuss the potential geographic origins of the individuals whose strontium values were examined. Comparisons of French and English sites are made as well as a discussion of individual life histories for specific burials.

6.1 Previously Studied Data

Previous isotope studies have taken place in Atlantic Canada and this thesis aims to build on those past works and link the results together. This thesis utilizes previously collected $\delta^{13}C$, $\delta^{15}N$, and $^{87}Sr/^{86}Sr$ data from St. Paul's Churchyard, examined by Pike (2013), in addition to $\delta^{13}C$, $\delta^{15}N$, and $^{87}Sr/^{86}Sr$ data from Wester Point Cemetery and $\delta^{13}C$ and $\delta^{15}N$ data from St. Luke's Anglican Cemetery, both analyzed by Harris (n.d.; 2015). The Wester Point cemetery (CjAf–08) was discovered in 2004 by housing developers in Portugal Cove, NL, which led to a salvage excavation of the disturbed cemetery by the Provincial Archaeology Office (PAO) (Harris 2015; Reynolds 2004). This area was inhabited primarily by people employed in the fisheries, according to the 1794 census of Portugal Cove (Young and NL Genweb 1998). The cemetery has not been used since the early nineteenth century, when Church cemeteries were established in the community (Canadian Registry of Historic Places [CRHP]). The results of the excavation included 13

individuals. Carbon and nitrogen isotopic analysis was completed for six individuals, while strontium analysis was only completed on four of the individuals (Harris 2014).

This current research also uses faunal isotope data from Guiry et al. (2012a) from Ferryland, NL and Dos de Cheval, NL , dating from the mid to late 17th-century, as comparative datasets for dietary isotope analysis. The results in Guiry et al. (2012a) are particularly valuable since the intended number of new faunal specimens for this thesis was restricted due to COVID-19 related interruptions. Isotopic data from Ellerbrok (2014), which examined the diet and origins of those buried in the Ste. Marie mass burial at Louisbourg will also be integrated into this discussion. This mass burial was discovered in 2006 and included 48 individuals, including 45 adults and three non-adults (Duggan 2010; Parish 2006,2007). This mass grave is likely the 1745 New England garrison that suffered from starvation and disease during the winter of 1745-1746 (Ellerbrok 2014). This work includes both faunal and human isotopic data which are useful as comparatives for the Block 3 individuals analyzed within this thesis.

6.2 Faunal Diet Reconstruction

This section discusses the data examined for this thesis compared with previously analyzed material (i.e., Guiry et al. 2012a; Ellerbrok 2014) in order to build a better understanding of faunal diet in Placentia and at the Fortress of Louisbourg. Understanding faunal diet is imperative because it provides a baseline from which local human diet can be explored. Figure 6.1 shows the average and standard deviation for those data previously examined (i.e., Guiry et al. 2012a; Ellerbrok 2014), as well as data from this thesis represented as single points.

6.2.1 Domestic Herbivores (Cows, Sheep/Goats)

This thesis sampled two cows and a sheep/goat from Placentia and two cows and a sheep/goat from Louisbourg. Domestic herbivores previously sampled (n=33) had a mean $\delta^{13}C$ of –21.0±1.4‰ and $\delta^{15}N$ of 6.1±1.1‰ (Guiry et al. 2012a; Ellerbrok 2014), which suggests a terrestrial C_3 plant diet with human husbandry potentially influencing the trophic level (see Figure 6.1). Out of the six samples analyzed for this thesis, one Louisbourg cow and the sheep/goat from each site falls within the range for domestic herbivores. The three other cow specimens (one from Louisbourg and two from Placentia) have $\delta^{13}C$ values that fall closer to –18.0‰, suggesting marine or C_4 plant input into their diets, though marine input is unlikely for the Placentia cow specimens due to their low $\delta^{15}N$ values (1.5‰ and 2.8‰). Regarding herbivores, an elevated $\delta^{15}N$ has been considered to indicate seaweed consumption due to seaweed $\delta^{15}N$ values usually assumed to be higher than those of terrestrial grasses (Jones and Mulville 2016; Mays and Beavan 2012; Gigleux et al. 2017; Schulting et al. 2017). Blanz et al. (2020), for example, found $\delta^{15}N$ values for seaweed samples from North Ronaldsay, Orkney, Scotland, averaging 5.9 ± 1.2‰ (n=20), with a range from 4.2‰–8.3‰.

Different explanations can be suggested for the variation in the diet of these domestic herbivores, including imposed grazing and foddering by humans or due to the importation of livestock. One possibility for the high $\delta^{13}C$ values and low $\delta^{15}N$ values seen is the consumption of aquatic plants that have a low trophic level along the coast (Balasse et al. 2005, 2006). Clark (1965:6) writes that it was difficult to keep livestock over the winter in Louisbourg due to inadequate sources of winter fodder as the wild

coastal-marsh hay was limited in both quantity and nutritional value. However, other studies show that salt marsh hay was widely used as fodder for overwintering livestock (Smith et al. 1989; Butzer 2002; Hatvany 2002). Within an Atlantic Canadian context, Guiry et al. (2021) studied cows and sheep from Acadian sites in New Brunswick, Nova Scotia, and Prince Edward Island and found that salt marsh resources played an important part in livestock fodder at these sites. The results suggest that cattle were grazed and/or foddered on a range of C_3-to-C_4 plants, with salt marshes containing the only economically important C_4 plant in the region, whereas the sheep had lower $\delta^{13}C$ values, which suggested that they were not grazed and/or foddered as substantially on salt marshes (Guiry et al. 2021). Many of the first settlers in New France came from the marshlands around La Rochelle, and likely brought with them knowledge of maintaining these areas (Butzer 2002; Hatvany 2002). It is likely that these methods regarding livestock fodder from salt marshes would have been employed at French colonial sites such as Placentia and Louisbourg. Another potential fodder could have been seaweed, which has been used as winter fodder in several parts of the European North Atlantic, including Brittany (Chapman 1970; Fleuriot 1986; Arzel 1987), Iceland (Hallson 1964), Ireland (Kelly 1997), Norway (Chapman 1970; Arzel 1987), and the Shetland Islands (Martin 1703; Fenton 1978). These marine plants differ from terrestrial plants isotopically, with a $\delta^{13}C$ mean of –27‰ for terrestrial C_3 plants (Marshall et al. 2008) and measured $\delta^{13}C$ values for seaweed varying from –21.2‰ to –14.0‰ (Balasse et al. 2009). Another possibility explaining the dietary variation is the animal husbandry practices imposed onto the cattle, such as foddering with imported foods like maize, which might

explain the higher $\delta^{13}C$ values (Britton et al. 2008). Foddering livestock with maize was practiced in the northeast United States, and this method could have made its way to Atlantic Canada, through the import of maize or of the livestock itself (Fischer et al. 1997; Klippel 2001). Louisbourg traded both livestock, including cattle, and foodstuffs, including corn, regularly with both Acadia and New England (Chard 1977; Robison 2000).

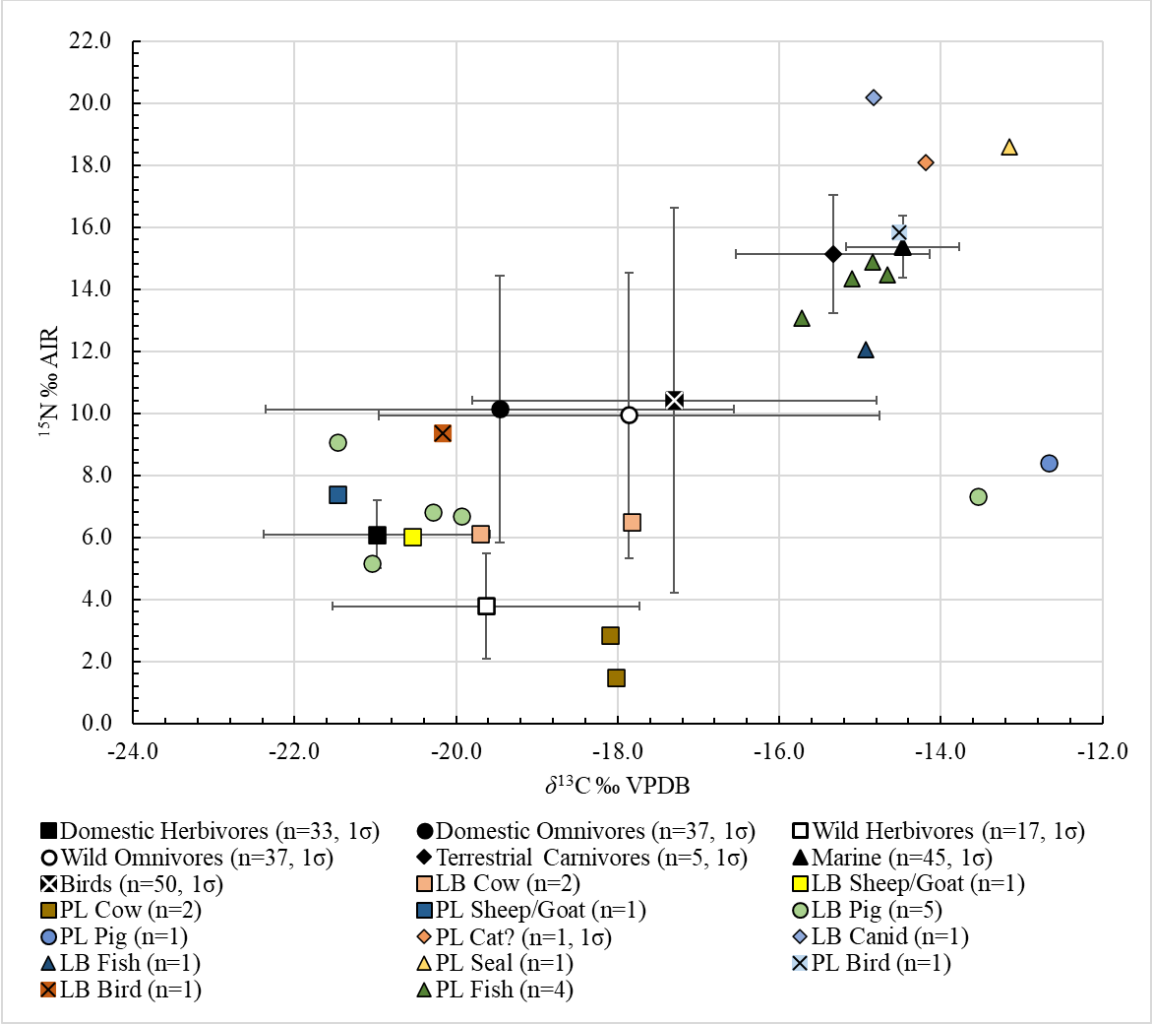

Figure 6.1. Scatterplot with average ±1σ (shown as points with error bars) for previously analyzed faunal data (Ellerbrok 2014; Guiry et al. 2012a). New faunal data from this thesis is represented by single points. LB= new Louisbourg data; PL= new Placentia data.

6.2.2 Domestic Omnivores (Pigs)

There were five pigs sampled from Louisbourg and one from Placentia. Previously sampled pigs from Newfoundland and Louisbourg (n=37) had a mean $\delta^{13}C$ of –19.5±2.9‰ and $\delta^{15}N$ of 10.1±4.3‰ (Guiry et al. 2012a; Ellerbrok 2014), which suggests their diets ranged from more C_3 terrestrial-based to those with more marine input. Almost all the newly sampled Louisbourg specimens (four out of five) fell within the range of the previously analyzed pigs from Newfoundland and Louisbourg, albeit toward a more C_3 terrestrial-based omnivore diet, while one Louisbourg pig ($\delta^{13}C$= –13.5‰, $\delta^{15}N$= 7.3‰) and one Placentia pig ($\delta^{13}C$= –12.7‰, $\delta^{15}N$= 8.4‰) fell far outside the range. The $\delta^{15}N$ values of these two individual pigs fell along the same approximate trophic level as the terrestrial C_3 pig group, suggesting a terrestrial based diet, but the $\delta^{13}C$ values were much higher, indicating possible C_4 plant input into their diets. These outlier pigs could have been imported from areas that use C_4 plants as fodder for pigs, such as in New England or Acadia (Fischer et al. 1997; McMahon 1985; Mannion 2000). This suggests a mix of where pig products were sourced, with some likely being raised and slaughtered locally and others being imported into Louisbourg and Placentia as salted provisions.

There were many methods in which pork products could be obtained, including being raised locally, imported as livestock, and/or slaughtered, salted, and barreled in Europe and sent over as provisions (Guiry et al. 2012a). Due to their more destructive nature than cows and sheep, ordinances concerning the keeping of pigs were passed in Louisbourg (Johnston 1993; Donovan 2006). The ordinance passed by Jacques Ange Le

Normant de Mézy commanded all who owned pigs to either fence them in their yard or take them to the country, and any pig found to be eating drying cod or hens was to be killed (Donovan 2006). This highlights that the diet of pigs could be highly variable, and they would consume a wide variety of foodstuffs. Salt pork is logged in import records to French and English fishing sites, suggesting that pig and cow meat could have also come from elsewhere (de la Morandière 1962). Therefore, due to the lack of fodder materials and record of salt pork imports, it is most likely that those in Louisbourg and Newfoundland were relying on pig products that came from outside the geographic region.

6.2.3 Terrestrial Carnivores

From Louisbourg one canid specimen was sampled, and from Placentia one probable cat specimen was sampled. Previously, five terrestrial carnivores were examined, including three dogs, a cat, and a lynx, with a mean $\delta^{13}C$ of –15.3±1.2‰ and $\delta^{15}N$ of 15.1±1.9‰ (Guiry et al. 2012a; Ellerbrok 2014). These values suggest a diet high in marine protein. Both the canid and probable cat from this study had nitrogen isotope values outside the range of other terrestrial carnivores, suggesting both consumed high levels of marine protein. These data make sense in the context of these animals living with humans at fishery sites in Atlantic Canada, as it is likely they would have consumed the scraps of human food (Guiry 2012b).

6.2.4 Marine (Fish and Seals)

There were six new marine specimens from Louisbourg and Placentia sampled for this thesis, including one fish from Louisbourg, four fish from Placentia, and one seal

from Placentia. Unfortunately, the species identification of these fish was not possible. Previously, 45 fish were examined from Newfoundland and Louisbourg, with a mean δ^{13}C of –14.5±0.7‰ and δ^{15}N of 15.4±1.0‰ (Guiry et al. 2012a; Ellerbrok 2014). Three of the new fish specimens had values that fell on the lower end of the isotopic range of previously examined cod (Guiry et al. 2012a; Ellerbrok 2014). The other two new fish specimens had lower δ^{15}N values. The diet of cod is highly variable and depends on the size of the fish, with smaller cod (<30 cm) preying on mysids, shrimps, amphipods, and crustaceans and larger piscivorous cod (>30 cm) preying primarily on crabs and other fish (Link and Garrison 2002). These differences in diet place the fish on different trophic levels within their ecosystem (Jennings et al. 2002; Barrett et al. 2008). The variability in diet found within these fish is expected; therefore, the variability in isotopic values across the new fish specimens examined likely represents fish caught at different stages of life in different locations.

One seal from Placentia was examined and had δ^{13}C and δ^{15}N values much higher than the mean of other previously examined marine mammals (see Figure 6.1) (Guiry et al. 2012a). This sample also fell outside the standard deviation of the previously examined seal data (δ^{13}C= –14.1±0.4‰, δ^{15}N= 16.7±1.3‰) (Guiry et al. 2012a) (see Figure 6.2). However, this specimen does fall within the range of seals (n=13) from other regions with an average δ^{13}C of –12.3±1.3‰ and δ^{15}N of 17.0±2.1‰ (Schoeninger and DeNiro 1984; DeNiro 1985; Sealy et al. 1987; Richards and Hedges 1999). While this could suggest that this seal might have come from elsewhere in the world, this seems unlikely as local fishermen would have caught and processed seal meat themselves. It is

more likely that this seal had a slightly different diet than the other specimens sampled at different Newfoundland sites. The diet of seals is highly variable, and while consisting mainly of fish, including Arctic cod, Atlantic cod, Atlantic herring, and capelin, seal diets also include a wide variety of other fishes, eel, cephalopods, crustaceans, and mollusks (Sergeant 1991; Murie and Lavigne 1999; Hammill et al. 2007). Therefore, the elevated nitrogen values in this seal specimen likely represent a diet based primarily on higher trophic level foods, such as large piscivorous fish, or fish that preyed on other fish (Richards and Hedges 1999; Jennings et al. 2002; Barrett et al. 2008; Müldner 2009).

