EXPLORING ENSLAVED AFRICAN LIFEWAYS: AN ISOTOPIC STUDY OF AN 18TH CENTURY CEMETERY (SE600) ON ST. EUSTATIUS, CARIBBEAN NETHERLANDS

by

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A thesis submitted to the Graduate Council of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Arts
with a Major in Anthropology
December 2019

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DEDICATION

For Gramma, Grandpa, Granny and Grandad.

ACKNOWLEDGEMENTS

I would first like to thank the St. Eustatius Center for Archaeological Research (SECAR), Fred van Keulen, and Dr. Ruud Stelten for their assistance and support. To the Caribbean Netherlands Science Institute (CNSI), thank you for hosting myself, my crew, and fellow researchers so research like this can be done. I would also like to thank Conchita Van Zanten, the property owner, without your interest and support none of this would be possible. I would like to thank the Center for Applied Isotope Studies (CAIS) at the University of Georgia for preparing and running my isotope samples. I would also like to thank the Center for Archaeological Studies (CAS) and Graduate College for the support that allowed me to further my education and pursue this project.

Next, I would like to thank the members of my thesis committee. To Dr. Nicholas Herrmann, thank you for your wealth of ideas and your advice. To Dr. Ashley McKeown, thank you for your patience, kindness, and for inspiring me to be a better bioarcheologist. To Dr. Todd Ahlman, my committee chair and mentor, your support has allowed me to do more than I could have ever imagined. Thank you for igniting my passion for Caribbean archaeology, teaching me to be a better academic, and making me an all-around better archaeologist.

I would also like to thank my cohort; without you I would have gone crazy. Your friendship has seen me through some difficult times, and it has been an honor to be in this program with you for the last 2 years. To Anna Follett, thank you for weathering my many mental breakdowns and being so supportive. To Laney Feeser, thank you for reading early drafts of this thesis and offering helpful feedback. To Robyn Kramer, thank you for your generosity and for answering all my pestering isotope questions. To Mindy Rogers and Kevin Verdel, thank you for helping me collect my faunal data on Statia. To my students in Statia, you are all rockstars and your help collecting my thesis data in Statia was invaluable. Thank you to everyone for their help and support.

Finally, I want to thank my family. To Mom, Dad, Steve, Lisa, Sarah, Shannon, Gramma, and Grandad, your support throughout this process has meant a lot and without it I would not be where I am today. To Kristyn, Autumn, and Ashley, thank you for your continued friendship and support. To my boyfriend, Austin, these past couple of years have been hard but thank you for being a source of undying love and support. Thank you for taking care of our little family while I was away completing this research. Last but not least, to Noodle, Pfelix, and Mowgli, thank you for the laughs and love when I needed it most, your wagging tails made every day better.

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LIST OF ABBREVIATIONS

Abbreviation	Description
ANOVA	Analysis of Variance
CAIS	Center for Applied Isotope Studies
CAM	Crassulacean Acid Metabolism
CSA	Canine Surrogacy Approach
DWIC	Dutch West Indies Company
EA-IRMS	Elemental Analyzer Isotope Ratio Mass Spec.
GEB	Grady Early Building (Texas State University)
GNIP	Global Network for Isotopes in Precipitation
IAEA	International Atomic Energy Agency
IRMS	Isotope Ratio Mass Spectrometer
MMD	Minimum Meaningful Difference
OIPC	Oxygen Isotopes in Precipitation Calculator
SECAR	St. Eustatius Center for Archaeological Research
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

ABSTRACT

St. Eustatius (Statia) is a small island in the Dutch Caribbean, with a total surface area of 21 km^2. Due to the island's small size and dry climate, it was generally ignored by colonial powers as a plantation island. First colonized by the Dutch in 1636, Statia would change hands 22 times between the 17^{th} and 19^{th} centuries. The island's free port made it a cornerstone of trade in the colonial Caribbean. The thriving trade economy on Statia cultivated a social environment set apart from others in the Caribbean with all parties, free and enslaved Africans included, having opportunities to participate in trade.

This thesis presents the results of stable isotope analysis of human remains from the Godet Cemetery (SE600), which is believed to be a cemetery for enslaved Africans associated with the Godet Plantation. This study uses nitrogen, oxygen, and carbon isotopic analyses to examine the diet, health, and residential history of these individuals prior to death. The ultimate goal of this thesis is to determine if the effects of the social environment documented on Statia during the colonial period was evident biologically. Additionally, the data presented in this study are compared to previously published Caribbean isotopic studies. This study finds that the Godet Cemetery individuals had an intermediate diet consisting of both C_3 and C_4 plants and a considerable quantity of marine proteins. Preliminary interpretation of the residential history suggests that four of these individuals were recent migrants to Statia in the years prior to death.

I. INTRODUCTION

The African diaspora in the New World and Caribbean has been extensively documented through historical records and archaeological research (Higman 1984; Kiple 1984; Corruccini et al. 1987; Hall and Higman 1992; Varney 2003; Madrigal 2006; Gilmore 2008, 2010, 2013, 2016; Schroeder et al. 2009; Eltis and Richardson 2010; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2018; Byrd 2014; Handler and Wallman 2014). This research is instrumental in documenting past lifeways of enslaved Africans. Notably, these marginalized groups are often left out of historical documents and narratives. Recently, isotopic analyses have expanded our understanding of residential history, migration patterns, diet and nutrition of the African Diaspora in the Caribbean (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2018). The Dutch Caribbean island of St. Eustatius (Figure 1), also known as Statia, offers an interesting opportunity to understand the lifeways of enslaved Africans.

Statia is relatively unknown to people today; however, historically, Statia was a major player in the Caribbean's colonial economy as a prime trade destination due to its free port status (Gilmore 2010, 2013). Statia's importance in the Caribbean colonial economy led to a social environment different from most of the colonial world (Gilmore 2013) where all social classes, including enslaved Africans, could participate. Unlike most islands in the Caribbean, enslaved Africans on Statia were employed in both rural and urban contexts. Enslaved Africans working in rural contexts were involved in sugar cane cultivation, raising provisions, and commercial trade in the island's