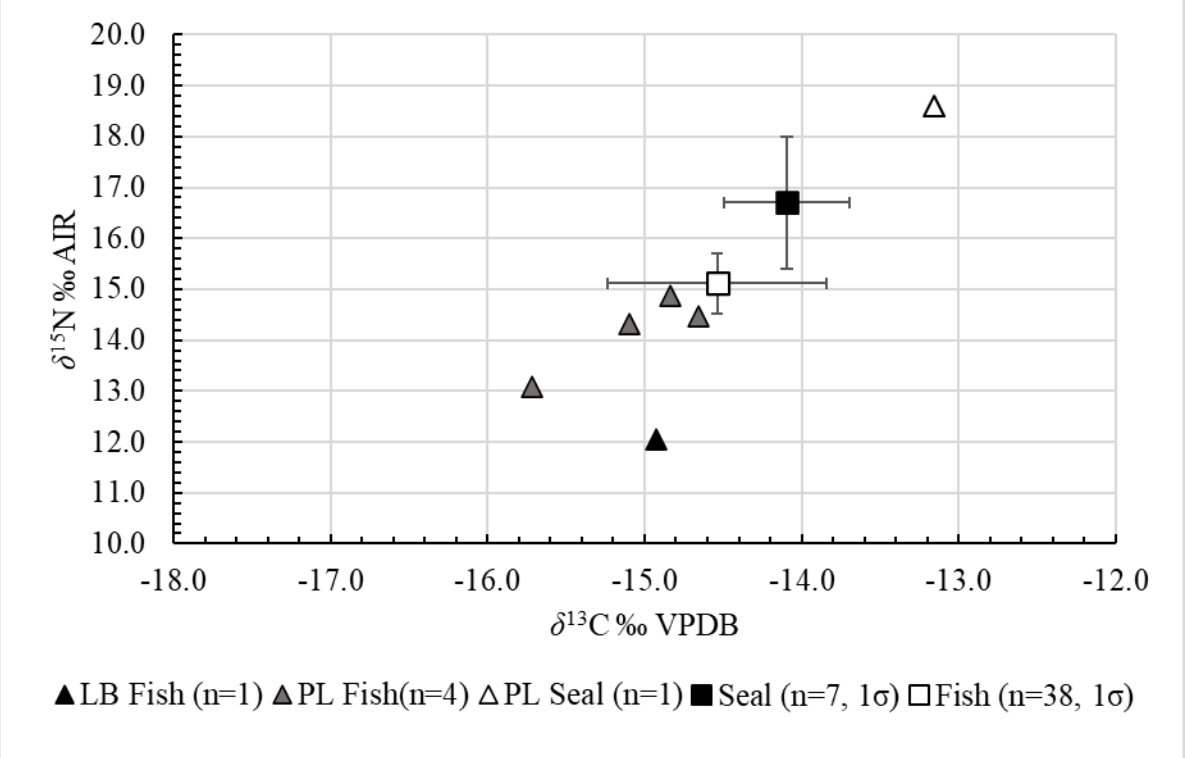

Figure 6.2. Scatterplot of Louisbourg (LB) and Placentia (PL) fish and seal data compared to the mean and standard deviation (1σ) of previously examined data (Ellerbrok 2014; Guiry et al. 2012a).

6.2.5 Birds

There was one bird sampled from Placentia and one bird sampled from Louisbourg (see Figure 6.1, Figure 6.3). The Louisbourg specimen fell in among the values of terrestrial omnivores, while the Placentia specimen fell within the marine animal range. The total range of bird isotope values for both $\delta^{13}C$ and $\delta^{15}N$ was wide, ranging from –12.7‰ to –19.9‰ and 0.1‰ to 18.3‰ (Guiry et al. 2012a; Ellerbrok 2014). When placed into a scatterplot (see Figure 6.3), three distinct groups emerged within the bird data. The Louisbourg bird specimen fell within the middle group, which consists of chickens, turkeys, a ring-billed gull, and a great horned owl, a goose, a duck, and a spruce grouse. The $\delta^{13}C$ and $\delta^{15}N$ suggest that this group subsisted on a mixed C_3 plant and marine input. The Newfoundland chickens and turkeys likely subsisted on a human-fed diet with more of a C_3 input compared to the other birds within this group. The unidentified Louisbourg specimen has values consistent with those of the Newfoundland chickens and turkeys and may represent those or similar terrestrial bird species. The chickens from Louisbourg fell into all three groupings of birds, with Ellerbrok suggesting that this variation is the result of isotopically diverse fodder or grazing foods, which appears to have been more isotopically diverse than that of the other birds from Louisbourg or the bird data from Newfoundland (Guiry et al. 2012a; Ellerbrok 2014).

The Placentia bird specimen fell within the bird group with the highest carbon and nitrogen isotope values, whose values are similar to that of the marine animals examined in Section 6.2.4. This group of birds was variable, including black-legged kittiwakes,

great black-backed owls, herring gulls, common ravens, a puffin, as well as chickens, dove/robins, turkeys, eider, goose, and avian. This group falls in a higher trophic level than the other birds examined at these sites. There is a division even within this trophic level, albeit a small one, between the more terrestrial birds and seabirds. This is evident when compared to the isotopic values of the fish from the previous section. Many of the sea birds in this group fall about 3‰ higher in nitrogen isotope values than the fish examined, suggesting their diet is based more on fish than the other birds, whereas the more terrestrial bird species likely consumed some marine foods while also ingesting terrestrial foods. The unidentified bird from Placentia falls in with the isotope values of seabirds like gulls, kittiwakes, and puffins of this group, meaning this specimen may have been a similar type of seabird.

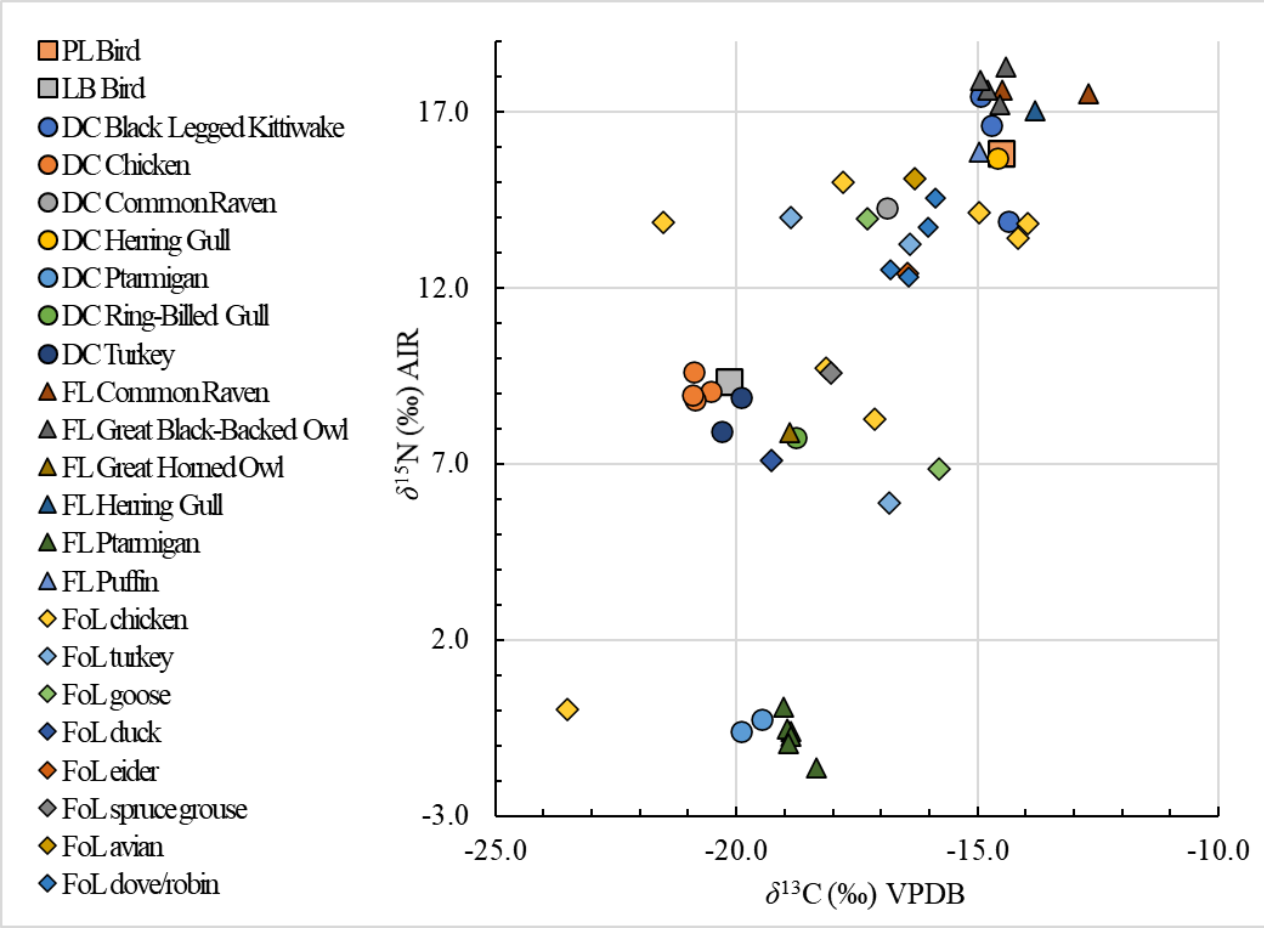

Figure 6.3. Scatterplot of bird $\delta^{13}C$ and $\delta^{15}N$ data from Newfoundland and Louisbourg. LB= new Louisbourg specimens (this thesis), PL= Placentia (this thesis), FL= Ferryland (Guiry et al. 2012a), DC= Dos de Cheval (Guiry et al. 2012a), FoL= Fortress of Louisbourg (Ellerbrok 2014).

6.2.6 Summary of the Faunal Data

Re-examining previous faunal data from both the Fortress of Louisbourg and from the various sites in Newfoundland was valuable, especially with the addition of newly analyzed Louisbourg and Placentia faunal data. These additions to the faunal isotopic data add to the growing amount of data that can be used for further isotopic studies. Investigating how these data compare to one another is beneficial for understanding human isotopic data as it provides a baseline on which to construct local

dietary patterns for humans. It is important to note that both Placentia and Louisbourg were sites that relied on trade for many goods, and livestock was often imported from elsewhere, especially in the first years of settlement (Donovan 2006). This historical information plays an important role in the interpretation of isotopic data from these regions, as it cannot be assumed that all fauna were born and raised in Atlantic Canada. Additionally, it presents an opportunity to explore these supply chains and where potential imports were coming from and the impact this may have had on the isotopic signature of these domesticates.

Many of the herbivores and omnivores appear to have consumed more of a C_3 terrestrial diet, with some having higher trophic positions. This might have come from foddering practices, which could have included imported C_4 plant materials (e.g., maize) or marine plant materials (e.g., seaweed) (Madgwick et al. 2012; Makarewicz 2014) or may be the result of grazing livestock in salt marshes (Guiry et al. 2021). Seaweed has been documented as being used as livestock fodder for centuries across the globe, though notably was popular in Europe, including France (Chapman 1970; Jackson and North 1973; Balasse et al. 2005, 2006). Recent studies have showed the importance of salt marshes in livestock feeding practices in Atlantic Canada and how it might influence isotope studies (Guiry et al. 2021). The outliers from the herbivore and omnivores groups likely represent animals imported as livestock or already butchered, as they have higher carbon isotopic values outside what would be expected for Newfoundland or Louisbourg, specifically the two pig outliers whose $\delta^{13}C$ values show C_4 input. The terrestrial carnivores within the samples have high nitrogen isotopic values, which makes sense in

the context of domestic carnivores living in and around fishing ports. These animals were likely consuming fish in the form of leftover scraps from the fishery due to the close human interaction these animals had (Guiry 2012b). It has been well-documented that domesticated carnivores were eating similar foods to humans (Cannon 1998; Guiry 2012b) The new fish data has variability in the isotopic values, but this is likely due to the variability in the types of fish caught in different regions and at different stages of the fish lifecycle (Jennings et al. 2002; Barrett et al. 2008). While the seal that was examined had higher isotopic values than previously examined seals in Newfoundland, its values fell within that of other faunal studies, suggesting this individual likely consumed a diet made up of more piscivorous fish than the other Newfoundland seals previously sampled (Richards and Hedges 1999; Guiry et al. 2012a). The two birds that were sampled were not identified by species; however, their isotopic values suggest the unidentified Louisbourg bird may have been a turkey or chicken, whereas the Placentia specimen may have been some type of seabird (Guiry et al. 2012a; Ellerbrok 2014).

6.3 Human Diet Reconstruction

6.3.1 Newfoundland Sites

Of the 34 individuals examined from Newfoundland, 30 (80%) fell within two standard deviations of the Newfoundland human mean ($\delta^{13}C$= –17.3±1.5‰, $\delta^{15}N$= 15.7±4.0‰, n=34) (see Figure 6.4). Knowing that the consumer's bone collagen averages approximately 3–5‰ higher in $\delta^{15}N$ values and 1‰ higher in $\delta^{13}C$ than what they ingest (Peterson and Fry 1987), this large cluster likely contains individuals with variable diets including those eating primarily C_3 terrestrial herbivores and omnivores to those

consuming primarily marine foods, particularly those with higher isotope values (see Figure 6.4). The four individuals that fell outside of this cluster included three St. Paul's individuals and one St. Luke's individual (St. Paul's Burials 10, 11, and NP 264/Ind. 1 and St. Luke's Burial 62A). St. Paul's Burial 11 had a δ^{15}N value similar to the mean of the cluster (16.0‰), and while their δ^{13}C value (–15.6‰) fell outside the range of standard deviation, both the carbon and nitrogen isotopic values were consistent with a diet containing the omnivorous fauna represented in Section 6.2. St. Paul's Burial 10 had a similar δ^{13}C value (–17.3‰) to that of the mean for the three Newfoundland sites examined in this thesis but had a higher δ^{15}N value (20.1‰), suggesting a higher trophic level. This individual will be discussed in further detail later in this chapter (see section 6.7.1). St. Paul's Burial NP264/Ind.1 and St. Luke's Burial 62A both had lower isotopic values than much of the cluster, suggesting more of a reliance on C_3 plant-based and terrestrial animal foodstuffs.

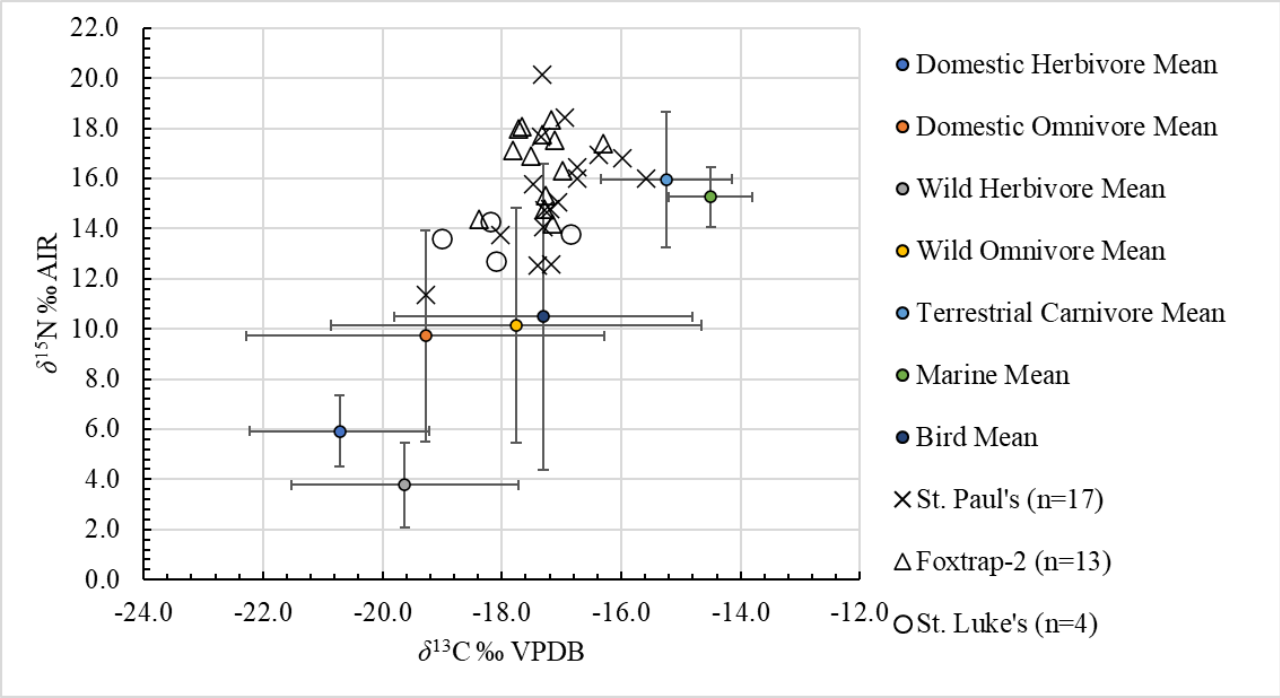

Figure 6.4. Scatterplot of Newfoundland human $\delta^{13}C$ and $\delta^{15}N$ data from St. Paul's (Pike 2013 and this thesis), Foxtrap-2 (this thesis), and St. Luke's (Harris [n.d.]). These data are compared to the mean for faunal data ± 1σ.

Overall, the individuals from the Newfoundland sites tended to consume a mixed terrestrial-marine diet, with variation in the amount of marine input into the diet. This makes sense in a historical context in which many of the people living in Newfoundland were involved with the fisheries and therefore likely consumed fish (Mannion 2000; Hodgetts 2006). However, the variability in marine input is worth commenting on. The four Foxtrap-2 individuals had lower nitrogen values than most of the individuals from other sites in Newfoundland. As pointed out in Chapter 5.2.1, there was a statistical significance between Foxtrap-2 and St. Luke's in their nitrogen values, which could be attributed to the small sample size available from Foxtrap-2. However, the amounts of marine foods people had access to likely varied based on their roles within their society

(Vigeant et al. 2017). Moore (1977) wrote that cod was exported for income, and people likely consumed other fish like haddock and lobster. This could also mean that some people, like those in Foxtrap-2, had more access to terrestrial based protein, such as cattle and pigs, while others, like those from St. Paul's and St. Luke's, may have consumed more marine based proteins, like fish (Hodgetts 2006; Tourigny 2009). These different foodstuffs and their uptake will be further discussed in Section 6.5.

6.3.2 Louisbourg Site

Within the Block 3 sample, 21 (84%) individuals fell within two standard deviations of the mean for the group (δ^{13}C= –18.2‰, δ^{15}N= 11.7‰, n=25). Visually there is a cluster within this range that includes 18 individuals who fall between the δ^{13}C values of –19.8‰ and –18.2‰ and the δ^{15}N values of 8.8‰ and 12.6‰ (see Figure 6.5). These individuals likely consumed a diet consisting of a variety of food items, including herbivores, omnivores, and marine animals. This likely also included foods grown in local gardens such as carrots, cabbages, celery, artichokes, turnips, cauliflowers, parsnips, peas, beans, and pumpkins (Donovan 2006). Block 3 burials 12 and 44 had δ^{13}C values of –21.6‰ and –20.0‰, respectively, and δ^{15}N values of 5.2‰ and 4.6‰, respectively. This places them between the means of all domestic herbivores and wild herbivores. However, they had very low δ^{15}N values, similar to those in contemporary studies of vegan diets where isotopic values of ~7‰ and 5.6 ± 1.2‰ occur (Macko et al. 1999; Ellegård et al. 2019) (see Section 6.7.2 for further discussion). Five Block 3 individuals fell outside of this cluster with highly variable isotopic values. Block 3 burials 5 and 18 had similar δ^{15}N values as the main cluster but had slightly higher δ^{13}C values of –16.3‰

and –15.1‰, suggesting slightly more intake of C_4 plants, or animals that subsisted on C_4 plants (see Section 6.7.3 for further discussion on burial 18). These individuals might have come from the United States, where diets based on C_4 plants, which includes maize, sorghum, sugarcane, and millet, were more prominent (van der Merwe 1982; Bender 1968; DeNiro 1987; Ambrose and Norr 1993). Block 3 burial 6 also fell within this similar trophic level regarding the δ^{15}N value, but with an even higher δ^{13}C value of –11.6‰. This suggests even more of an intake of C_4 plants into the diet than burials 5 and 18 (see Section 6.7.4). Block 3 burials 25 and 19 had δ^{13}C values of –16.1‰ and –15.0‰ and δ^{15}N values of 17.0‰ and 18.6‰, respectively, which indicates a high marine protein input into their diet (see Section 6.7.5 for further discussion on burial 19). These individuals fell 2–3‰ above the means for both marine animals (fish and seal) and terrestrial carnivores, the latter of which were likely consuming marine protein, as discussed previously in sections 6.2.5 and 6.2.6. This suggests that marine protein, like piscivorous fish and marine mammals such as seals, contributed significantly to the diet of these individuals.

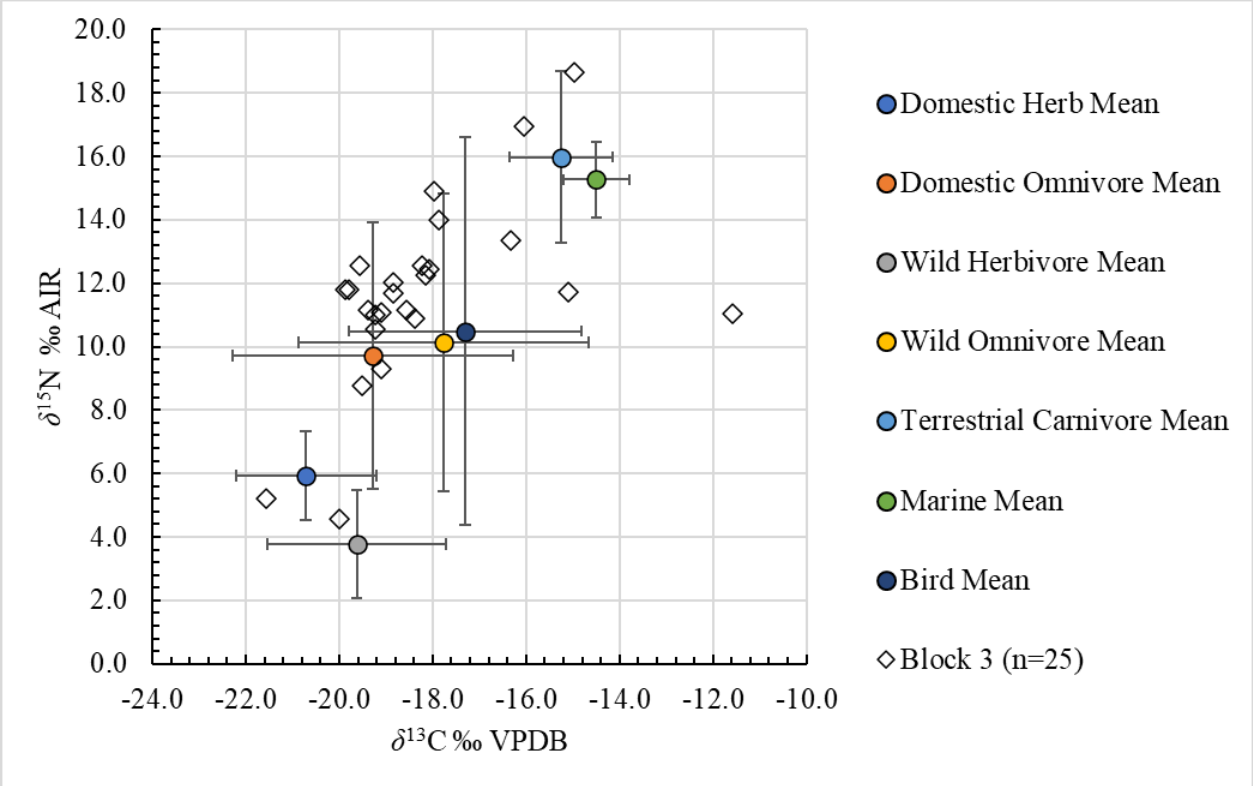

Figure 6.5. Scatterplot of Louisbourg $\delta^{13}C$ and $\delta^{15}N$ data from Block 3 (this thesis). These data are compared to the mean for faunal data ± 1σ.

6.3.3 Comparing Sites from Newfoundland and Louisbourg

When examining the human data from all the Newfoundland sites and Louisbourg, a clear trend appeared (see Figure 6.6). Most of the Block 3 individuals and the Newfoundland individuals showed a similar C_3 plant-based terrestrial diet with high marine contributions in many cases. The isotopic similarities between the Newfoundland sites and the Block 3 individuals likely reflects similar diets and the shared reliance on the fisheries. The Block 3 cemetery was used only during the first decade of French settlement at Louisbourg, meaning that these individuals represent the population that moved from Placentia in 1713 following the Treaty of Utrecht. As discussed previously, the diets of individuals in both French and English sites in this region of Atlantic Canada

included foods like turnips and beans, bread, fish, and meats from chickens, pigs, sheep, and cows (Prowse 1896; Mannion 2000; Donovan 2006; Crompton 2012; Vigeant et al. 2016), making these isotopic similarities unsurprising. While similarities in isotopic values does not mean that these individuals lived in the same place, in the context of this thesis we know that the people moved from one location (i.e., Placentia) to another (i.e., Louisbourg), and these data further support this.

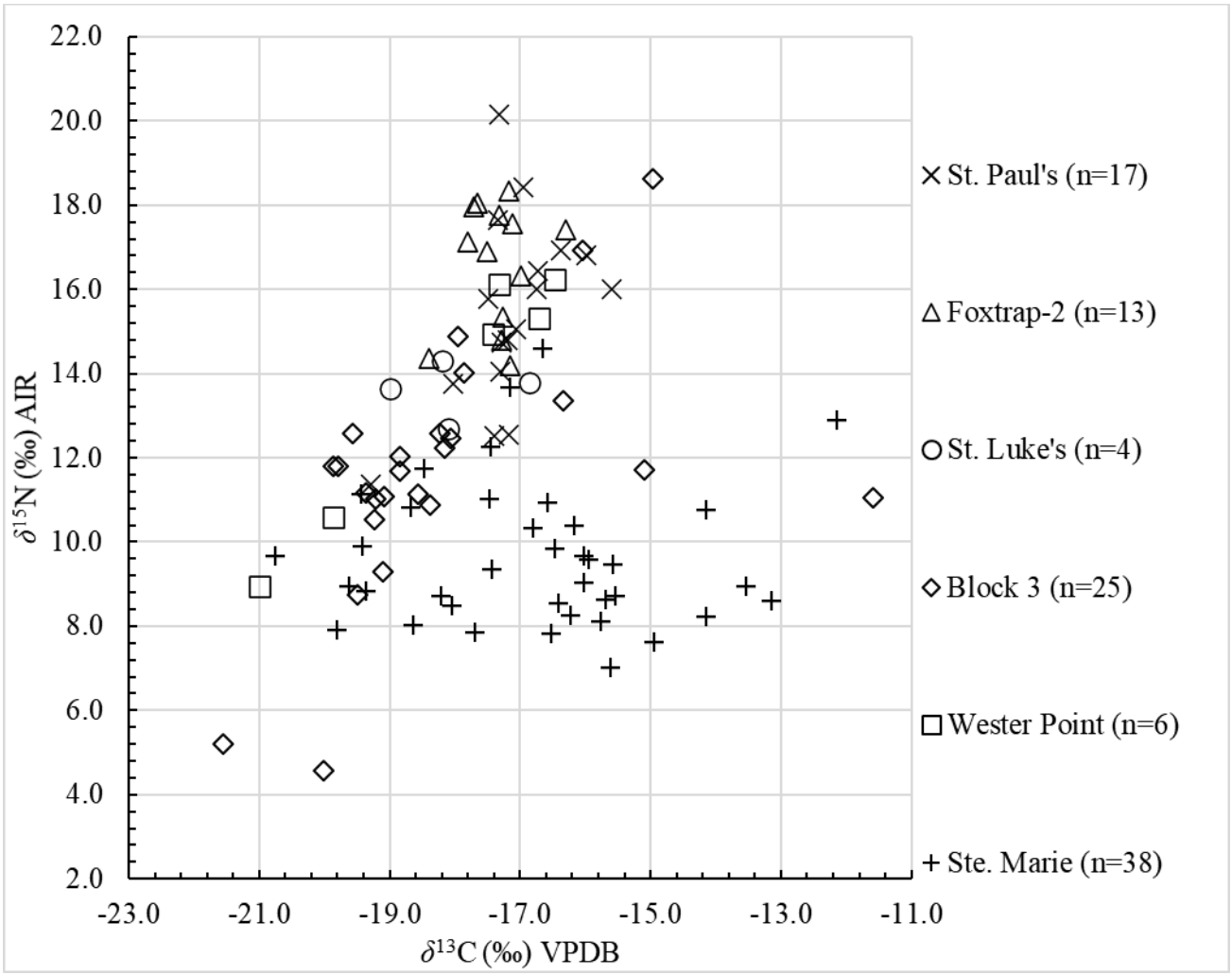

Figure 6.6. Scatterplot human $\delta^{13}C$ and $\delta^{15}N$ data from St. Paul's (Pike 2013 and this thesis), Foxtrap-2 (this thesis), and St. Luke's (Harris [n.d.]), Block 3 (this thesis), Wester Point (Harris 2015), and Ste. Marie (Ellerbrok 2014).

As discussed in Chapter 2, both Newfoundland and Louisbourg relied on imported foodstuffs, including items such as flour, wheat, peas, oatmeal, cheese, butter, oil, wine, and salt meat (Pope 1994; Varkey 2002). These isotopically varied foods likely played a part in the variation seen within the diets of these populations, as they were imported from different regions including France, Britain, the West Indies, Acadia, and Canada (see sections 2.4 and 2.5.2). The reliance on marine resources can be seen in multiple individuals from this study. However, not all marine protein was cod-based. Because these sites were valuable cod fishing sites, much of this product was exported, therefore, those living in the colonies likely consumed other types of fish to supplement their diet (Moore 1977), such as dogfish, skates/rays, herring, salmon, trout, mackerel, swordfish, lamprey, sturgeon, eel, shad, haddock, flounder and halibut, among others (Denys 1672:175; Cumbaa 1976). The Foxtrap-2 site might have relied on more terrestrial protein with more farming occurring in the area (Korneski 2013). This variation in marine input may also speak to socioeconomic status (Vigeant et al. 2017). At other sites in Newfoundland, such as Ferryland and Dos de Cheval, upper status households are indicated by resources related to activities outside of the cod fishery, like raising livestock such as cattle and hunting wild game (Tourigny 2009). These activities suggest a level of socioeconomic status that allowed for time away from fishing activities. This suggests that a higher marine input into an individual's diet could reflect a lower socioeconomic status, as they would not have the resources to afford foods that were not centered around the fishery. According to de la Morandière (1962:78), fish was

important in the diet of fishers, most especially the lowest status crew members. In contrast, however, higher status individuals living in post-medieval Europe accessed meats of all kinds including fish, whereas those with lower socioeconomic status ate mostly cereal-based foods (Croix 1981; Quellier 2007). It is far more likely that the individuals discussed in this thesis reflect the patterns previously identified in Newfoundland where access to food was likely correlated with socioeconomic status tied to the fisheries.