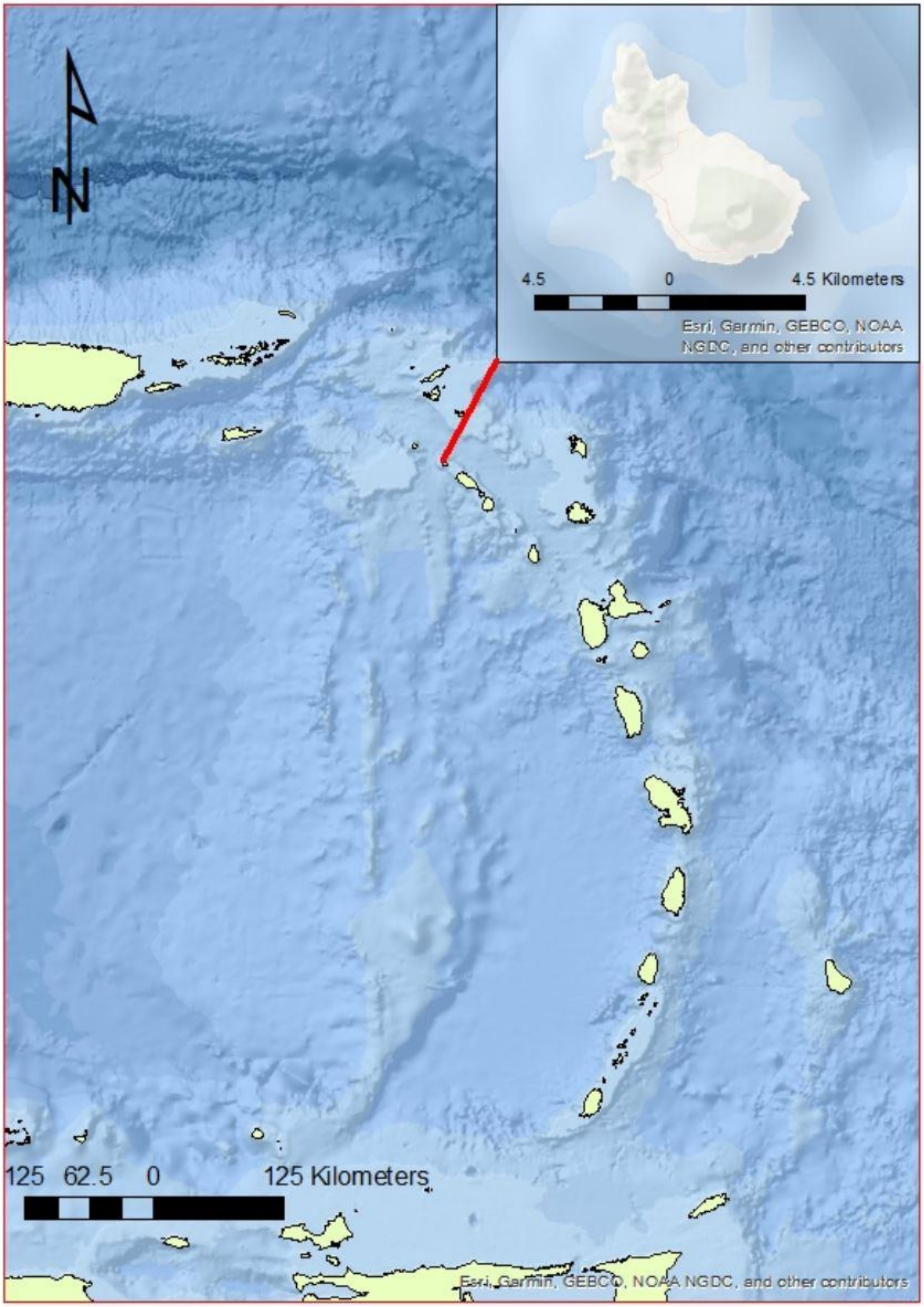

Figure 1. Map of Caribbean and St. Eustatius.

warehouses, and likely the illegal processing of imported sugar into refined products, such as rum. Enslaved Africans in urban contexts worked in the hundreds of warehouses lining the coast, as shipbuilders, or other specialized tasks (Gilmore 2010: 52-53). Enslaved Africans working in the commercial warehouses were permitted certain opportunities and monetary incentives in exchange for their handling of merchant's goods. Contact with other tradespeople would have provided ample opportunity for enslaved Africans to participate in the trade economy (Gilmore 2010: 57-58). The ability for enslaved Africans to make their own money by participating in trade meant they were capable of buying their freedom quicker than slaves on other islands. At its peak, the free African population on Statia was as high as 13%, which is in stark contrast to the 3% that was typical of most of the Caribbean (Gilmore 2013). Additionally, this also meant that enslaved Africans could buy some of their own food or other goods and services they may have needed (Madrigal 2006; Gilmore 2010). This distinction is important, because it is what sets the social environment on Statia apart from the rest of the colonial Caribbean. While enslaved Africans on other islands primarily worked on plantations, the access that enslaved Africans had to commercial activities on Statia is unparalleled (Gilmore 2010: 63-65).

There is little stable isotope research to support the assertions being made about the distinct environment of colonial Statians. Stable isotope analysis has been successfully used to track residential history and diet of human and faunal skeletal remains from different islands in the Caribbean (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2017, 2018). These studies have developed an isotopic baseline for dietary and migration studies of enslaved

Africans throughout the Caribbean (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2018). The success of previous isotopic studies in the Caribbean makes the application of these analyses an effective methodology to develop a more detailed representation of enslaved life on Statia.

This thesis utilizes oxygen, carbon, and nitrogen isotopic analysis to examine the residential history, diet, and health of enslaved Africans buried at the Godet Cemetery (SE600) (Figure 2) on Statia and understand how these factors reflect Statia's historical social environment. To accomplish this task, bone collagen and bone apatite samples from 11 individuals buried at the Godet Cemetery were isotopically analyzed. These samples are compared to eight recently deceased faunal samples collected from various locations around Statia and previous isotopic studies from the Caribbean. Research has shown that comparison of isotopic values from humans to those of local fauna are a good indicator of bioavailable isotopic ratios (Tykot 2004; Laffoon 2012).

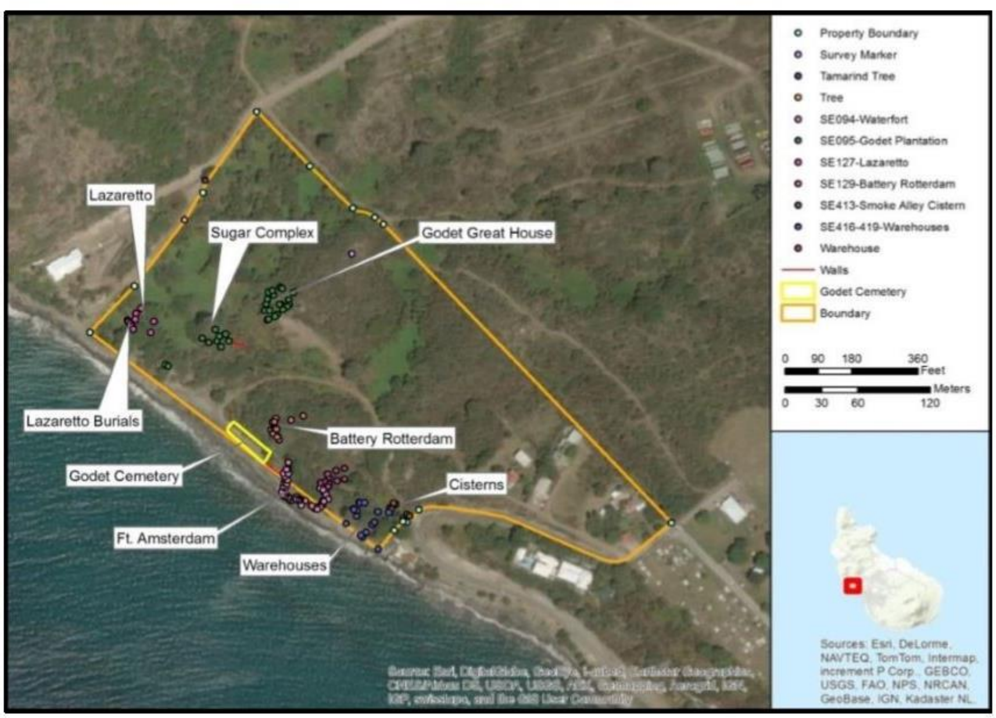

Figure 2. Map of the Godet Property. Map by Todd Ahlman.

Research Questions

The following research questions compose the core of this study that examines the residential history, diet, and health of enslaved Africans buried at the Godet Cemetery (SE600) on Statia and for understanding how these factors reflect Statia's social environment during the 18th century.

1. What was the residential history of these individuals in the years prior to death? Are there local and recently non-local individuals in the population?
2. What was the diet of the individuals buried in the Godet Cemetery? Was it primarily terrestrial, marine, or a combination?
3. How was the health of the individuals buried in the Godet Cemetery? Are there any isotopic indications of malnutrition?
4. What do these results say about life on the Godet Plantation? Are these results in line with what is currently known about the social environment on Statia at the time?

Research Assumptions

Three assumptions have been made and assumed to be true for this research: 1) buried individuals are likely of African ancestry (Dr. Ashley McKeown, Personal Communication 2018; Wanstead and Rogers 2019); 2) individuals buried in the cemetery are likely associated with the Godet Plantation (Dr. Ashley McKeown, Personal Communication 2018; Tucker 2019); and 3) individuals consuming local resources will have isotopic signatures similar, but enriched, to that of the local faunal samples.

Research Hypotheses

It is hypothesized that most individuals in this study resided on Statia for most, if not all, of their lives. It is hypothesized that these individuals will likely be locals because many enslaved Africans brought to Statia did not end up there, rather Statia was a stopping point before being redistributed throughout the Caribbean and Americas. The diet of these individuals will be a diverse, generalized diet, consisting of a combination of C_3, C_4, terrestrial, and marine resources. Previous isotopic analysis of enslaved populations and zooarchaeological studies from nearby Caribbean islands suggest an intermediate diet is common for Caribbean enslaved populations (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2013; Kelly and Wallman 2014; Wallman and Grouard 2017). Due to the social environment present on Statia, the diet of enslaved Africans would have had greater nutritional value than expected for similar populations and would suggest less dietary, nutritional, and protein stress. A biological profile developed from skeletal remains will be used to estimate ancestry, sex, indications of nutritional stress and/or pathologies, while isotopic data will be used to determine recent residential history, diet and health.

Research Contents

This research addresses questions about residential history, diet, and health of the individuals recovered from the Godet Cemetery. An introduction to stable isotopes and their uses in Caribbean archaeology are addressed in Chapters II and III. Chapter IV introduces Statia, examining the island’s complicated history, and the Godet Cemetery (SE600), reviewing previous research and excavations at the site. Chapter V details the burials, preparation, and techniques used to analyze the samples. Chapters VI and VII discuss isotopic analysis results for each sample and inferences on diet, health, and residential history from the results. Chapter VIII summarizes and concludes this research.

II. THEORETICAL BACKGROUND

The elements found on the periodic table are the fundamental units of which everything is made. Each element on the periodic table is ordered by its atomic mass or the sum of an atom's protons and neutrons. Isotopes are atoms of an element that contain different numbers of neutrons in their nuclei (Meier-Augenstein and Kemp 2009). This difference in neutrons changes the atomic weight of the element, though it retains the same chemical characteristics. Over 90 elements found in nature have more than one isotopic form and many do not decay. These isotopes that do not decay but stay in the same elemental form are stable isotopes (Meier-Augenstein and Kemp 2009).

Generally, figures for elemental isotope abundance are given as a percentage. For example, the stable isotope abundances of ^{16}O, ^{17}O, and ^{18}O are 99.757, 0.038, 0.205 atom%, respectively. When determining the natural abundance of a given material, isotope abundance is expressed as a ratio. This ratio usually consists of the minor and heavier isotope over the major and lighter isotope of a given element, such as the ratio for oxygen generally given as $^{18}O/^{16}O$. Changes in the natural abundance of isotopes is quite small and to make these data more manageable the measured ratio is expressed in comparison to a known isotopic reference standard. Stable isotope analysis is typically completed using an isotope ratio mass spectrometer (IRMS). IRMS instruments can detect very small changes in isotope abundance (Carter and Barwick 2011).

The following section discusses the standards, equations, and theoretical background of stable isotopes. Specifically, this section discusses carbon, nitrogen, and oxygen isotopes since they are the focus of the present study. The theory discussed in this chapter is primarily focused on the isotopic analysis of mammalian tissues and the information that stable isotope analysis yields about these tissues. There are many uses for stable isotope analysis and only a subset is discussed below.

Delta Notation

Changes in the natural abundance of isotopes are typically very small. To make these values more manageable, they are expressed in delta notation (δ). The equation for delta notation is as follows:

$$(1)\quad \delta = \frac{R_{sample} - R_{standard}}{R_{standard}} \times 1000\,‰$$

The results of the notation equation are expressed in permille (‰). Permille is defined as parts per thousand; it is frequently confused with parts per million. Positive δ values indicate a higher abundance of the heavier isotope and negative δ values indicate a lower abundance of the heavier isotope than the reference standard (Meier-Augenstein and Kemp 2009).

Reference Scales

Data for all light isotopes are reported in the standard reference scale for that element. The basis of isotope geochemistry is the global comparison of data sets, which requires the standardization of measurements (Clark and Fritz 1997). These reference scales are in place to ensure that isotope results from different labs are comparable. Nitrogen isotope ratios are reported relative to AIR. Oxygen isotope ratios are generally reported relative to Vienna Standard Mean Ocean Water (VSMOW). The results of carbon analyses are reported relative to the Vienna Pee Dee Belemnite (VPDB) standard. For consistency, when results are in both VSMOW and VPDB, there are accepted equations to allow the conversion from one standard to the other.

$$(2)\ \delta^{18}O_{VSMOW} = 1.03091 \times \delta^{18}O_{VPDB} + 30.91$$ (Carter and Barwick 2011)

$$(3)\ \delta^{18}O_{VPDB} = 0.97002 \times \delta^{18}O_{VSMOW} - 29.98$$ (Coplen 1988)

In addition to international standards, researchers can also benefit from sampling the local environment. This allows researchers to create their own standards with a known local origin, also known as isotope bioavailability. By establishing a bioavailable isotopic range, researchers can directly compare a variety of samples from the same location throughout time (Tykot 2004). There is some debate in the field about whether modern or archaeological samples are better for establishing this standard (Hoefs 2009). The use of a comparative sample is dependent on the research question being investigated.

Carbon Isotopes

Carbon isotope ratios in bone are frequently used to examine diet prior to death. Diet reconstruction is possible due to the differential fractionation processes of atmospheric CO_2 during photosynthesis (Tykot 2004). There are two stable isotopes of carbon that are common in nature, ^{12}C and ^{13}C. Small differences in the $^{12}C/^{13}C$ ratio are measured using an isotope ratio mass spectrometer. Carbon isotope measurements are reported using delta notation, $\delta^{13}C$, relative to the internationally recognized standard, ‰VPDB (Tykot 2004).

Previous research has shown that different bone tissues reflect various portions of the diet (White and Armelagos 1997; Tykot 2004, 2006; France and Owsley 2015). Bone collagen better reflects dietary proteins, while bone apatite reflects a mixture of protein, carbs, and fats (Tykot 2004). Both bone collagen and apatite are constantly being resorbed and replenished, so its carbon composition is most reflective of the dietary averages over the last few years of life. In contrast, the carbon composition of tooth enamel reflects the diet at the time of crown formation (Tykot 2004).

Table 1. Carbon Isotope Fractionation in Foodwebs (Tykot 2004: 435).

Sample Material	C_3 Photosynthesis	C_4 Photosynthesis
Plants	-26.5‰	-12.5‰
Collagen	-21.5‰	-7.5‰
Apatite	-14.5‰	-0.5‰

For dietary studies, the results of carbon isotopic analyses are indicative of the photosynthetic pathway that the plant uses to synthesize carbon. Plants utilizing the C_4 pathway are typically grasses native to hot, arid environments and have $\delta^{13}C$ values averaging -12.5‰. Trees, shrubs, and grasses from temperate regions typically follow the C_3 pathway and have $\delta^{13}C$ values averaging -26.5‰ (Tykot 2004, 2006; Table 1). CAM (crassulacean acid metabolism) plants are unique. These plants switch between C_3 and C_4 depending on the environment they are in (Tykot 2006). Table 1 above illustrates the carbon values expected for pure C_3, pure C_4, and intermediate feeders. Additionally, Table 2 below gives examples of commonly eaten foods in the Caribbean that utilize these different photosynthetic pathways.