6.3.4 Summary

The historical record indicates that individuals living in Newfoundland fishing villages and ports consumed a mixed terrestrial and marine diet and the isotopic data support this interpretation. The data also suggest that many Block 3 individuals had diets similar to those in Newfoundland, which makes sense considering these Block 3 individuals represent those who were forced off the island of Newfoundland following the Treaty of Utrecht. Marine contribution to these diets ranged from low to high and was not confined to any single site, suggesting that individuals consumed various amounts of fish and other marine protein sources. This might have been in part due to socioeconomic status and the access to terrestrial protein versus marine protein (Tourigny 2009; Vigeant et al. 2017).

6.4 Determining a Strontium Baseline

6.4.1 Underlying Geology

Examining the underlying bedrock of an area allows for a rough first approximation of the local bioavailable strontium. The bedrock and surficial geologies of both the Avalon Peninsula and Cape Breton Island are highly variable and complex, though both fall into the Avalon Zone (Figure 6.7), consisting of Late Proterozoic sedimentary and volcanic rocks, including sandstone, quartzite, conglomerate, shale, and basalt (Geological Survey of Canada 1957). Previous work using rubidium-strontium (Rb-Sr) dating has been done in nearby locations, with similar underlying geology to the sites within this thesis and provides an approximation of the biologically available $^{87}Sr/^{86}Sr$ for the area (Fairbairn et al. 1966). This method measures the $^{87}Sr/^{86}Sr$ for the rock. The Fourchu group in southeastern Cape Breton Island, considered to be Late Proterozoic, gave $^{87}Sr/^{86}Sr = 0.7151 \pm 0.0123$ and an age of 508 ± 40 million years (Fairbairn et al. 1966). The Bull Arm group in eastern Newfoundland, considered to be Proterozoic, gave $^{87}Sr/^{86}Sr = 0.7306 \pm 0.0284$ and an age of 494 ± 30 million years (Fairbairn et al. 1966). The Harbour Main group, widespread on the Avalon peninsula and considered to be Late Precambrian, gave $^{87}Sr/^{86}Sr = 0.7281 \pm 0.0184$ and an age of 568 ± 29 million years (Fairbairn et al. 1966). Due to the location of all the sites examined in this thesis in Newfoundland and Louisbourg being at or near the ocean coast, the strontium content within the soil was probably also influenced by sea spray, meaning that the strontium isotope values within soil will likely be drawn towards that of the ocean (i.e., $^{87}Sr/^{86}Sr$ value = 0.70923) (DePaolo and Ingram 1985; Whipkey 2000).

The bedrock geology of the area around Placentia, NL is part of the Bull Arm Formation in the Musgravetown Group, and consists of mafic flows, as well as minor felsic flows and clastic sedimentary rocks, dating to the Neoproterozoic era of the Late Precambrian (1,000-541 million years ago [mya]) (King 1988). The bedrock geology around the Harbour Grace, NL area is a part of the Fermeuse Formation in the St. John's Group and is made up of shale and thin lenses of sandstone and siltstone dating to the Neoproterozoic era of the Late Precambrian (1,000-541 mya) (King 1988). The bedrock geology around the Foxtrap, NL area dates to the Middle Cambrian (~513-500 mya) and is part of the Manuels River Formation in the Harcourt Group, made up of shale and lenses of limestone, as well as mafic pillow lava and pyroclastics (King 1988). The underlying bedrock geology of the Louisbourg area is described as the Kennington Cove member of the Forchu group (Barr et al. 1996). It is made up of mainly volcanic and sedimentary rocks, including volcanic tuffs, basalt, and rhyolite, from the late-Proterozoic, estimated to be from ~575 mya (Fry 1995; Barr et al. 1996; Keppie 2000).

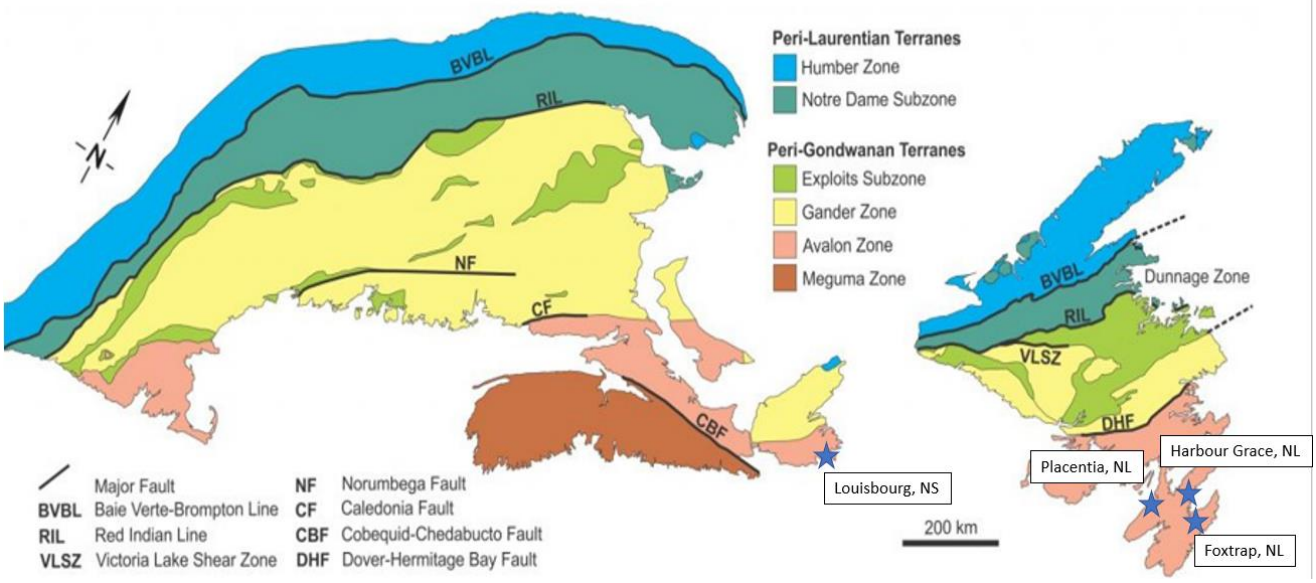

Figure 6.7. Generalized geologic map of the northern Appalachian orogen, adapted from Hibbard et al. 2006 by Honsberger and Bleeker 2018. Sites examined in this thesis are labelled.

6.4.2 Bioavailable Strontium

This thesis utilizes the bioavailable strontium isotope baseline created by Ellerbrok (2014), which was developed through the analysis of nine archaeological faunal specimens from the area of Louisbourg. Ellerbrok (2014) used the commonly employed method of calculating a range of two standard deviations from the mean of all selected fauna (Price et al. 2002). This method has been used in other works and is believed to create a conservative estimate of the isotopic variation within an area (Nafplioti 2008; Conlee et al. 2009; Giblin 2009; Shaw et al. 2009). Ellerbrok (2014) found the $^{87}Sr/^{86}Sr$ mean ± 2σ for the faunal data to be 0.710039 ± 0.001499, with a 2σ range of 0.002999 corresponding to values from 0.708540 – 0.711539. Any $^{87}Sr/^{86}Sr$ values from samples that fall within this range could be considered to be of local origin, whereas those that fall

outside this range are considered to be non-local in origin. Within this range for strontium isotope values falls the value of seawater (0.70923, [DePaolo and Ingram 1985]). As a coastal site that is more likely to be influenced by sea spray, this is expected at Louisbourg and the Newfoundland sites examined within this thesis (Whipkey et al. 2000).

6.5 Human Origins Reconstruction

The movement of people and commodities associated with the fisheries in Atlantic Canada was complex and substantial. It was not a unidirectional movement but included seasonal migrations between Europe and the fishing grounds of the North Atlantic. Increasingly more people set up permanent settlements and began overwintering, primarily on the Avalon Peninsula of Newfoundland (Candow 2006; Carroll 2008; Rose 2008). The human populations that lived in these areas consisted primarily of those who had moved to the area from Europe to be involved directly with the fisheries, including fisherfolk from the coasts of France, England, and Ireland (Johnston 1995a, 2001; Carroll 2008; Mannion 2013). It was hypothesized that the strontium isotope values of the individuals examined from sites in Newfoundland and Louisbourg would represent those from western Europe, like France, England, and Ireland, or potentially of the area they lived in Atlantic Canada if they were born there. Limitations exist with the examination of only strontium isotopes for origins reconstruction. Since strontium isotopic values represent the underlying geology of an area, there can be overlap between the $^{87}Sr/^{86}Sr$ of different regions with similar underlying geology, which makes pinpointing a specific location of origin difficult. This

thesis employs the approach of narrowing down potential places of origins based on historical context and using previously published isoscape maps to suggest potential geographic areas that people might have come from. Several isoscape maps for various geographic areas exist, including of England (Evans et al. 2010), France (Willmes et al. 2018), and the contiguous United States (Bataille and Bowen 2012).

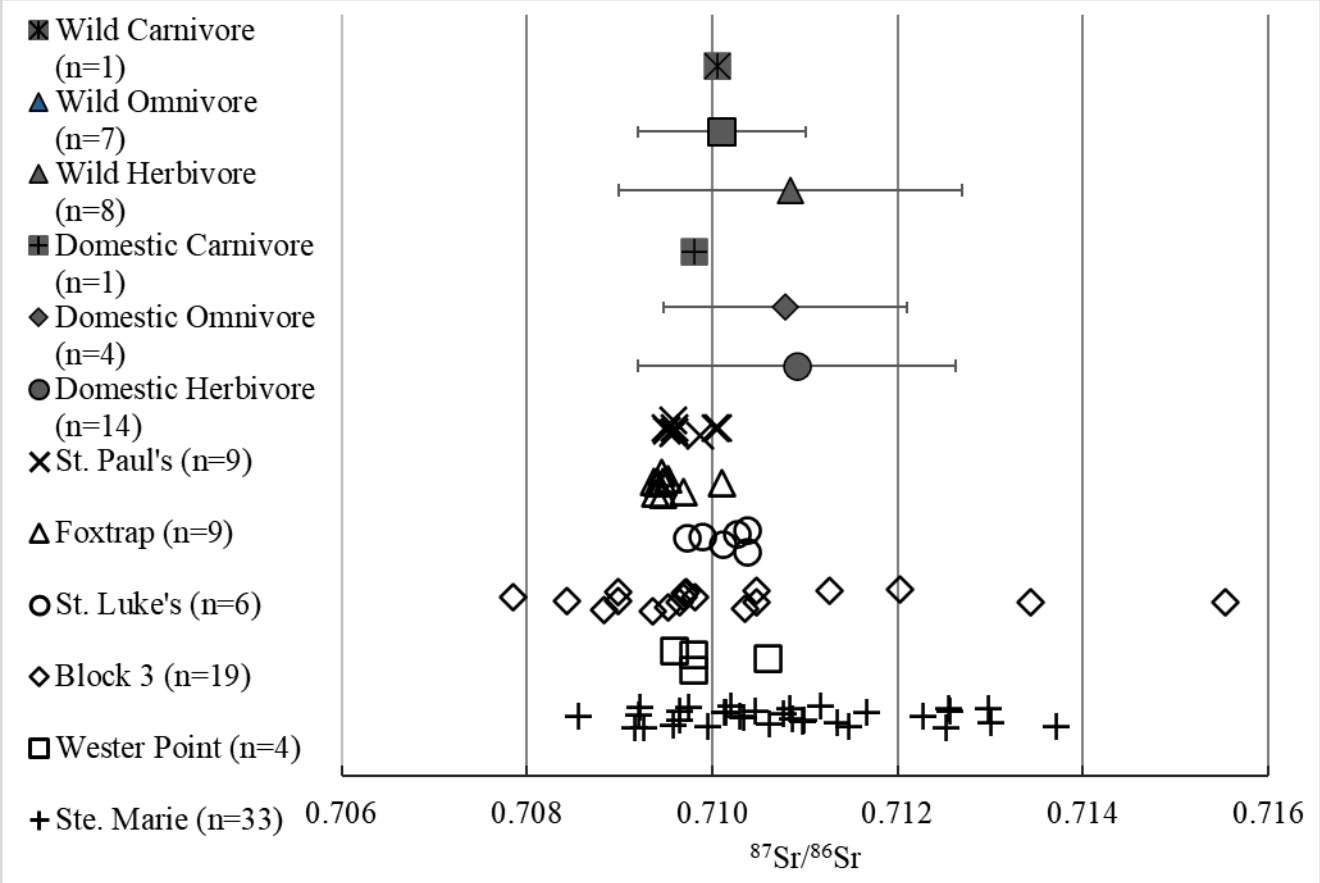

Figure 6.8. Plot of faunal $^{87}Sr/^{86}Sr$ mean ±1σ (Ellerbrok 2014) and human $^{87}Sr/^{86}Sr$ data from St. Paul's (Pike n.d. and this thesis), Foxtrap (this thesis), St. Luke's (this thesis), Block 3 (this thesis), Wester Point (Harris 2015), Ste. Marie (Ellerbrok 2014).

All the individuals from Newfoundland sites were within the 'local' strontium range based on the Louisbourg faunal material falling between 0.708540 and 0.711539 (Ellerbrok 2014), suggesting they originated in an area with bedrock of the same or

similar material (see Figure 6.8). Much of the Newfoundland human data overlaps with strontium isotopic values found in Britain (Evans et al. 2010), Ireland (Snoeck et al. 2020), France (Willmes et al. 2018), and the United States (Bataille and Bowen 2012; Chesson et al. 2012). Within the context of these burials and the history of the sites examined, having strontium isotopic values that match with these locations is unsurprising. It is likely that these individuals were born and raised near the coast (Ryan 1983; Janzen 1987). Most of the *habitants* in Placentia came from La Rochelle on the coast of France, with others coming from Ile de Ré, Saint-Malo, and other similar regions. Eventually more individuals came from regions such as Provence and Bayeux in France, as well as Quebec (Thibodeau 1959-1960; Landry 2008:142; Crompton 2012). These locations all have strontium isoscape values that fall within the 'local' range being used for the sites in Newfoundland and Louisbourg, meaning that the individuals buried in Placentia could have originated in coastal France (Willmes et al. 2018). The sites of St. Paul's and Foxtrap-2 both had primarily English fishing populations, whereas Harbour Grace had fishermen who, in part, came from the Channel Islands (Messurier 1916) and Foxtrap was made up of fishermen who moved from elsewhere in Newfoundland (Korneski 2013). When their $^{87}Sr/^{86}Sr$ were compared to a strontium isoscape map of England, similar signatures exist and suggest origins in the southeast or southwest portion of England, where values range from 0.708 to 0.710 (Evans et al. 2010).

In the Block 3 data, there were 14 individuals who fell within this local range from 0.708540 to 0.711539 (Ellerbrok 2014), and five who fell outside of this range (see Figure 6.8). Two of these outliers (burials 20 and 3) fell below the lower value of the

range at 0.7079 and 0.7084, respectively. The other three outliers (burials 10, 12, and 7) fell above the upper value at 0.7120, 0.7134, and 0.7155. There was a lot of variability in the strontium values for individuals from the Block 3 site, with $^{87}Sr/^{86}Sr$ ranging from 0.7079-0.7155. When compared to Ellerbrok's (2014) strontium values from the Ste. Marie sample, the Block 3 individuals did show a wider range of variation, albeit only slightly (see Figure 6.8). While it would be years before Louisbourg became a diverse colonial settlement with a large garrison, there was still a variety of people who contributed to the initial settlement of the site, coming from Placentia as well as other locations in eastern Canada (McLennan 1918; Johnston 2004). Movement between colonies was also common, so it is not unlikely that individuals who came from away ended up being buried in Louisbourg. The Block 3 site represents a sample population made up of in-migration to Louisbourg at the start of the official French occupation, which may have included people coming from Placentia, France, other parts of New France (such as Quebec or Acadia), and even other parts of Europe. Because high (>0.715) $^{87}Sr/^{86}Sr$ values typically originate from older, high Rb/Sr rocks (Bentley 2006), it is assumed that the three outliers with higher $^{87}Sr/^{86}Sr$ values came from areas with older underlying bedrock, such as the northeast and Midwest United States, the west coast and central parts of France, and southwest England (Beard and Johnson 2000; Evans et al. 2010; Bataille and Bowen 2012; Willmes et al. 2018). In contrast, individuals with lower $^{87}Sr/^{86}Sr$ values likely originated in locations that have younger bedrock, such as the south and western United States or eastern parts of France (Beard and Johnson

2000; Bataille and Bowen 2012; Willmes et al. 2018). These patterns will be further explored in section 6.7.

6.5.4 Summary

The Newfoundland strontium values fell within a small range, which suggests that these individuals all originated from isotopically similar regions, whereas the Block 3 individuals had significantly more variation in strontium isotopic values, suggesting either a wider range of geographic origins or that their strontium values were highly influenced by a marine focused diet. It is not surprising that the Newfoundland individuals had strontium isotopic values close to that of seawater, as the Newfoundland sites are all coastal, and any potential origins for these individuals, if not Newfoundland, would likely also be coastal, as they would have likely come from English, Irish, or French coastal areas. While this may be true for some of the individuals buried in the Block 3 cemetery, there was also more varied origins within this population based on their wide range of $^{87}Sr/^{86}Sr$, meaning that not all the individuals came from coastal locations and therefore the values are less reflective of seawater influence.

6.6 Comparisons of French and English Data

The sites examined within this thesis can generally be broken up into groups representing French or English individuals, which is determined based on historical information that has been previously discussed (see Chapter 2). French sites include the St. Luke's site in Placentia, NL, during the period before French colonists were forced to leave in 1713 and the area was then inhabited by English and Irish settlers, and the Block 3 site at the Fortress of Louisbourg, NS, which was in use for only the first decade of

occupation in Louisbourg (1713-1723) (see Chapter 2) (McCarthy 1973; Johnston 1984). English sites include the St. Paul's Anglican Church site in Harbour Grace, NL and Foxtrap-2 in Foxtrap, NL, both occupied by English colonists and fishermen (see Chapter 2) (Pike 1996; Pitt and Pitt 2015b). The Ste. Marie site examined by Ellerbrok (2014) is hypothesized to be comprised mostly of New Englanders and the Wester Point cemetery, examined by Harris (2015) is also considered to have English origins.

6.6.1 French vs. English dietary patterns

Due to cultural differences, it was hypothesized that many French and English diets would differ isotopically. This may be true when discussing the diet of those populations living in France and Britain at the time; however, there is evidence that this may have not been the case in their respective colonies located in Atlantic Canada. Comparing the Newfoundland and Louisbourg sites to temporally and geographically similar sites in France, England, Quebec, and New England can provide some further insight into dietary staples at the time. For example, the French site of La Rochelle, France (n=13, 1σ) has been shown to have mean $\delta^{13}C$ and $\delta^{15}N$ values of –18.4 ± 0.4‰ and 12.7 ± 1.0‰ (Vigeant et al. 2017), and post medieval data from the English site of All Saints Cemetery (n=16, 1σ) has mean $\delta^{13}C$ and $\delta^{15}N$ values of –19.0 ± 0.4‰ and 12.6 ± 0.9‰ (Müldner and Richards 2007a). These data suggest that both sites had a mixed terrestrial-marine dietary input. Comparable sites from New France and New England include Notre Dame, Quebec (n=43, 1σ), with mean $\delta^{13}C$ and $\delta^{15}N$ values of –19.6 ± 0.6‰ and 11.5 ± 1.1‰ (Vigeant et al. 2017), and the Walton Family Cemetery in Connecticut (n=16, 1σ), with mean $\delta^{13}C$ and $\delta^{15}N$ values of –14.1 ± 0.8‰ and 9.7 ±

0.4‰ (France et al. 2013). The Notre Dame site had a diet similar to the French site of La Rochelle, with slightly less marine input, likely due to its location near fresh water (Vigeant et al. 2017). In contrast, the Walton Family cemetery site has a diet containing C_4 terrestrial based foods, like maize and little marine input (France et al. 2013).

Three of the Newfoundland (St. Luke's, St. Paul's, and Foxtrap) sites had higher $\delta^{13}C$ and $\delta^{15}N$ isotope means than these comparative European and other North American sites, suggesting they had increased marine input into their diets (see Figure 6.9). The Block 3 site had a slightly lower nitrogen mean than the La Rochelle and All Saints Cemetery, but a higher nitrogen mean than the Walton Family Cemetery. The Block 3 nitrogen values were most comparable to the Notre Dame individuals. Examining the means of carbon and nitrogen isotopes, Block 3 and St. Luke's, both considered French sites within this research, fell below that of the sites considered to be English. Most individuals in Newfoundland, and many from the Block 3 site, consumed a diet isotopically higher than both the continental French and English individuals, suggesting those living in Atlantic Canada had more of a reliance on marine protein than those in Europe. The sites of St. Luke's and Wester Point had very similar means for both $\delta^{13}C$ and $\delta^{15}N$ values, despite one being French and one being English. The similarities between these sites suggests a homogenization of dietary inputs in Atlantic Canada, and differences in diet were likely not distinctive between the French and English colonies.

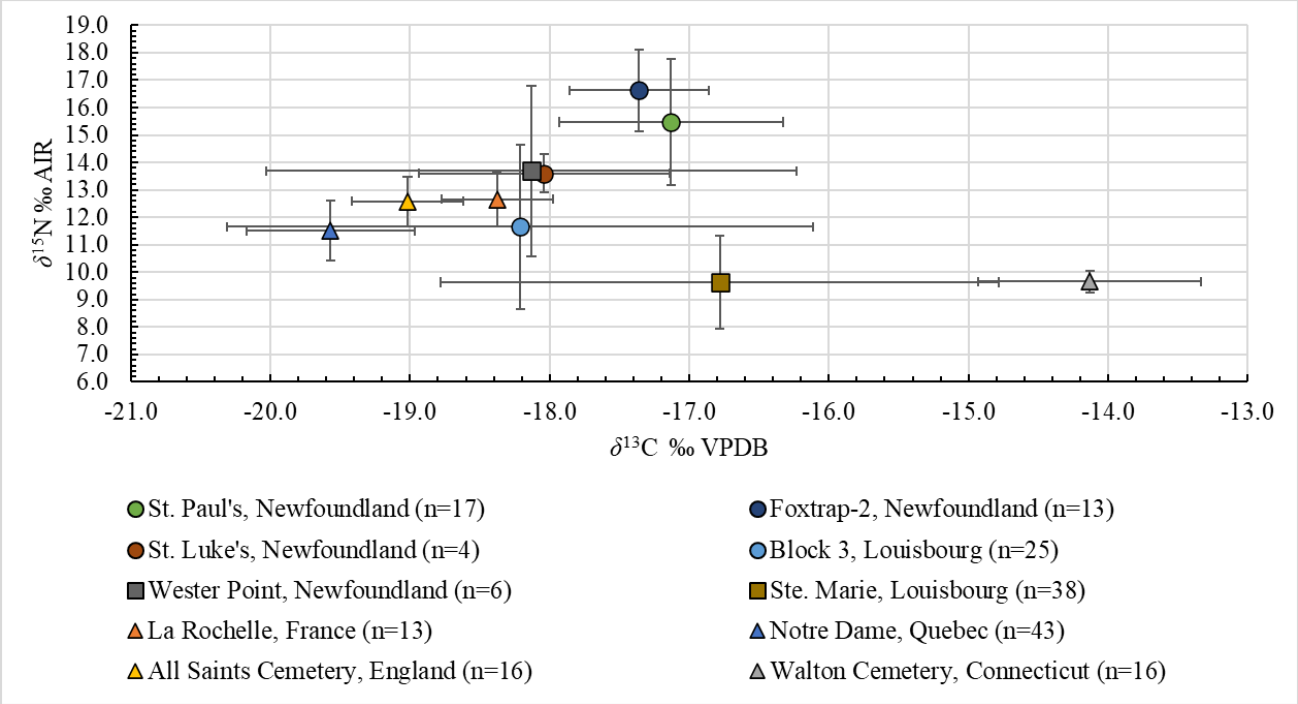

Figure 6.9. Plot of comparative sites for human mean $\delta^{13}C$ and $\delta^{15}N$ (± 1σ) data. St. Paul's (Pike 2013 and this thesis), Foxtrap-2 (this thesis), St. Luke's (Harris, n.d.), Block 3 (this thesis), Wester Point (Harris 2015), Ste. Marie (Ellerbrok 2014), La Rochelle, France and Notre Dame, Quebec (Vigeant et al. 2017), Walton Family Cemetery, Connecticut (France et al. 2013), and All Saints Cemetery, England (Müldner and Richards 2007a).

6.6.2 French vs. English mobility patterns

It is known that populations at the time were highly mobile, and both French and English individuals involved in the early fisheries moved between Europe and the North Atlantic colonies seasonally (Lear 1998; Crompton 2012). French fishermen often came from La Rochelle and Brittany (Fagan 2006; Landry 2008) and English fishermen came from West Country England and Ireland (Pope 2004; Mercer 2008). During the migratory fishing period that began in the 16th century, fishing vessels travelled to the fishing grounds off the coast of Newfoundland in the spring, fished for the summer months, and then travelled home in the fall before winter (Pope 2004). Even when settlement began,

people were still moving between Europe and Newfoundland to transport fish and goods. It is difficult to see this movement within isotopic data because strontium in enamel is incorporated during childhood development, so the $^{87}Sr/^{86}Sr$ only indicates where individuals originated and does not track movement during adulthood. Even then, bedrock geology can be similar in different geographic locations, so it is only possible to examine the likelihood of local' versus 'non-local' individuals. What we can say is that most individuals buried in Newfoundland had very similar $^{87}Sr/^{86}Sr$, and many had values similar to that of seawater, suggesting coastal origins and/or a diet involving marine food. It is likely that these people moved from areas in Europe with similar $^{87}Sr/^{86}Sr$ or were born in Newfoundland.

The Block 3 site had the widest range of strontium isotopic values, which suggests a wide range of origins for the individuals buried there. This would make sense, as the site included people forced out of Placentia, NL as well as people from France, New France, and other parts of what is today Canada (Johnston 1995a,b,c, 2001). The Block 3 cemetery was only in use for the first decade of the Fortress' existence (from 1713 to 1723 [Johnston 1996, 2001]), and with the youngest individual estimated to be about 16 years old, none of the individuals buried in the Block 3 cemetery would have been born in Louisbourg.

Overall, French and English individuals seem to have had similar mobility patterns within the context of Atlantic Canada based on the strontium isotopic data. Most individuals originated in regions with similar underlying geology. Due to the lack of a bioavailable strontium baseline for Newfoundland, as well as the overlapping of

underlying bedrock strontium values across many of the regions highlighted in the historical records, only generalizations can be made regarding these data. The potential for more work in this area will be presented in Chapter 7.

6.7 Individual Life Histories

The individuals that were examined in this thesis had a variety of diets and places of origin. Several of the individuals examined in this thesis stand out isotopically and warrant further discussion. This section seeks to examine these burials more thoroughly, looking at both dietary input and potential regions of origin when possible, allowing for more insight into their specific life history.

6.7.1 St. Paul's Burial F10

This individual was a juvenile between 1 and 1.5 years old at the time of death. Their δ^{15}N value (20.1‰) was the highest of all the individuals sampled from Newfoundland. Due to their age, it was hypothesized that this high value was the result of breastfeeding. Their δ^{13}C value (–17.3‰) also supports this hypothesis. Breastfeeding was the primary source of infant nourishment in 17th- and 18th-century North America (Treckel 1989) and generally placed infants at a higher trophic level than their mother (Schurr 1998). Comparing this individual's nitrogen isotopic value to the average δ^{15}N value of the women from the same site, we would expect it to be approximately one trophic level higher. The δ^{13}C and δ^{15}N values of the three women buried at the same site had averages of –16.8 ± 0.8‰ and 14.0 ±1.8‰, respectively. Therefore, the juvenile's δ^{15}N value is 3.3‰ higher than that of the adult women from the same site, placing the juvenile in a higher trophic position. This means that at the time of death, this individual

was still likely consuming breastmilk as its main form of sustenance and had not yet been weaned. (Schurr 1998). While there is no strontium data for this individual, because of their young age at the time of death, it is likely they were born in Harbour Grace, or the surrounding area.

6.7.2 Block 3 Burials 12 and 44

Burial 12 was a 20–40-year-old adult male and burial 44 was a 27–35-year-old adult male. Their $\delta^{13}C$ values were –21.6‰ and –20.0‰, respectively, and their $\delta^{15}N$ values were 5.2‰ and 4.6‰, respectively. These two individuals had the lowest isotope values of all those examined in this study, including any of the comparative studies as well. These results suggest that these two individuals consumed little or no animal protein, as their values fell at or below that of herbivores. Burials 12 and 44 had $^{87}Sr/^{86}Sr$ equal to 0.7134 and 0.7103, respectively. This places burial 12 outside the 'local' range for this study and higher than all but two other individuals, meaning that they likely originated elsewhere. Examining the isoscape map for the contiguous United States suggests that this individual may have originated from the northeastern states as far west as Pennsylvania or West Virginia, where strontium values range between 0.713-0.715 (Bataille and Bowen 2012). While regions further west and south show a similar strontium signature, it is unlikely that this individual originated outside the northeast based on their C_3 terrestrial based diet. This individual may have also originated from the west coast of France or the southwest of England (Bataille et al. 2018). These locations are more probable based on the diet consisting only of C_3 terrestrial foods, as at the time, Europeans did not have access to many C_4 foods, such as maize (van der Merwe 1982),

common in the western and southern United States. It also makes sense in the fishery context, as many people involved with the fisheries came from the west coast of France and England (Messurier 1916; Thibodeau 1959-1960; Landry 2008:142; Crompton 2012). Burial 44 falls within the 'local' strontium range, similar to other individuals, meaning they could have originated in either Louisbourg or Newfoundland, or another local area with similar strontium values.

6.7.3 Block 3 Burial 18

This individual was an adult male under the age of 45 years whose $\delta^{13}C$ and $\delta^{15}N$ values were –15.1‰ and 11.7‰, respectively, and these values were higher than many other individuals from Block 3. This individual was consuming a mix of C_3 and C_4 foods, with some contributions from marine sources. Their diet was unlike all other individuals from Newfoundland and most of the other Block 3 individuals. Interestingly, these values are most similar to the means of individuals living in the northeast United States, from regions such as Connecticut and Pennsylvania (see Figure 6.10) (France et al. 2014) (see Figure 6.10). Their $^{87}Sr/^{86}Sr$ value was 0.7095, which fell among a cluster of other Block 3 individuals and just above the seawater value. This does not mean that they necessarily came from the same geographic location but rather locations with similar strontium isotope values. Hypothesizing that this individual came from the United States, their strontium value suggests that they could have originated from somewhere along a coastline, though that is not the only location that can have these values. Consulting the map model of $^{87}Sr/^{86}Sr$ variation in the contiguous United States created by Bataille and Bowen (2012:45), there are locations from which this individual theoretically could have

originated along the eastern seaboard, such as coastal regions of Massachusetts, Connecticut, and New York. These data suggest that this individual originated outside of Atlantic Canada and moved there towards the end of their life.

6.7.4 Block 3 Burial 6

This adult individual was less than 30 years of age at the time of death and their sex could not be determined. They had a δ^{15}N value of 11.1‰ and a δ^{13}C value of –11.6‰, which was the highest δ^{13}C value in this study. This person likely consumed primarily C_4 terrestrial foods such as maize and some marine foods. Comparing these carbon and nitrogen isotope values to the overall means of northern and southern states, burial 6 is closer to the means found in the mid-Atlantic and southern United States like Delaware, Washington DC, and Virginia (δ^{13}C= –12.0 ± 2.0‰; δ^{15}N= 10.7 ± 0.9‰) than to the means of more northern regions like Pennsylvania and Connecticut (δ^{13}C= –14.9 ± 2.2‰; δ^{15}N= 10.7 ± 0.9‰) (see Figure 6.10) (France et al. 2014). Differences in the diets between southern and northern US states was due to isotopically enriched C_4 grasses and corn crops being far more common in the warmer southern regions, while the more temperate Northern regions had more C_3 based plants (France et al. 2014). Southern United States diets would have higher δ^{13}C values because both wild and domesticated animals consumed local plants and maize was a staple in southern diets (Pace 1993).