Table 2. Examples of Foods Utilizing the Different Photosynthetic Pathways (Moore et al. 1995).

C_3	C_4	CAM
Potatoes	Corn	Agave
Sweet Potatoes	Sugar Cane	Cacti
Cassava	Cabbage	Pineapple
Yams	Millet	
Rice	Sorghum	
Wheat		
Oats		
Citrus		
Soursop		

Nitrogen Isotopes

Like carbon, nitrogen ratios in human bone are used to examine diet due to the differential fractionation of nitrogen during fixation or absorption (Tykot 2004). Nitrogen values are a good indicator for the types of protein, marine versus terrestrial, that an organism is consuming. There are two nitrogen isotopes commonly found in nature: ^{14}N and ^{15}N. Small differences in the $^{15}N/^{14}N$ ratio can be measured using an isotope ratio mass spectrometer. Nitrogen measurements are expressed in delta notation, $\delta^{15}N$, relative to the international reference standard, ‰AIR (Tykot 2004).

Plant nitrogen isotopes are dependent on how nitrogen is obtained: either by symbiotic bacterial fixation or directly from soil nitrates (Tykot 2004). Nitrogen is passed along the food chain with a 2-3‰ increase for each trophic level, which is an organism's place in the food chain. Individuals with a diet consisting of primarily terrestrial animals and plants usually have collagen $\delta^{15}N$ values of 6-10‰. In contrast, consumers of predominantly freshwater or marine fish, seals, and sea lions may have collagen $\delta^{15}N$ values of 11-20‰ (Table 3). Nitrogen values for marine and terrestrial organisms vary depending on rainfall, altitude, and other factors (Tykot 2004).

In addition to distinguishing dietary proteins, nitrogen isotopes are also an indicator of protein stress, which is a reason for higher than expected nitrogen values. Protein stress or inadequate dietary proteins can lead to the breakdown of existing body tissues to provide materials for the synthesis of new tissues (Varney 2003). Previous studies that analyze nutritional deficiencies isotopically have had moderate success determining when an individual suffered from protein deficiencies (White and Armelagos 1997; Katzenberg and Lovell 1999).

Table 3. Expected Nitrogen Values for Consumed Proteins (Tykot 2004: 437).

Protein Consumed	**$\delta^{15}N$ values (‰ AIR)**
Terrestrial	6-10
Freshwater or Marine	11-20

Oxygen Isotopes

Oxygen has three isotopes found naturally in the environment: ^{16}O, ^{17}O, and ^{18}O. The International Atomic Energy Agency (IAEA) has developed the Global Network for Isotopes in Precipitation (GNIP). The GNIP obtains monthly samples from over 1000 stations in over 125 countries. Waterisotopes.org, is a website designed by Dr. Gabriel Bowen from the University of Utah. The site compiles data from the GNIP and additional sources into an interactive interface (IAEA/WMO 2019) that can be used to estimate and illustrate the expected $\delta^{18}O$ ratios for different world regions.

Oxygen isotopes values in residential history studies are assumed to reflect the isotopic values of consumed water and the climatic environments where an individual lived (White et al. 2007). Temperature, altitude, humidity, latitude, and distance from the sea all effect oxygen isotope composition of meteoric water.

In addition to varying with climatic environment, oxygen isotope analysis can also vary due to isotope fractionation. Fractionation is the rate at which different isotopes undergo chemical reactions (van der Merwe 1982). Due to the relatively constant body temperature of mammals, the fractionation taking place in mammalian issues is relatively similar (Budd et al. 2004). For humans, the fractionation calibration developed by Levinson et al. (1987) is one of the most widely accepted. The calibration is as follows:

(4) $\delta_p = 0.46\ \delta_w + 19.4$

Where δ_p is the phosphate in human skeletal material and δ_w is the $\delta^{18}O$ of drinking water.

Isotopes and Human Skeletal Tissues

There are a variety of different human skeletal tissues that can be isotopically analyzed. Enamel and bone bioapatite, as well as bone collagen, are ideal for isotopic studies because of their general resistance to degeneration. In addition, hair has been used in isotopic studies of diet and nutrition (Hatch et al. 2006; Mekota et al. 2006; Neuberger et al. 2013). However, the following section focuses on tooth and bone bioapatite and bone collagen, as these are more likely to be preserved in archaeological contexts.

Tooth enamel is one of the most resistant materials on earth to degeneration and has a high likelihood of being preserved. As hydroxyapatite in tooth enamel is formed, isotopes are incorporated and remain fixed after formation is finished. The lack of remodeling after formation makes teeth a good early life history indicator (Budd et al. 2004). The figure below shows the age in humans at which crown enamel begins to be formed in the permanent dentition. Enamel formation begins in utero and continues throughout childhood with different teeth developing at routine intervals throughout life. Depending on the tooth being analyzed, isotopic analysis of tooth enamel can target specific age ranges and life stage (Cox and Sealy 1997; Table 4).

Table 4. Human Tooth Enamel Formation (Schroeder et al. 2009: 549).

Tooth	Crown Formation Begins	Crown Formation Complete
Central Incisor	3-4 mo	4-5 yrs
Lateral Incisor	3-4 mo	4-5 yrs
Canine	4-5 mo	6-7 yrs
First Premolar	1.75-2 yrs	5-6 yrs
Second Premolar	2.25-2.5 yrs	6-7 yrs
First Molar	Birth	2.5-3 yrs
Second Molar	2.5-3 yrs	7-8 yrs
Third Molar	8-10 yrs	12-16 yrs

Unlike tooth enamel, bone apatite and bone collagen do not remain fixed. Rather they continuously remodel throughout life. The continuous remodeling of bone apatite and bone collagen means that isotopic analysis of these tissues most accurately reflect the last years of life. The rate of remodeling is dependent upon the age, sex, and skeletal element being isotopically analyzed and understanding the rate of remodeling ultimately determines the period of an individual's life being analyzed (Cox and Sealy 1997). The turnover rate of the inorganic component of bone is illustrated in Table 5 below; the organic portion of bone may react differently.

Table 5. Turnover Rate of the Inorganic Portion of Bone (Cox and Sealy 1997: 212).

Age	% Remodeled
1 year	100-200
3-7 years	10
8 years	1
20-60 years	0.3-3

Cox and Sealy (1997) report that vertebrae remodel faster than other bones; 72% at age 1, 20% at 5-6 years, 30% at 10 years, 24% at 20 years, and 8% in adults. In addition, Cox and Sealy (1997) report that trabecular or spongey bone remodels 3-10 times faster than cortical or compact bone. In general, trabecular bone remodels 10% per year and cortical remodels 2.5% per year (Cox and Sealy 1997). For stable isotope analysis, the type of skeletal tissue and the rate of remodeling determines the life stage being examined. Cortical bone gives an average signature over a longer period of time before death and trabecular bone reflects the later stages of life. It is thought that bone collagen and bone apatite can give insight into the last 2 to 25 years of life depending on the skeletal element analyzed.

Many isotopic studies involving bone apatite and bone collagen use ribs for analysis due to the high rate of bone remodeling or turnover and giving more recent isotopic information due to ribs reflecting the last 2-5 years of life (Ryan et al. 2018). The analysis of one skeletal element over another is dependent upon the research question being asked. Studies looking for a wider range of information should utilize skeletal elements with a slower rate of turnover.