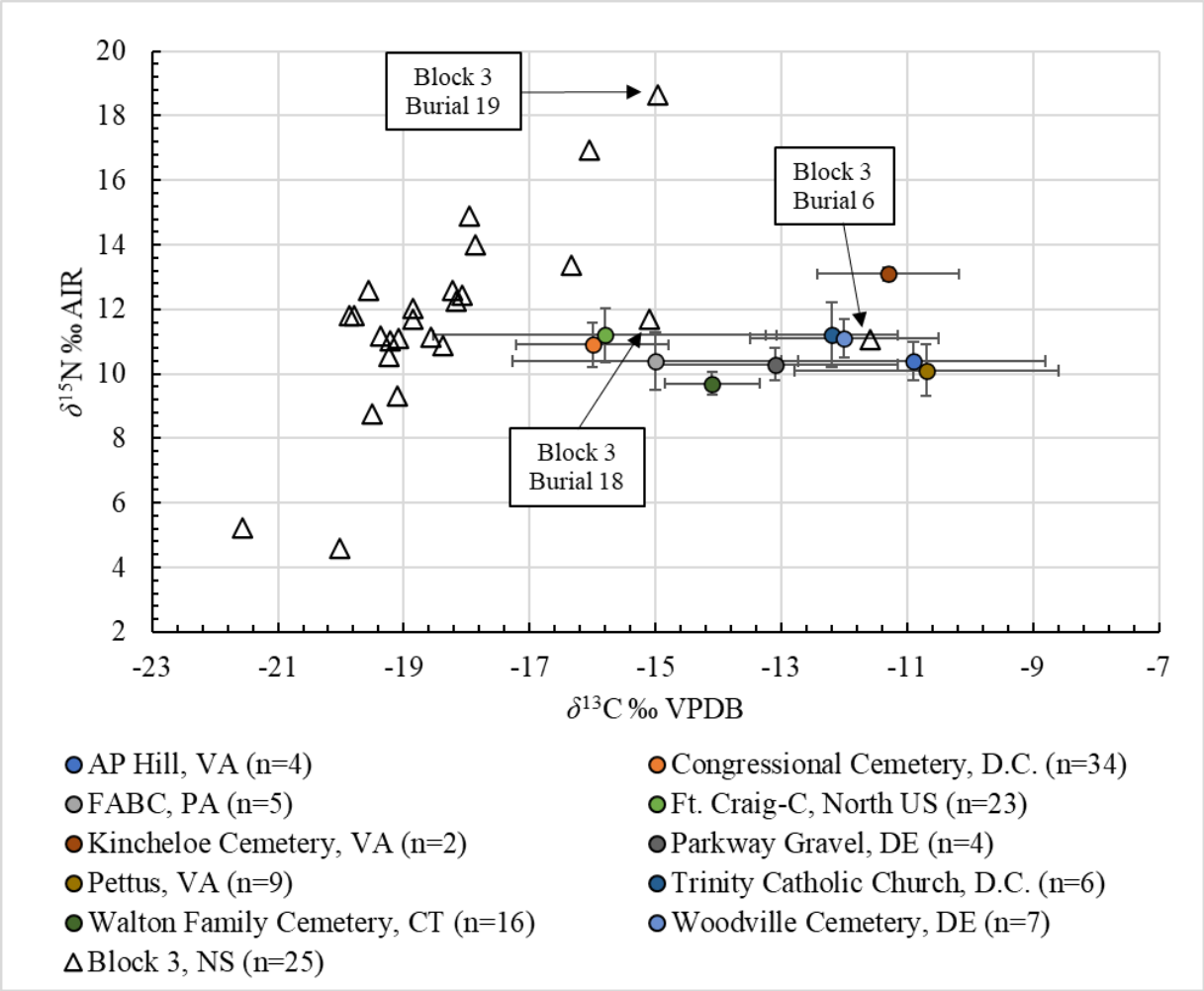

Figure 6.10. Scatterplot depicting Block 3 $\delta^{13}C$ and $\delta^{15}N$ values and mean ±1σ $\delta^{13}C$ and $\delta^{15}N$ of select sites from the United States (France et al. 2014). Sites representing various geographic regions of the United States are labelled. Block 3 burials 6, 18, and 19 are also labelled.

6.7.5 Block 3 Burial 19

Burial 19 was a late adolescent male aged between 17 and 18 years and had the highest adult nitrogen isotope values ($\delta^{15}N$ = 18.6‰) out of all the individual data presented in this study. This high nitrogen value suggests a large proportion of their diet consisted of marine foods. This would make sense for someone living in an area heavily involved with the fisheries. This individual's $^{87}Sr/^{86}Sr$ value (0.7105) was consistent with

several other Block 3 individuals and within the range of what is considered to be 'local'. This individual could have potentially originated in Newfoundland and moved to Louisbourg during the first years of French occupation, or could have originated in Europe, likely France, somewhere along the coast, as their strontium values are consistent with the isoscape values for either region. Being a young male, this individual could have been involved in the fishery or come over as a soldier and considering the regions that *habitants* and soldiers originated from (see Figure 2.2), both of these are possible scenarios.

6.7.6 Block 3 Burials 3 and 20

These two individuals were noteworthy because they were the only two individuals whose $^{87}Sr/^{86}Sr$ values fell below the 'local' range at Fortress Louisbourg (see Figure 6.11). Burial 3 was a probable adult male aged between 18-21 years with a $^{87}Sr/^{86}Sr$ value of 0.7084, and burial 20 was an adult male aged between 20-35 years with a $^{87}Sr/^{86}Sr$ value of 0.7079. The $\delta^{13}C$ and $\delta^{15}N$ values of these individuals fell within that of most burials from the Newfoundland sites as well as other Block 3 burials, representing a mixed terrestrial and marine diet with C_3 input. Their low strontium values, however, suggest potentially non-local origins, though these individuals fall just below the 'local' range. One potential place of origin with similar isotopic signatures is the British Isles, including central and eastern parts of Britain, where the Cretaceous chalk-based strontium isotope value of 0.7083 ± 0.0006 is similar (Evans et al. 2019) or areas in Scotland, where Tertiary volcanic rocks have a $^{87}Sr/^{86}Sr$ value of 0.7078 (Montgomery et al. 2003). Similar strontium values are also found in northern and

western France (Willmes et al. 2018). It is possible these two individuals may have been local; however, limited strontium isoscape data in Atlantic Canada impedes our ability to explore this possibility.

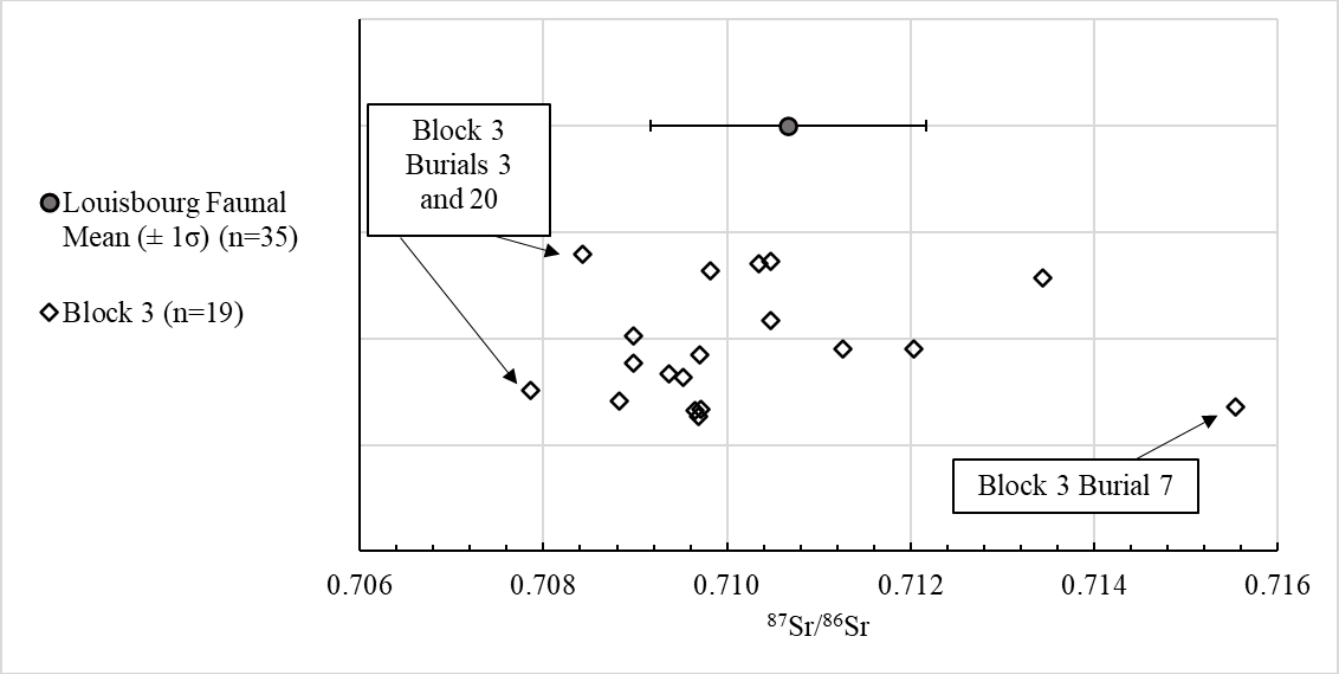

Figure 6.11. Plot of the Louisbourg faunal $^{87}Sr/^{86}Sr$ mean ±1σ (n=35) (Ellerbrok 2014) and Block 3 $^{87}Sr/^{86}Sr$ data (this thesis). Burials 3, 7, and 20 are labelled.

6.7.7 Block 3 Burial 7

Burial 7 was an adult male aged 30-35 years with a $^{87}Sr/^{86}Sr$ value of 0.7155, the highest strontium value obtained in this study (see Figure 6.11). This high value suggests the individual was not local to Atlantic Canada and likely originated outside of any sites examined within this thesis. When comparing this value to the strontium isoscape map of France (Willmes et al. 2018), this individual could have potentially originated on the west coast of France or from central France, where $^{87}Sr/^{86}Sr$ values range between 0.7140-0.7167 (Willmes et al. 2018:84). The diet of burial 7 was similar to many of the

Newfoundland diets, with mixed terrestrial and marine inputs, represented by $\delta^{13}C$ and $\delta^{15}N$ values of –19.4‰ and 11.2‰, respectively. The combination of strontium, carbon and nitrogen isotope data suggests this individual likely originated away from the coast but did have a diet including some marine foods. While strontium values like this exist in the eastern United States, the absence of C_4 input into the diet means it is an unlikely region of origin. Therefore, it is most probable that this individual migrated to Atlantic Canada from France.

6.8 Conclusions

This thesis utilized both previously published and newly produced data to tie together an analysis of both diet and potential origins for individuals buried in Atlantic Canada at the sites of St. Paul's Anglican Church in Harbour Grace, NL, Foxtrap-2 in Foxtrap, NL, St. Luke's Anglican Church in Placentia, NL, and the Block 3 cemetery in Louisbourg, NS. It set out to examine French and English populations to better understand the variability in diet and movement in Atlantic Canada during the 18th- and 19th-centuries. Isotopic values of faunal specimens from both previously examined data (Guiry et al. 2012a; Ellerbrok 2014) and those produced for this study allowed for dietary comparisons between sites, as well as creating a baseline from which to assess the dietary habits of the human populations that were living in these various locations.

Individuals from the Newfoundland sites had similar diets represented by a mix of C_3 terrestrial and marine foods. The Block 3 individuals had varied dietary isotopic values, including C_3 and C_4 dietary inputs, with some individuals consuming primarily terrestrial diets while others consumed a mixed diet containing both terrestrial and marine

foods. Marine foods were expected for all the sites examined because of the close ties to the fisheries, and the isotopic values of many individuals reflects a marine-focused diet.

Unfortunately, it was difficult to discern exact origins based on strontium isotopic values alone. The $^{87}Sr/^{86}Sr$ values of the individuals buried in Newfoundland were all relatively similar, falling within 0.001221 of one another. These values fell near or just above the value for seawater, suggesting coastal origins, potentially within Atlantic Canada, from the coasts of England or France, or somewhere with similar $^{87}Sr/^{86}Sr$ signatures. The $^{87}Sr/^{86}Sr$ values for the Block 3 individuals were more varied, suggesting more diverse origins. The strontium values for some individuals were similar to those from the Newfoundland sites, suggesting origins in Atlantic Canada or coastal regions of England or France. Other individuals however, had strontium isotopic values more like those found in the United States.

With a few exceptions, the sites examined within this research had many similarities. These data support the historical record which outlines that the Block 3 cemetery was likely comprised of individuals uprooted from Placentia in 1713 and moved to Louisbourg. The Block 3 individuals had many things in common with the individuals from the three other Newfoundland sites in terms of both diet and potential regions of origin. Similarities existed between the French and English individuals as well, suggesting that individuals living in Newfoundland and Louisbourg were connected through their consumption patterns despite being culturally distinct.

Chapter 7. Conclusions and Future Work

The main goal of this thesis was to investigate the archaeological and historical connections between Placentia, NL and Louisbourg, NS. This goal was achieved through the examination of the diet and geographic origins of individuals who died in Newfoundland and Louisbourg in the 18th- and 19th-centuries, as well as identifying whether any significant differences in diet existed between the identified French and English populations. This was accomplished using a combination of interdisciplinary methods, drawing on historical, archaeological, and bioarchaeological records, and isotope biogeochemistry to try and understand patterns of diet and movement within and between these Atlantic Canadian populations. Additionally, the stable isotope data acquired through this thesis were compared to previously published human and faunal data to build a more complete interpretation of the groups examined and expand the growing isotopic literature in this underrepresented region.

7.1 What the Faunal Material Revealed

The purpose of examining the faunal material from Placentia and Louisbourg was to further expand and enhance the current isotopic data for faunal material in the region, as well as aid in assessing the food resources available to the local populations living there. The faunal material analyzed in this research was compared to previously studied faunal data to compare and contrast these datasets. Overall, much of the stable isotope data for each animal group matched that of previous data for these regions of interest. However, the stable isotope data from some specimens examined fell outside of what would be considered 'local' faunal resources. These outliers, from the herbivore and

omnivore ecological groups were likely imported as livestock or as food for the local inhabitants. Isotopic data suggests that there was a strong likelihood that seaweed, or other marine plant material, was used as fodder resulting in the identified isotopic patterns for some of the specimens examined. It is also probable that domestic carnivores (i.e., dogs and cats) consumed a diet heavy in marine-based protein sources similar to those of the local human populations.

7.2 The Diets and Origins of Newfoundland and Louisbourg Individuals

At the beginning of this thesis, several research questions were put forward, inquiring about what the diets and potential geographic origins of individuals buried in 18th- and 19th-century Newfoundland and Louisbourg might have been, as well as if any significant dietary differences existed between the French and English populations at the sites examined. Results of this work suggest that individuals who were buried in Newfoundland had very similar diets and came from similar geographic regions, while those buried in the Block 3 cemetery had a more variable diet and likely immigrated to Atlantic Canada from a variety of locations, suggesting a more heterogenous population at Louisbourg. Isotopic results suggest that there was a lot of overlap in the diets and potential regions of origin for the individuals in these colonial settlements, suggesting access to similar foodstuffs and even trading between these colonies. It is important to note that while there were distinct differences between the French and the English in Europe during this period, we do not necessarily expect to see the same pattern in the colonies due to differences based on the unique needs of these colonists (Kumar 2006). This means that, while diets were influenced by the country of origin, there was likely a

more generalized diet shared by colonists based on what supplies were available (Hodgetts 2006; Vigeant et al. 2016). The similarities that exist regarding the region of origin of individuals in both Newfoundland and Louisbourg is likely due to the high number of people coming from coastal regions in Europe, which influenced their strontium isotopes in similar ways due to the effect of sea spray. Those individuals in Louisbourg whose strontium values suggests a difference in region of origin may have come from locations further inland in Europe or in North America, where their strontium isotopes were not affected by sea spray.

Overall, the individuals who were buried at the Newfoundland sites of St. Paul's Anglican Church, Foxtrap-2, and St. Luke's Anglican Church, consumed a mixed terrestrial-marine diet. Because these individuals were found to have comparable isotopic values, it is likely that these populations were consuming very similar diets. This makes sense for the populations living on the island who all had access to similar foodstuffs. In terms of geographic regions of origin for the individuals examined, the strontium values for all these individuals were relatively similar and were closely associated with the strontium signature of ocean water, indicating potential coastal origins. This suggests these individuals may have originated from a variety of coastal regions including those in Newfoundland, England, Ireland, or France, all of which have similar isotopic signatures to ocean water. It should be noted that the sample size for these three sites is quite small and represents a small portion of the population living in these areas at the time.

In contrast, the individuals buried in the Block 3 cemetery at the Fortress of Louisbourg had a variety of dietary inputs. There was a large cluster of individuals who

had comparable isotopic values and likely consumed a diet with C_3 terrestrial herbivore and omnivore protein, as well as marine foods. Two Block 3 individuals (Burials 12 and 44) had $\delta^{13}C$ and $\delta^{15}N$ values lower than individuals from all sites examined, indicating no consumption of animal protein with values similar to those of contemporary vegan diets (Macko et al. 1999; Ellegård et al. 2019). There were also a few individuals whose isotopic values suggested a C_4 terrestrial herbivore and omnivore proteins, as well as individuals whose isotopic values suggest an increased consumption of marine protein. When considering the region of origin for the Block 3 individuals, they showed more diversity than those from the Newfoundland sites. It should be noted that the sample size of the Louisbourg site was larger than each of the Newfoundland sites and likely represents a broader sample of the population, which could contribute to this increased diversity. As the Block 3 individuals likely represent those who were forced out of Placentia, NL, the population composition was also supplemented by those emigrating from France, other New France colonies, and Canada (Johnston 1995a,b,c, 2001).

7.3 Future Work

There is a great deal of potential for future work related to the outputs of this thesis. One of the most significant is the creation of a biologically available strontium isotope baseline for Newfoundland and Atlantic Canada. Sampling strontium from faunal materials in order to create a baseline for the island and maritime region would aid greatly in the interpretation of human strontium values. Another potential for future work is the analysis of carbon and oxygen isotope values from the sites examined within this thesis. These analyses would improve the discussion regarding the potential regions of

origin for these individuals, as well as changes in diet over the life course. An additional avenue for future work is to continue with isotope analysis of other historic sites in Atlantic Canada. This would allow for a more in-depth discussion of the history of Atlantic Canada in the 18th- and 19th-centuries.

This research contributes to the growing area of historic archaeological isotope data, especially in Atlantic Canada. It also offers a direct means of assessing the diet and potential regions of origin of the individuals who were buried at the Newfoundland sites of St. Paul's Anglican Church, Foxtrap-2, and St. Luke's Anglican Church and the Block 3 cemetery at the Fortress of Louisbourg. These isotopic data, along with the historical literature available, gives insight into these Atlantic Canada populations, specifically their dietary patterns and regions of origin. While historically the English and French fought to control land and resources in North America, the individuals living in these regions had similar isotopic signatures despite deep political and cultural divides.

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Appendix 1

Table A.1. Measured $\delta^{13}C$ and $\delta^{15}N$ values and collagen quality indicators in human bone samples from the sites examined within this thesis. Bold and italicized numbers indicate values that fall outside the acceptable range.

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F3	left humerus	1648	17.7	–17.31	14.05	43.2	15.6	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F4	right clavicle	1649	17.5	–16.73	16.45	43.9	15.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F7	left humerus	1645	12.5	–17.40	12.51	43.5	15.1	3.4
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013		right rib frag.	1646	12.6	–17.17	12.56	41.3	14.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F10	right humerus	1647	13.4	–17.32	20.14	43.9	15.1	3.4

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F11	right humerus	1644	8.5	–15.59	16.01	38.7	14.0	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F13	left humerus	1643	6.0	–15.98	16.82	44.0	16.1	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F21	right femur	1651	4.9	–18.02	13.75	38.4	13.2	3.4
St. Paul's Anglican Church, Harbour Grace, NL	Run by K. Pike 2013	F22	right humerus	1650	7.2	–17.06	15.06	39.8	14.5	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 253/ F6	fetal skull frags	4928	13.4	–17.48	15.77	42.2	15.6	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 255/F9	fetal neurocranial frags	4929	17.1	–17.34	17.65	43.5	16.1	3.2

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 259/ F15	left femur	4930	21.6	–17.22	15.18	***49.9***	16.3	3.6
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 260/ F16	right femur	4931	21.3	–16.74	16.00	44.4	16.2	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 261/ F19	right femur	4932	16.2	–17.28	14.73	44.0	16.2	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 264/ Ind. 1	left ramus	4933	16.7	–19.28	11.36	42.7	15.8	3.2
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP264/ Ind. 2	right ramus	4934	14.0	–16.38	16.93	42.7	16.0	3.1
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP 264/ Ind. 3	lower left mandible	4935	18.9	–16.95	18.43	44.7	16.16	3.2

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Paul's Anglican Church, Harbour Grace, NL	Garlie/ Munkittrick	NP264/ non-adult	ribs	4936	22.9	–17.19	14.79	42.7	15.5	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	4	unknown long bone	5162A	6.8	–17.81	17.13	41.6	14.8	3.3
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	4 (duplicate)	unknown long bone	5162B	6.8	–17.67	16.51	42.7	15.1	3.3
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	7	unknown long bone	5163	3.5	–17.17	18.34	41.4	14.7	3.3
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	8	skull fragment	5164	13.1	–16.98	16.32	43.7	16.1	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	9	frontal bone	5165	5.8	–17.29	14.79	41.5	14.6	3.3

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	10	maxilla	5166A	5.5	–17.32	17.76	42.9	15.6	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	10 (duplicate)	maxilla	5166B	5.5	–17.31	17.65	41.8	15.4	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	11	left clavicle	5167	3.5	–17.11	17.55	40.6	14.8	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	12	right humerus	5168	14.6	–16.30	17.41	44.5	16.4	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	13	maxilla	5169	3.0	–17.16	14.20	42.1	15.2	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	14	right ulna/ radius	5170A	2.9	–17.51	16.89	43.36	15.7	3.2

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	14 (duplicate)	right ulna/ radius	5170B	2.9	–17.45	15.14	42.5	15.4	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	20	right cranium	5171	2.4	–18.39	14.36	41.1	14.7	3.3
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	23	petrous portion	5172	12.3	–17.66	18.06	44.1	16.1	3.2
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	26	right temporal	5173	7.4	–17.26	15.34	42.1	15.6	3.1
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	30	left humerus	5174A	4.7	–17.72	17.96	41.7	14.8	3.3
Foxtrap–2, Foxtrap, NL	Garlie/ Munkittrick	30 (duplicate)	left humerus	5174B	4.7	–17.94	14.44	42.1	14.1	3.5

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
St. Luke's Anglican Cemetery, Placentia, NL	Run by A. Harris	62A	unknown	2834	2.2	–19.00	13.63	42.3	14.9	3.3
St. Luke's Anglican Cemetery, Placentia, NL	Run by A. Harris	67	unknown	3312	9.6	–18.10	12.70	43.2	15.6	3.2
St. Luke's Anglican Cemetery, Placentia, NL	Run by A. Harris	62 B	unknown	2848		–18.20	14.30	44.8	14.8	3.5
St. Luke's Anglican Cemetery, Placentia, NL	Run by A. Harris	62 C	unknown	2849	9.8	–16.86	13.79	43.3	15.0	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	1	rib	4772	4.3	–18.16	12.24	44.1	15.3	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	2	rib	4773A	5.8	–18.85	12.03	43.5	15.5	3.3

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	Garlie/ Munkittrick	2 (duplicate)	rib	4773B	5.8	–18.75	12.05	44.0	15.8	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	3	rib – left 2nd	4774	3.8	–18.57	11.15	43.4	14.9	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	4	rib	4775	1.2	–19.22	11.01	43.7	15.1	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	5	right radius	4776	8.3	–16.33	13.36	44.3	15.6	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	6	left fibula	4777	5.9	–11.59	11.05	44.7	15.9	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	7	rib	4778	1.7	–19.37	11.16	43.5	15.5	3.3

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	Garlie/ Munkittrick	8	rib	4779	2.6	–19.09	11.09	42.9	15.3	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	9	rib	4780	1.6	–19.11	9.30	43.1	15.5	3.2
Block 3, Louisbourg, NS	Garlie/ Munkittrick	10	rib	4781	9.8	–17.86	14.01	44.7	16.0	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	11	rib	4782	5.4	–19.79	11.79	44.0	15.7	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	12	rib	4783	2.1	–21.56	5.21	43.6	15.4	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	13	rib	4784	2.8	–18.23	12.57	42.3	14.7	3.4

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	Garlie/ Munkittrick	14	–	–	–	–	–	–	–	–
Block 3, Louisbourg, NS	Garlie/ Munkittrick	15	rib	4785	***0.5***	–18.07	12.45	41.5	14.5	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	16	rib	4786A	6.4	–19.56	12.57	43.7	15.6	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	16 (duplicate)	rib	4786B	6.4	–19.48	12.58	44.6	16.0	3.4
Block 3, Louisbourg, NS	Garlie/ Munkittrick	17	left radius	4787	3.9	–18.38	10.88	44.2	15.8	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	18	rib – left 2nd	4788	11.6	–15.09	11.71	41.5	14.6	3.3

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	Garlie/ Munkittrick	19	rib	4789	1.2	–14.97	18.64	41.5	14.6	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	20	rib	4790	2.5	–19.50	8.76	41.1	14.7	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	21	long bone – meta–carpal or –tarsal	4791	7.6	–19.87	11.81	44.6	15.7	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	22	right radius	4792	3.7	–18.85	11.68	44.1	15.4	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	23	right radius	4793A	10.5	–17.96	14.89	44.9	16.0	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	23 (duplicate)	right radius	4793B	10.5	–17.93	14.85	44.6	16.1	3.1

Site	Source	Burial	Element	MARC	Yield (%)	$\delta^{13}C$ ‰ VPDB	$\delta^{15}N$ ‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio
Block 3, Louisbourg, NS	Garlie/ Munkittrick	24	left radius	4794	8.6	–19.23	10.54	44.0	15.7	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	25	rib	4795	17.2	–16.05	16.94	44.5	15.9	3.3
Block 3, Louisbourg, NS	Garlie/ Munkittrick	BURIAL (44?)	cranial – frontal sinus	4796	3.9	–20.01	4.58	44.1	15.6	3.3

Table A.2. Measured $\delta^{13}C$ and $\delta^{15}N$ values and collagen quality indicators in faunal bone samples from Placentia, Newfoundland and the Fortress of Louisbourg, NS. Bold and italicized numbers indicate values that fall outside the acceptable range.

Site	Animal	Element	MARC	Yield (%)	$\delta^{13}C$‰ VPDB	$\delta^{15}N$‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Fish	pre–maxilla	5299	0.8	–14.66	14.47	36.5	13.6	3.1	
Placentia, NL	Fish	pre–maxilla	5300	0.5	–	–	–	–	1.5	*
Placentia, NL	Fish	pre–maxilla	5301	1.0	–	–	–	–	1.9	*
Placentia, NL	Fish	pre–maxilla	5307	1.0	–14.84	14.88	34.6	12.4	3.3	
Placentia, NL	Fish	pre–maxilla	5308	1.5	–14.83	12.36	35.8	13.4	3.1	
Placentia, NL	Fish (b)	“	5308B	"	–16.61	13.79	36.6	12.4	3.4	
Placentia, NL	Fish	pre–maxilla	5310	0.5	–	–	–	–	–	*
Placentia, NL	Fish	pre–maxilla	5312	0.5	–	–	–	–	–	*
Placentia, NL	Fish	pre–maxilla	5313	0.5	–	–	–	–	–	*
Placentia, NL	Fish	pre–maxilla	5314	1.4	–15.05	12.67	30.3	11.3	3.1	
Placentia, NL	Fish (b)	“	5314B	"	–15.15	15.97	31.6	11.6	3.2	

Site	Animal	Element	MARC	Yield (%)	$\delta^{13}C$‰ VPDB	$\delta^{15}N$‰ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Cow	femur	5316	11.1	–18.56	2.44	45.1	14.1	***3.7***	*
Placentia, NL	Cow	long bone	5318	13.0	–21.55	6.04	43.5	13.3	***3.8***	*
Placentia, NL	Cow	humerus	5319	8.7	–18.02	1.49	44.3	14.3	3.6	
Placentia, NL	Cow (b)	“	5319B	"	–18.1	2.84	42.8	13.8	3.6	
Placentia, NL	Seal	rib	5325	12.3	–22.03	7.26	41.3	13	***3.7***	*
Placentia, NL	Seal	carpal/ metacarpal	5326	8.9	–11.86	16.58	42.7	13.4	***3.7***	*
Placentia, NL	Seal	phalange	5327	3.8	–13.15	18.6	33.1	11.7	3.3	
Placentia, NL	Bird	ulna	5332	18.5	–19.61	3.04	43.4	13.4	***3.8***	*
Placentia, NL	Bird	ulna	5334	9.6	–14.52	15.84	42	14	3.5	
Placentia, NL	Bird	ulna	5341	14.1	–15.12	17.28	44.4	12.6	***4.1***	*
Placentia, NL	Fox?	humerus	5349	11.1	–19.7	6.15	42.7	13.2	***3.8***	*
Placentia, NL	Fox/cat	femur– juvenile	5353	19.2	–16.83	12.33	43	12.9	***3.9***	*
Placentia, NL	Fox?	long bone (radius)	5354	17.0	–12.66	17.15	40.5	12.9	***3.7***	*

Site	Animal	Element	MARC	Yield (%)	$\delta^{13}C‰$ VPDB	$\delta^{15}N‰$ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Rat	jaw	5355	18.9	–16.41	12.61	42.7	12.7	***3.9***	*
Placentia, NL	Rat (b)	“	5355B	"	–16.49	10.97	43.7	13.4	***3.8***	*
Placentia, NL	Squirrel?	tibia	5356	19.3	–16.51	13.64	44.4	13.1	***3.9***	*
Placentia, NL	Squirrel?	tibia	5357	14.4	–16.13	12.44	42.5	12.9	***3.9***	*
Placentia, NL	Fox?	humerus	5363	16.0	–14.5	14.81	42.5	13	***3.8***	*
Placentia, NL	Hare/ Cat	metatarsal	5364	14.9	–14.25	18.05	42.3	13.9	3.5	
Placentia, NL	Hare/ Cat (b)	“	5364B	"	–14.13	18.09	44.1	14.3	3.6	
Placentia, NL	Pig	mandible	5368	6.0	–12.67	8.41	42.6	13.8	3.6	
Placentia, NL	Pig	mandible	5369	17.6	–20.99	5.51	44.7	14.2	***3.7***	*
Placentia, NL	Pig (b)	“	5369B	"	–21.12	5.14	44.3	14.2	***3.7***	*
Placentia, NL	Pig	mandible	5370	17.5	–19.74	3.23	44.1	12.8	***4***	*
Placentia, NL	Sheep/ Goat	humerus	5376	17.3	–19.75	4.68	43.9	13.8	***3.7***	*
Placentia, NL	Sheep/ Goat	humerus	5377	13.3	–21.47	7.37	43.5	14.3	3.5	

Site	Animal	Element	MARC	Yield (%)	$\delta^{13}C‰$ VPDB	$\delta^{15}N‰$ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Placentia, NL	Sheep	humerus	5378	13.2	–20.2	4.06	44.3	14	***3.7***	*
Placentia, NL	Sheep (b)	“	5378B	"	–20.22	6.9	44.2	13.5	***3.8***	*
Fortress of Louisbourg, NS	Fish	premaxilla	5231	3.0	–14.93	12.06	40.8	15.3	3.1	
Fortress of Louisbourg, NS	Cow	phalanx	5232	13.0	–19.62	4.08	42.7	13.1	***3.8***	*
Fortress of Louisbourg, NS	Cow (b)	“	5232B	“	–19.7	6.11	42.5	14.2	3.5	
Fortress of Louisbourg, NS	Pig	metatarsal	5233	17.0	–13.54	7.32	42.8	15.9	3.1	
Fortress of Louisbourg, NS	Sheep/Goat	humerus	5234	6.4	–20.54	6.01	42.5	15.9	3.1	
Fortress of Louisbourg, NS	Canine	root of tooth	5235	13.3	–14.83	20.17	42.9	16.1	3.1	
Fortress of Louisbourg, NS	Bird	humerus	5236	6.3	–20.16	9.35	42.3	15.7	3.1	
Fortress of Louisbourg, NS	Pig	cervical vertebra	5290	19.2	–19.93	6.69	43.5	15.9	3.2	
Fortress of Louisbourg, NS	Pig	astragalus	5291	7.3	–20.29	6.8	42.5	16.2	3.1	
Fortress of Louisbourg, NS	Pig	3rd/4th metatarsal epiphysis	5292	12.4	–21.04	5.17	41.7	15.9	3.1	

Site	Animal	Element	MARC	Yield (%)	$\delta^{13}C‰$ VPDB	$\delta^{15}N‰$ AIR	% wt. C	% wt. N	C/N Atomic Ratio	Rejected or Lost
Fortress of Louisbourg, NS	Pig (b)	“	5292B	“	–21.06	5.67	41.6	15.8	3.1	
Fortress of Louisbourg, NS	Pig	3rd/4th phalanx	5293	8.0	–21.47	9.06	41.9	15.6	3.1	
Fortress of Louisbourg, NS	Cow	astragalus	5294	3.5	–17.83	6.49	40.7	15.2	3.1	

Table A.3. Measured and corrected $^{87}Sr/^{86}Sr$ values for the sites examined., as well as the standard error (SE) for each measured $^{87}Sr/^{86}Sr$ value, the ^{88}Sr voltage (V), ^{85}Rb voltage (V) and $^{84}Sr/^{86}Sr$ value.