In addition to the rate of bone remodeling, collagen yield is another important factor effecting stable isotope analyses. Collagen yield is expressed as a weight percentage or weight ratio (mg/g). According to van Klinken (1999), modern, fresh bone has a collagen yield of about 22%, decreasing as exposure increases. In areas such as Africa, the United States, and the tropics, collagen yield of buried bone tends to be quite low. This is because in hotter areas, where precipitation is substantial, bones lose collagen quickly (van Klinken 1999). For isotopic studies, van Klinken (1999) states that when collagen content drops below 0.5%, contamination becomes hard to remove. The suggested cut-off point for collagen analyses is anywhere between 1-3.5%, dependent upon the region being studied (van Klinken 1999).

Fauna as Bioavailable Reference Standards

As mentioned previously, local fauna has been successfully used to establish a bioavailable reference standard for a region (Tykot 2004; Hoefs 2009; Price et al. 2010; Wright et al. 2010; Guiry et al. 2012; Guiry 2012; Guiry and Grimes 2013; Laffoon et al. 2014; Edwards et al. 2017; Laffoon et al. 2017). The use of fauna as a bioavailable reference standard has been used by numerous isotopic studies, particularly those utilizing strontium isotope analysis (Price et al. 2010; Wright et al. 2010). Local fauna is good for this type of baseline because they are utilizing the same landscapes for food and water. A number of different types of fauna have been used to establish these ranges, including fish, cattle, turtles, dogs, and a plethora of others (Price et al. 2010; Wright et al. 2010). However, research into the applicability of certain fauna over others as proxies for humans in isotopic studies has found that dogs (*Canis familiaris*) and pigs (*Sus scrofa*) are especially useful (Guiry et al. 2012; Guiry 2012; Guiry and Grimes 2013; Laffoon et al. 2017).

Of the fauna utilized in these studies, much research has been done on the applicability of dogs as proxies for human activities (Guiry 2012; Guiry and Grimes 2013; Laffoon et al. 2017). The use of dogs as human proxies makes use of the Canine Surrogacy Approach (CSA) which analyzes archaeological domesticated dog remains to get insight into their human keeper's dietary practices (Guiry 2012; Guiry and Grimes 2013; Laffoon et al. 2017). A major assumption behind this approach is that dogs are consuming human food refuse or scraps. The dog's consumption of the same foods and water as humans makes them an excellent specimen for comparative isotopic analysis and the creation of a bioavailable isotopic baseline for both dietary and migratory studies.

Limitations

There are several factors that can skew isotopic analysis results that should be taken into consideration: fractionation, diagenesis, the nursing effect, and inter-laboratory variation. Isotope fractionation is the rate at which different isotopes undergo chemical reactions (van der Merwe 1982). Fractionation is most prominent when the mass differences between the different isotopes is larger than the total mass of the element. For this reason, lighter isotopes tend to have higher rates of fractionation (Hoefs 2009). Biological materials undergo fractionation at different rates, and it is important to understand and apply the correct fractionation factor to the analyses. The fractionation equation for mammalian tooth enamel and bone collagen is:

(5) $\alpha_{A\text{-}B} = R_A/R_B$ (Gat 1996; Walters and Michalski 2016)

$\alpha_{A\text{-}B}$ is the fractionation factor from food to enamel. R_A is the ratio of the heavier isotope to the lighter isotope in the food. R_B is the ratio of the heavier isotope to the lighter isotope in the mammalian enamel and collagen (Gat 1996; Walters and Michalski 2016).

Diagenesis is physical or chemical changes to the bone caused by the addition of contaminants such as humic acids, nitrogen containing compounds, or the loss of initial organic material (Schoeninger and Moore 1992). The removal of contaminants is possible with the proper solvents; however, it is not always possible. Previous research suggests the diagenesis of carbonates is harder to assess than phosphates (Sharp et al. 2000). The difficulty assessing the diagenesis of carbonates is the reason phosphates are preferred for isotopic testing. Well preserved phosphate material has been held as a method of "seeing through" the diagenesis associated with carbonates (Sharp et al. 2000). Regardless, diagenesis continues to be a serious problem in the field of stable isotope analysis.

Consistency in the sample data likely indicates that diagenesis has not occurred. However, lower than expected isotopic values could potentially indicate diagenesis (Sharp et al. 2000). There are many ways to identify degradation, but in practice, the easiest and most reliable indicator is collagen yield (van Klinken 1999).

The third limitation in isotopic analysis is the nursing effect. As the body breaks down food to synthesize and renew tissues, the changes are preserved in the isotopic composition of the consumer's tissues (White et al. 2004). This is also true for babies and young children that are receiving nutrients from their mother's breastmilk. Since children are ingesting nutrients reflective of their mothers' diet, babies and young children typically have isotopic values replicating that of their mothers. When conducting stable isotope analysis on a population level, it is best to keep this in mind when selecting elements and individuals to sample. The nursing effect is also the primary reason for eliminating young individuals from these types of analysis as they do not represent their own values but those of their mother.

Finally, inter-laboratory variation can be a factor effecting the accuracy of results. When analyzing results from different laboratories, it is important to understand and assess the possible variability (Pestle et al. 2014). In order to do just this, Pestle et al. (2014) presents the Minimum Meaningful Difference (MMD) (Table 6). The MMD is an empirically derived threshold for the significant comparison of results from different laboratories. The following table shows the MMD values for isotopic comparison of collagen and apatite.

Table 6. MMD Values (Pestle et al. 2014: 11).

Isotope	MMD (‰)
$\delta^{13}C_{coll}$	0.6
$\delta^{15}N_{coll}$	0.9
$\delta^{13}C_{ap}$	1.2
$\delta^{18}O_{ap}$	3.1

For collagen, differences exceeding the threshold as listed in Table 6 have a high likelihood of being biological rather than due to pretreatment or analysis. Pestle et al. (2014) finds that the results of stable isotope analysis of bone collagen from one lab can be directly compared to the results from another lab with little concern. In contrast, apatite MMD values appear to be significantly affected by inter-laboratory variability. This suggests that analytical results of bioapatite from different laboratories might not be directly comparable (Pestle et al. 2014). Ideally, the MMD values for apatite should work the same as those for collagen. If the difference between the sample and expected values of bioapatite exceed the threshold, this should indicate the difference is caused by biological factors rather than pretreatment or analysis procedures (Pestle et al. 2014).

III. ISOTOPES IN CARIBBEAN ARCHAEOLOGY

The last several years have seen a marked increase in the number of isotopic studies focused on the Caribbean (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2018). The Caribbean is an ideal region for isotopic analyses due to its global importance during the colonial period and the forced migration of people during the Trans-Atlantic Slave Trade. During this time, hundreds of thousands of people were forcefully brought to the Caribbean from Africa. In addition to this forced migration, new foods were being introduced into enslaved African diets.

Previous Caribbean isotopic studies have focused on childhood residential history and diet (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon 2013) and provide further insight into the lives of Caribbean populations during the height of the colonial period. The following section discusses four isotopic studies from the Lesser Antilles. These studies serve as a starting point for the research in the present study and help establish an expected isotope range for the circum-Caribbean.

The Forced Migration of Africans to Barbados

Schroeder et al. (2009) utilized carbon, nitrogen, oxygen, and strontium isotopic analyses to assess the life history of enslaved Africans from the Newton Plantation cemetery on Barbados that was utilized from the 17th to 19th centuries. This study focuses on the residential history and diet of individuals from the cemetery. The results of this study have become the comparative standard for studies involving forced migration because they were able to identify first generation enslaved Africans in the burial population.

Barbados, unlike many nearby islands, is made primarily of Pleistocene limestone and oxygen isotopic values from Barbados tend to be lower than most of the Caribbean and Africa. The oxygen isotope values of ground water in Barbados varies between -5.0 to -2.5‰ (Schroeder et al. 2009). Enslaved Africans on Barbados were getting their water from wells, cisterns, and open ponds and would likely have isotopic values similar to the ground water. In contrast, the oxygen isotope composition of water in Africa varies from -2.0‰ on the coast to -6.0‰ or -7.0‰ in areas further inland. In addition to consuming local ground water, enslaved Africans on Barbados were also growing food stuffs typical of enslaved people in the Caribbean, including starchy root vegetables and nearby marine resources.

Schroeder et al. (2009) sampled 1 gram (g) of rib bone, 1g of compact femoral bone, and one deciduous or permanent first molar (M1) from 25 juvenile and adult individuals. Remains that were incomplete or comingled were avoided. The isotopic analysis found a mean $\delta^{13}C$ value of -10.0±0.9‰ and a mean $\delta^{15}N$ value of +14.1±0.7‰. These results indicate that the diet of the individuals consisted mainly of C_4 crops and marine resources. In addition to analyzing diet, the authors examined residential history using strontium and oxygen isotopic values. Local individuals had strontium values similar to modern marine value and oxygen isotopic values (-5.5 to -3.5‰) within the expected ground water range. In contrast, non-local individuals had strontium isotopic values that were relatively elevated and oxygen isotope values were more negative (-6.2 to -5.4‰) compared to local individuals.

Reconstructing Diet on Montserrat and Guadeloupe

Sparkes et al. (2012) examined the diet of enslaved Africans buried at the Harney site on Montserrat and the Sainte-Marguerite site on Guadeloupe. Both sites are historic cemeteries dating to the mid-18th century and osteological and contextual analyses showed that the individuals buried were likely of African ancestry. The reconstruction of diet and lifeways was conducted using carbon and nitrogen stable isotope analysis. A total of 86 individuals were sampled for this study: 76 from Guadeloupe and 10 from Montserrat. Sparkes et al. (2012) hypothesized that the foods consumed by enslaved Africans would be evident in these isotopic values. The study results found that the plants commonly consumed by these individuals were a mix of C_3 root crops (e.g., cassava, yams, sweet potatoes) and C_4 tropically adapted grains (e.g., maize, millet, and guinea corn). The overall mean and range of $\delta^{13}C$ was -14.8±1.61‰ (-14.0 to -18.2‰) and the mean and range for $\delta^{15}N$ was 14.9±1.92‰ (9.3 to 17.9‰) (Table 7). The high nitrogen values strongly indicate an aquatic component to the diet. Both islands have freshwater streams and bodies that were likely used for fishing. In addition, imported salt fish was reportedly given to the enslaved people as protein (Sparkes et al. 2012). The diet of enslaved Africans reflects the consumption of fresh and salted fish as a source of protein.

This study serves as a baseline for dietary studies in the Northeastern Lesser Antilles. Prior to this study, the reconstruction of enslaved African diet was imperfect due to the lack of baseline data. The most interesting part of these results was the considerable aquatic component of the diet. In addition to diet, Sparkes et al. (2012) found that the site had additional potential to represent a "mixed" population of various social statuses, indicated by the presence of elaborate coffins entombing the “richer” individuals.

Table 7. Carbon and Nitrogen Isotopic Values (Sparkes et al. 2012: 5).

Site	n	Mean $\delta^{13}C$ ‰	Range	Mean $\delta^{15}N$ ‰	Range
Harney site, Monserrat	10	-15.5	-14 to -18.2	13.2	11.7 to 14.5
Sainte-Marguerite, Guadeloupe	76	-14.7	-11.6 to -20.5	15	9.3 to 17.9

Life History of an Enslaved African on Saba

Laffoon et al. (2018) analyzed the lifeways of a single individual based on five teeth recovered from a buried cache in an African domestic area at the Spring Bay Flat sugar and indigo plantation on Saba. These teeth were all from the same individual based upon consistency in size, morphology, the degree of occlusal wear, and matching interproximal wear facets. Laffoon et al. (2018) use a multi-isotope approach involving strontium, oxygen, nitrogen, and carbon isotopic analyses of tooth enamel. The results of this study serve as an additional reference for the expected values for first generation Africans in the Caribbean. Prior to this, the only other reference values for expected isotopic signatures of first generation forced African migrants were documented by Schroeder et al. (2009).

This study found that the strontium range (0.70986 to 0.71364) for all the teeth was higher than the expected bioavailable range for Saba (Laffoon et al. 2018). The expected strontium range for Saba (0.707 to 0.709) would be closer to the marine strontium value. The oxygen isotope values were similar and showed no systematic changes between teeth (-4.8‰ to -3.8‰). The carbon isotope results followed a similar pattern to the strontium values with earlier forming teeth having higher than expected carbon values for Saba. The higher than expected values were attributed to migration from the C_4 crop zone of Africa. The lower carbon values and higher nitrogen values in later forming teeth indicate a dietary shift to more C_3 plants and marine resources (Laffoon et al. 2018).

The study conducted by Laffoon et al. (2018) compared the historic values to isotope values from pre-historic Sabans and found that the historic values were significantly higher than the prehistoric and bioavailable isotopic values for Saba. This study only analyzes one individual and further comparisons to similarly provenanced samples from Saba would be useful for determining the efficacy in using oxygen isotopes to determine residential history.

Oxygen and Carbon Isotope Analysis for Investigating Origins

The final study discussed in this chapter is the most comprehensive collection of expected oxygen and carbon isotopic values for the Caribbean. Laffoon et al. (2013) compiled isotopic values from a variety of different contexts to establish a comprehensive baseline of isotopic values for the circum-Caribbean. Laffoon et al.'s (2013) study used carbon and oxygen isotope values to examine ancient mobility, rather than strontium, due to the issue of equifinality with strontium isotopic analysis. Equifinality is when strontium values from two similar geologic, yet geographically different, areas are the same (Laffoon et al. 2013).

Eight sites, each on a separate island in the Caribbean, that were analyzed for this study and a total of 49 individuals were examined. These sites date from the ceramic period (500 BC to AD 500) to the early post-contact period (AD 1492-1550). Previous research indicates that certain individuals buried at these sites were possibly of African or Mesoamerican origin (Laffoon et al. 2013). This study found that the mean oxygen value for the Antillean sample was -2.6‰ (-3.4‰ to -1.1‰). The results of the carbon analysis find a mean value of -11.2‰ (-14.2‰ to -7.2‰) for the Antillean population. Laffoon et al. (2013) then compares these values to previously published values for the Caribbean and Mesoamerica.

This study shows that the diet of the Antillean individuals was limited in consumption of C_4 resources. The oxygen results showed very little variation within the sample. Laffoon et al. (2013) asserts that it is possible that oxygen isotope analysis in the Caribbean is more useful for determining origins outside of the Caribbean rather than within. According to Laffoon et al. (2013), these preliminary results indicate that carbon and oxygen isotope analysis can be useful for migratory studies focused on origins outside of the Caribbean. The results from this study, as well as the compiled values from other studies can be seen in Table 8 below. It should also be noted that the majority of the sample comes from a prehistoric context.

Table 8. Isotopic Means and Ranges Throughout the Caribbean (Laffoon et al. 2013: 754).