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	3	LRM2	4390	0.710099	0.710069	0.000008	13.9	0.001183	0.056415
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	7	LLM2	4391	0.709617	0.709586	0.000009	13.9	0.000187	0.056442
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	21	ULM2	4392	0.709521	0.709490	0.000008	23.4	0.000445	0.056473
St. Paul's Churchyard, Harbour Grace, NL	Run by K. Pike 2013	22	LRM2	4393	0.709628	0.709597	0.000008	19.0	0.000266	0.056464
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	251/F4	ULPM 4	5219	0.710081	0.710035	0.000005	20.4	0.000206	0.056438

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	254/F7	LLM1	5220	0.709561	0.709515	0.000009	10.8	0.000593	0.056382
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick		LLM3	5221	0.709638	0.709592	0.000010	13.7	0.000257	0.056420
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	258/F13	URM2	5222	0.709914	0.709868	0.000006	26.0	0.002050	0.056479
St. Paul's Churchyard, Harbour Grace, NL	Garlie/ Munkittrick	NP 264/ Ind. 1	LLM1	5223	0.709627	0.709581	0.000007	18.3	0.002555	0.056470
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	4	LRM2	5178	0.709431	0.709384	0.000007	16.5	0.000193	0.056458
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	7	ULM2	5179	0.709425	0.709379	0.000008	11.1	0.000143	0.056380

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	9	URM2/ 3	5180	0.710148	0.710102	0.000016	4.2	0.000136	0.056377
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	10	ULM2	5181	0.709511	0.709465	0.000010	8.1	0.000160	0.056368
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	11	LLM2	5182	0.709463	0.709417	0.000008	9.7	0.000142	0.056494
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	12	LRM2	5183	0.709577	0.709531	0.000010	9.9	0.000229	0.056420
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	13	URM2	5184	0.709519	0.709473	0.000010	10.1	0.000185	0.056481
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	14	URM2	5185	0.709506	0.709460	0.000015	5.9	0.000245	0.056470

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
Foxtrap-2, Foxtrap, NL	Garlie/ Munkittrick	30	LRM2	5186	0.709732	0.709686	0.00010	9.3	0.000255	0.056428
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	62A	URM2	4675	0.710268	0.710228	0.000009	11.2	0.070409	0.056456
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	63	URM1	4676	0.710389 0.710365	0.710377*	0.000006 0.000009	20.3 9.6	0.000075 0.000579	0.056457 0.056456
	Run by Munkittrick		URM2	4677	0.710124	0.710083	0.000005	23.2	0.000064	0.056452
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	66A	LRM1	4679	0.709733	0.709692	0.000017	5.1	0.000228	0.056429
	Run by Munkittrick		LRM2	4680	0.710377	0.710336	0.000010	9.6	0.00855	0.056488

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
St. Luke's Anglican Cemetery, Placentia, NL	Run by Munkittrick	67	URM1	4683	0.709898	0.709858	0.000009	8.2	0.000306	0.056488
Block 3, Louisbourg, NS	Garlie/ Munkittrick	1	LLM2 (3?)	4695	0.708980	0.708940	0.000006	33.5	0.000324	0.056481
Block 3, Louisbourg, NS	Garlie/ Munkittrick	2	URM2	4696	0.708832	0.708791	0.000008	16.0	0.000429	0.056424
Block 3, Louisbourg, NS	Garlie/ Munkittrick	3	ULM2	4697	0.708427	0.708386	0.000007	23.6	0.000299	0.056469
Block 3, Louisbourg, NS	Garlie/ Munkittrick	4	URPM 4	4698	0.709708	0.709667	0.000010	9..9	0.000083	0.056414
Block 3, Louisbourg, NS	Garlie/ Munkittrick	7	LLPM4	4699	0.715542	0.715502	0.000014	7.1	0.000415	0.056407

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
Block 3, Louisbourg, NS	Garlie/ Munkittrick	8	LLM2	4700	0.709691	0.709651	0.000008	14.7	0.001046	0.056517
Block 3, Louisbourg, NS	Garlie/ Munkittrick	9	ULPM 4	4701	0.709711	0.709671	0.000007	15.5	0.001540	0.056475
Block 3, Louisbourg, NS	Garlie/ Munkittrick	10	LLM2	4702	0.712033	0.711993	0.000010	10.2	0.000210	0.056451
Block 3, Louisbourg, NS	Garlie/ Munkittrick	12	LLM2	4703	0.713437	0.713396	0.000008	11.4	0.000103	0.056448
Block 3, Louisbourg, NS	Garlie/ Munkittrick	13	ULM2	4704	0.709363	0.709323	0.000009	16.0	0.000207	0.056476
Block 3, Louisbourg, NS	Garlie/ Munkittrick	15	ULM2	4705	0.710472	0.710432	0.000005	28.9	0.000104	0.056466

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
Block 3, Louisbourg, NS	Garlie/ Munkittrick	16	ULM2	4706	0.711262	0.711222	0.000008	13.5	0.000228	0.056452
Block 3, Louisbourg, NS	Garlie/ Munkittrick	17	LRM2	4707	0.708987	0.708946	0.000008	18.0	0.000905	0.056493
Block 3, Louisbourg, NS	Garlie/ Munkittrick	18	LRM2	4708	0.709527	0.709487	0.000007	16.9	0.000275	0.056527
Block 3, Louisbourg, NS	Garlie/ Munkittrick	19	URPM 4	4709	0.710481	0.710441	0.000009	13.0	0.000273	0.056434
Block 3, Louisbourg, NS	Garlie/ Munkittrick	20	URM2	4710	0.707855	0.707815	0.000006	24.7	0.000307	0.056477
Block 3, Louisbourg, NS	Garlie/ Munkittrick	23	ULM2	4711	0.709815	0.709775	0.000008	13.3	0.000220	0.056447

Site Name	Source	Burial	Tooth	MARC	Measured $^{87}Sr/^{86}Sr$	Corrected $^{87}Sr/^{86}Sr$	1 SE	^{88}Sr (V)	^{85}Rb (V)	$^{84}Sr/^{86}Sr$
Block 3, Louisbourg, NS	Garlie/ Munkittrick	25	URPM 3	4712	0.709650	0.709610	0.000011	8.0	0.000096	0.056472
Block 3, Louisbourg, NS	Garlie/ Munkittrick	44	LLPM4	4713	0.710349	0.710309	0.000011	11.6	0.000085	0.056455

Table A.4. $\delta^{13}C$ and $\delta^{15}N$ values of calibration standards (EDTA #2 and USGS62) and check standard (B2155).

	δ^{15}N‰ AIR			**δ^{13}C‰ VPDB**		
	Calibration Standards		**Check Standard**	**Calibration Standards**		**Check Standard**
Run	*EDTA #2*	*USGS62*	*B2155*	*EDTA #2*	*USGS62*	*B2155*
1	-0.98	20.19	5.91	-40.43	-14.78	-27.24
1	-0.99	20.19	5.94	-40.36	-14.83	-27.28
1	-1.00	20.18	5.89	-40.37	-14.80	-27.30
1	-0.96	20.19		-40.42	-14.81	
1	-1.00	20.17		-40.38	-14.80	
2	-0.99	20.21	5.95	-40.42	-14.81	-27.32
2	-1.02	20.16	5.90	-40.41	-14.83	-27.21
2	-0.95	20.16	5.87	-40.41	-14.86	-27.43
2	-1.01	20.25	5.77	-40.34	-14.74	-27.44
2	-1.03	20.12		-40.50	-14.89	
2	-0.98	20.20		-40.38	-14.80	
3	-2.65	20.16	5.94	-40.35	-14.79	-27.16
3	-2.57	20.18	5.91	-40.35	-14.79	-27.22
3	-2.87	20.20	5.94	-40.37	-14.77	-27.24
3	-3.11	20.12	6.01	-40.33	-14.78	-27.18
3	-2.44	20.18		-40.44	-14.74	
3	-2.69	20.18		-40.45	-14.88	
4	-1.63	20.13	5.92	-40.35	-14.83	-27.20
4	-1.17	20.18	6.00	-40.46	-14.70	-27.22
4	-1.27	20.20	5.95	-40.38	-14.82	-27.33
4	-1.07	20.17	5.98	-40.39	-14.83	-27.15

	δ^{15}N‰ AIR			δ^{13}C‰ VPDB		
	Calibration Standards		**Check Standard**	**Calibration Standards**		**Check Standard**
Run	*EDTA #2*	*USGS62*	*B2155*	*EDTA #2*	*USGS62*	*B2155*
4	-1.03	20.13		-40.29	-14.76	
4	-1.52	20.21		-40.41	-14.80	
5	-2.56	20.14	6.05	-40.38	-14.83	-27.19
5	-2.71	20.26	5.95	-40.34	-14.75	-27.21
5	-2.93	20.15	6.01	-40.42	-14.83	-27.21
5	-2.70	20.26	5.94	-40.37	-14.76	-27.22
5	-2.76	20.14		-40.39	-14.83	
5	-3.49	20.06		-40.39	-14.75	

Table A.5. Correction standard NIST SRM987 measurements from three different runs. Bold numbers in the difference from accepted column are what the strontium samples in each run are adjusted by. ([a]TIMS value from Avanzinelli et al. 2005).

Correction Standard	$^{87}Sr/^{86}Sr$	Difference from accepted
St. Paul's MARC 4390-4393		
SRM987	0.710276	0.000028
	0.710272	0.000024
	0.710285	0.000037
	0.710269	0.000021
	0.710287	0.000039
	0.710294	0.000046
	0.710276	0.000028
	0.710260	0.000012
	0.710269	0.000021
	0.710300	0.000052
Ave	0.710279	**0.000031**
1 S.D.	0.000012	
SRM987[a]	0.710248	
Block 3 and St. Luke's		
SRM987	0.710268	0.000020
	0.710272	0.000024
	0.710291	0.000043
	0.710292	0.000044
	0.710289	0.000041
	0.710287	0.000039
	0.710298	0.000050
	0.710290	0.000042
	0.710292	0.000044

Correction Standard	$^{87}Sr/^{86}Sr$	Difference from accepted
Block 3 and St. Luke's (continued)		
SRM987	0.710274	0.000026
	0.710312	0.000064
	0.710296	0.000048
	0.710268	0.000020
	0.710307	0.000059
Ave	0.710288	**0.000040**
1 S.D.	0.000013	
SRM987[a]	0.710248	
St. Paul's and Foxtrap 2		
SRM987	0.710289	0.710281
	0.710296	0.710288
	0.710291	0.710283
	0.710277	0.710269
	0.710292	0.710284
	0.710301	0.710293
	0.710303	0.710295
	0.710300	0.710292
	0.710287	0.710279
	0.710294	0.710287
	0.710304	0.710296
Ave	0.710294	**0.000046**
1 S.D.	0.000008	
SRM987[a]	0.710248	

Table A.6. Quality control standard NIST SRM 1400 measured from three different runs. ([b]TIMS values (n=20) taken from Galler et al. 2007).

Quality Control Standard	$^{87}Sr/^{86}Sr$	Difference from accepted
St. Paul's MARC 4390-4393		
SRM1400_75	0.713147	-0.000001
SRM1400_76	0.713140	-0.000008
SRM1400_48	0.713130	-0.000018
SRM1400_69	0.713156	0.000008
Ave	0.713143	**-0.000005**
1 S.D.	0.000011	
SRM1400[b]	0.713148	
Block 3 and St. Luke's		
SRM1400_79	0.713174	0.000026
SRM1400_80	0.713109	-0.000039
SRM1400_81	0.713164	0.000016
SRM1400_82	0.713135	-0.000013
SRM1400_92	0.713157	0.713157
Ave	0.713148	**0.000000**
1 S.D	0.000026	
SRM1400[b]	0.713148	
St. Paul's and Foxtrap 2		
SRM1400_118	0.713168	0.000020
SRM1400_120	0.713189	0.000041
SRM1400_121	0.713150	0.000002
Ave	0.713169	**0.000021**
1 S.D.	0.000019	
SRM1400[b]	0.713148	

Appendix 2

Appendix 2 contains examples of code used in this thesis using R 3.6.0 software.

A.1. The following code was used to group the dataframe by multiple columns including count, mean, standard deviation, median, and interquartile range:

```
group_by(HSD,Site) %>%
  summarise(
    count= n(),
    mean= mean(d13C, na.rm = TRUE),
    sd= sd(d13C, na.rm = TRUE),
    median= median(d13C, na.rm = TRUE),
    IQR= IQR(d13C, na.rm = TRUE))
```

A.2. The following code was used to run the Shapiro-Wilk normality test:

```
shapiro.test(HSD$d13C)
```

A.3. The following code was used to run the Kruskal-Wallis rank sum test:

```
kruskal.test(d13C~Site, data = HSD)
```

A.4. The following code was used to run the Dunn (1964) Kruskal-Wallis multiple comparison, with p-values adjusted with the Benjamini-Hochberg method:

```
install.packages("FSA")

library("FSA")

HSD<-read_csv("MAthesis - July 2021/R csv data/NL CNdata 3.29.21.csv")

dunnTest(d13C~Site,
         data = HSD,
         method = "bh")
```

A.5. The following is an of code used to create the figures for this thesis. This code created a boxplot illustrating the spread of the isotope values and shows the central tendency line indicating the median of the data, a box that represents the Interquartile Range, and whiskers that indicate the 25th and 75th percentiles of the data:

```
ggboxplot(HSD, x="Site", y="d13C",
          outlier.shape=NA,
          color= "Site", palette= c("black", "black", "black", "black"),
          order = c("St. Paul's", "Foxtrap2", "St. Luke's", "Block 3"))+
  labs(x= "Site",
       y= "*&delta;*<sup>13</sup>C (&permil;VPDB)")+
  theme(text = element_text(size=16, family = "serif"))+
  theme(axis.title.y = element_markdown())+
  theme(legend.position = "none")+
  geom_jitter(position = position_jitter(width = .1, height=0))+
  theme(axis.text.x = element_text(angle=45, hjust=1))
```