Region	**$\delta^{18}O_{ca}$ (‰) Mean (range)**	**$\delta^{13}C_{ca}$ (‰) Mean (range)**
Saba	-2.3 (-2.7 to -2.0)	-11.7 (-12.8 to -9.9)
Guadeloupe	-2.1 (-2.8 to -1.3)	-11.2 (-12.1 to -10.8)
St. Thomas	-2.4 (-3.1 to -1.8)	-11.3 (-12.1 to -9.3)
Saint Lucia	-2.8 (3.4 to -2.0)	-11.0 (-12.0 to -9.1)
Trinidad	-2.8 (-3.3 to -2.1)	-9.1 (-12.5 to -7.2)
Dominican Republic	-2.3 (-2.8 to -1.8)	-13.1 (-14.2 to -12.4)
Puerto Rico	-2.0 (-2.9 to -1.1)	-12.1 (-13.1 to -11.10)
Cuba	-2.7 (-3.3 to -2.0)	-12.2 (-12.9 to -11.4)
Antilles (pooled)	-2.5 (-3.4 to -1.1)	-11.5 (-14.2 to -7.2)
Barbadian	-4.3 (-5.5 to -3.5)	-10.5 (-12.4 to -8.8)
African	-5.8 (-6.2 to -5.4)	-16.0 (-19.9 to -10.6)

Faunal Isotopic Studies in the Caribbean

In addition to isotopic studies involving human remains, there have been a few studies utilizing faunal remains in the Caribbean (Klippel 2001; Laffoon et al. 2014, 2017). The most successful of these studies have used animal tooth pendants and dog burials to track animal migration and human trade patterns (Laffoon et al. 2014, 2017). The understanding of animal paleomobility and diet can give insight into human activities, particularly with dog remains. The study conducted by Laffoon et al. (2017) looked to establish whether or not dog and human remains from similar contexts have similar isotopic values. Dogs were chosen for this analysis due to the likelihood that they were fed human food refuse or scavenged human foods (Laffoon et al. 2017). The results of this study found that dogs and humans do indeed have similar isotopic values. These results are also in line with the Canine Surrogacy Approach (CSA). As mentioned in the previous chapter, CSA isotopically analyzes dog remains to gain further insight into their human keeper's dietary practices (Guiry 2012; Guiry and Grimes 2013). Laffoon et al. (2017)'s study illustrates the usefulness of comparing faunal remains, in this case dog, to human remains. Additionally, it supports the Canine Surrogacy Approach and its applicability to isotopic studies in the Caribbean.

In addition to isotopic studies of animal paleomobility, there have also been faunal isotopic studies focused on diet. Klippel (2001) conducted carbon isotopic analysis on cow remains from Brimstone Hill Fortress in St. Kitts. In addition to indicating the types of grasses being consumed by the cattle, isotopic analysis can also be used to determine the quality of salt beef. Determining the quality of food being consumed by those living at Brimstone Hill is extremely important for understanding the diet and lifeways of these individuals. Though Klippel's (2001) study can give an indication into the quality of the protein being consumed, it is not a good bioavailable reference sample for humans due to key differences in diet between grazing animals and humans.

These studies utilizing faunal remains are good indicators of the types of fauna that are useful for establishing a bioavailable isotopic range. Laffoon et al.'s (2017) study demonstrated that dogs can be a useful proxy for humans in isotopic studies. Klippel's (2001) study demonstrated that though grazing animals can be used for quality assessment, these animals such as cows and goats/sheep, are not useful for provenancing or dietary comparisons because they are primarily eating grasses.

Importance of Isotopes in the Caribbean

Isotopic analyses of Caribbean populations are extremely beneficial for historical reconstruction. The history of forced migration to this region and the dietary change associated with migration makes the Caribbean an interesting isotopic study area. Isotopic analysis of enslaved peoples can give insight into the lifeways of a population whose identity was taken from them. The mass forced migration of these people typically came with little documentation and the erasure of all former identity.

Most forced migrants to the Caribbean came from many different places in Africa, including Upper and Lower Guinea and West Central Africa. The identity of these people was deeply ingrained, and evidence can sometimes be seen biologically and culturally in burial populations throughout the Caribbean (Jamieson 1995). Isotopic analysis offers an interesting way to understand these under-represented groups and learn more about the lifeways of these individuals.

The historical record has typically always been documented by the colonizer. This means that the lives of non-Europeans are not well represented in the written record, if documented at all. Isotopic analysis of non-European Caribbean populations has the potential to reveal previously unknown aspects of peoples' lives. It also offers the opportunity to approximate what enslaved peoples were consuming and compare that to the historical records documenting required provisions.

Isotopic analysis remains an incredibly useful technique with great research potential in the Caribbean. This technique offers a way to investigate the lifeways of every group residing in the Caribbean, as well as tracing patterns of migration and trade. The Caribbean's importance during the colonial period is frequently overlooked by present day researchers. The Caribbean has a plethora of information to offer regarding the interactions of 17^{th} and 18^{th} century colonial powers and the lifeways of people residing in the region.

IV. ST. EUSTATIUS, CARIBBEAN NETHERLANDS

The Dutch Caribbean island of St. Eustatius (Statia) has a surface area of 21km^2 and is 9km long and 4.5km wide. First colonized by the Dutch in 1636, Statia would change hands 22 times between the 17th and 19th centuries (Attema 1976; Gilmore 2016). The early period of colonization in the Caribbean was characterized by the Trans-Atlantic Slave Trade and plantation economies. Due to the island's small size and dry climate, Statia was unsuitable as a plantation island (Gilmore 2016). Though Statia did not thrive as a plantation island, it became a cornerstone of trade in the Caribbean. The island's geographic location and landscape with an easily accessible harbor and flat central plain allowed for a robust commercial and maritime economy (Allen 2017). At the height of Statia's presence as a premium trade destination, over 7,100 merchant and slave ships passed through the island's port (Gilmore 2013). Nicknamed the "Golden Rock", Statia was a top trade destination in the Caribbean and remained so until the mid-19th century.

During Statia's economic peak, around 1789, approximately 4,944 enslaved Africans lived on the island (Gilmore 2016). Many enslaved people worked in warehouses that lined the coast, rather than the island's few plantations. Most enslaved Africans brought to Statia were redistributed throughout the Americas as part of the Trans-Atlantic slave trade. Slaves that remained on Statia experienced a social environment set apart from all others in North America and the colonial Caribbean (Gilmore 2008; Stelten 2013). The Dutch outlawed the slave trade in 1821, however, the unofficial slave trade remained active for several years after its abolition (Gilmore 2010). Around the time that the slave trade was outlawed by the Dutch government, Statia's economic prosperity was also beginning to decline.

Today, Statia is a Dutch special municipality and relies on tourism (mostly scuba diving) and oil transshipment to fuel their economy (Allen 2017). The primary language spoken on the island is English, demonstrating the continued British presence throughout the Caribbean. Though almost two centuries have passed since Statia's colonial heyday, many issues that affected the people on the island then are still issues today. The largest and most pressing issue being the lack of naturally occurring water on the island. To remedy this, cisterns remain a major solution to this problem and can be found underneath or near many buildings.

Enslaved Africans on Statia

The importance of Statia to the world's trade networks affected everyone on the island from merchants and traders to enslaved and freed Africans. The result of this was a social environment set apart from all others in the colonial Caribbean (Gilmore 2013). Some enslaved Africans in the Caribbean, and particularly on Statia, had greater access to economic outlets for their own wealth production activities (Gilmore 2008).

On Statia, most enslaved Africans participated in the trade economy and many were able to buy their freedom at rates greater than on other islands. During the 18th century, Statia had a free African population approaching 13% of the total population, which was relatively high in comparison to the 3% that was typical of the Caribbean (Gilmore 2013). Slaves on Statia were allowed occasional days off, usually Sundays, where they generally devoted their time to activities of their choosing. It was during this personal time that enslaved Africans participated in the trade and market economy (Handler and Wallman 2014). There were many cases when enslaved Africans would rent out their labor during what little personal time they had to make more money to put towards buying their freedom or other merchant goods. (Gilmore 2010).

Research into Statia's history makes it clear that enslaved Africans were integral to the island's economy. As mentioned above, enslaved and freed Africans were participating in mercantile trade and many worked in warehouses along the shore (Gilmore 2016). However, more interesting are the writings that include information about the lifeways of the free and enslaved Africans residing on Statia. Previous research into lifeways has focused on interactions between free and enslaved Africans and Europeans on Statia (Gilmore 2008, 2013, 2016). These interactions are important because there is evidence that Statian slaves were perceived and treated differently by their enslavers than those in the North American colonies and much of the Caribbean (Gilmore 2016). This is evidenced by the ability of slaves to traverse the island, conduct business, and even undertake expeditions off the island on behalf of their owner (Gilmore 2016).

Research collected during Byrd's (2014) synthesis of the excavations at multiple slave villages gives further insight into enslaved life. Byrd found that enslaved Africans were primarily brought from 3 regions: Upper Guinea (Senegambia to Sierra Leone), Lower Guinea (Gold Coast to Bight of Benin), and Kongo-Angola (West Central Africa). Slaves destined for the Dutch Caribbean were primarily from the western portion of the Upper Guinea region (Eltis and Richardson 2010). The majority of slave homes on Statia were located in the Lower Town and European slave owners lived in the Upper Town. This living arrangement was different from other colonial contexts where slave housing was located where they could be closely monitored by their enslavers to ensure they would not run off. This was not the case in Statia, as Statia is relatively small and the primary jobs were in the warehouses, enslaved Africans were given opportunities that were not typical of enslaved African who worked long hours on sugar, coffee, and other plantations. In addition, enslavers entrusted slaves on Statia with greater opportunities because of the nature of their work.

Enslaved Africans in the Caribbean typically acquired food as either rations from the estate or from their provision grounds. On many islands, and likely on Statia, planters were forced to provide slaves a small area of land to grow their own provisions. Previous studies have found that slaves were growing guinea yams, okra, corn, sweet potatoes, tomatoes, cabbage, carrots, breadfruit, yucca, citrus, avocado, papaya, soursop, mango, coconut, and akee trees (Mintz 1974; Byrd 2014). Byrd's (2014) study reported agave in some provisioning grounds, but she determined it was likely an anomaly and not a major food source. In addition to using provisioning grounds for themselves, enslaved Africans were also growing produce to sell at the marketplace (Kelly and Wallman 2014; Wallman and Grouard 2017). Yams were the primary commodity sold by enslaved Africans. Though many enslaved Africans on Statia grew or traded for the fruits and vegetables they ate, they partially relied on provisions from the estate for proteins.

Rations Provided to Enslaved Africans in the Caribbean

On many Caribbean islands there were laws dictating what plantation owners and enslavers were required to provide their slaves. During the late 18th century, on St. Kitts, Nevis, and Antigua, provisions for enslaved Africans were dictated by the Leeward Islands Slave Law of 1798 (Higman 1984). This law required that slave owners provide 9 pints (pt) of corn or equivalent quantities of beans, peas, wheat flour, rye flour, Indian corn meal, oatmeal, rice, cassava flour, biscuits, yams, potatoes, eddoes, tanias, plantains, or bananas, 1.25 lbs of herring, shad, mackerel, or other salted provisions, or 2.5 lbs of fresh fish or provisions. Where provisioning grounds were provided, laws permitted planters to reduce rations by half while maintaining allowances of salt or fresh provisions (Higman 1984).

On French Caribbean islands, provisions for enslaved Africans were dictated by the *Code Noir* or Black Code, which was implemented in 1685. This required French West Indies planters to provide weekly allowances of 2.5 pots of cassava flour or 3 cassava weighing at least 2.5 lbs, 2 lbs of corned beef, and 3 lbs of fish or other things in proportion (Kelly and Wallman 2014). A 1786 ordinance required French planters to distribute plots, allowing every slave to cultivate their own crops.

Although these laws mandated the provisions given to enslaved Africans, planters did not adhere to these laws. In many cases, planters gave slaves less than the required amount of proteins, especially when sugar prices decreased or access to North American markets were closed. To address the lack of protein in their diet, enslaved Africans supplemented and diversified their rations by using their personal time to procure proteins in their carb heavy diet (Kelly and Wallman 2014). Similar laws to those mentioned above were likely in place on most islands in the Caribbean. Madrigal (2006) states that diets of enslaved peoples on Dutch colonies were generally carb heavy and low in animal protein. Additionally, Dutch slaves were likely also given provisioning grounds to cultivate their own crops during their personal time (Fred van Keulen, Personal Communication 2019).

Zooarchaeological Analyses of Slave Diet

Archaeological analyses of slave communities have revealed the ways slave communities navigated their survival and dealt with cruelties. Kelly and Wallman (2014) conducted zooarchaeological analyses on Guadeloupe and Martinique and found that slave societies relied on a combination of terrestrial and marine fauna. Although slave societies relied on terrestrial and marine fauna as a source of protein, Kelly and Wallman's (2014) analysis revealed highly diverse marine protein sources. In the Guadeloupe assemblage, 93% were marine invertebrates, such as chiton and clams. The Martinique assemblage had relatively high numbers of marine vertebrate and invertebrate species present. The terrestrial fauna present archaeologically were primarily pig, sheep, goat, and cattle (Kelly and Wallman 2014). Kelly and Wallman (2014) state that small mammals, fish, and other small animals are likely significantly under-represented due to the method of dry screening during excavation.

Wallman and Grouard (2017) found that historic records rarely mention fishing as a common activity practiced by enslaved Africans during their personal time. Instead, fishing was described as an activity reserved for highly "specialized" slaves residing on wealthy estates. The zooarchaeological analyses documented by Kelly and Wallman (2014) and Wallman and Grouard (2017) found evidence to the contrary as relatively high frequencies of marine vertebrate and invertebrate identified remains demonstrates that marine proteins were a significant and important part of enslaved African diet. It is likely that enslaved Africans used their personal time to procure marine resources from nearby sources. The variety of marine resources recovered from previous analyses illustrates the self-sufficiency of enslaved Africans and how they were able to create a system of foodways to provide themselves with adequate nutrition, assembled out of the resources available to them (Kelly and Wallman 2014).

Summary

On Statia, some enslaved Africans had access to important resources, such as marine proteins, and were active participants in the local economy. It was not uncommon for enslaved Africans to sell the surplus produce from their provisioning grounds and fishing expeditions to accumulate their own personal wealth (Madrigal 2006; Kelly and Wallman 2014; Wallman and Grouard 2017). The active participation of enslaved Africans in the trade economy made social relationships on Statia different from those on surrounding islands and different from known European-African relationships in the Americas (Gilmore 2008; Stelten 2013). The participation of these different groups in the economy means that enslaved Africans had access to goods, such as provisions and material items that were often unavailable to them otherwise (Gilmore 2008). The ability to accumulate personal wealth and buy items they needed served as an important subsistence strategy in times of hardship (Gilmore 2008: 48). These goods could have peppered all aspects of life, including residential, ceremonial, and burial practices. The ability to purchase goods previously inaccessible means that researchers have changed preconceived ideas about what items belonged to whom. Enslaved Africans may have had greater access to European goods and services than previously thought, as shown in the archaeological record.

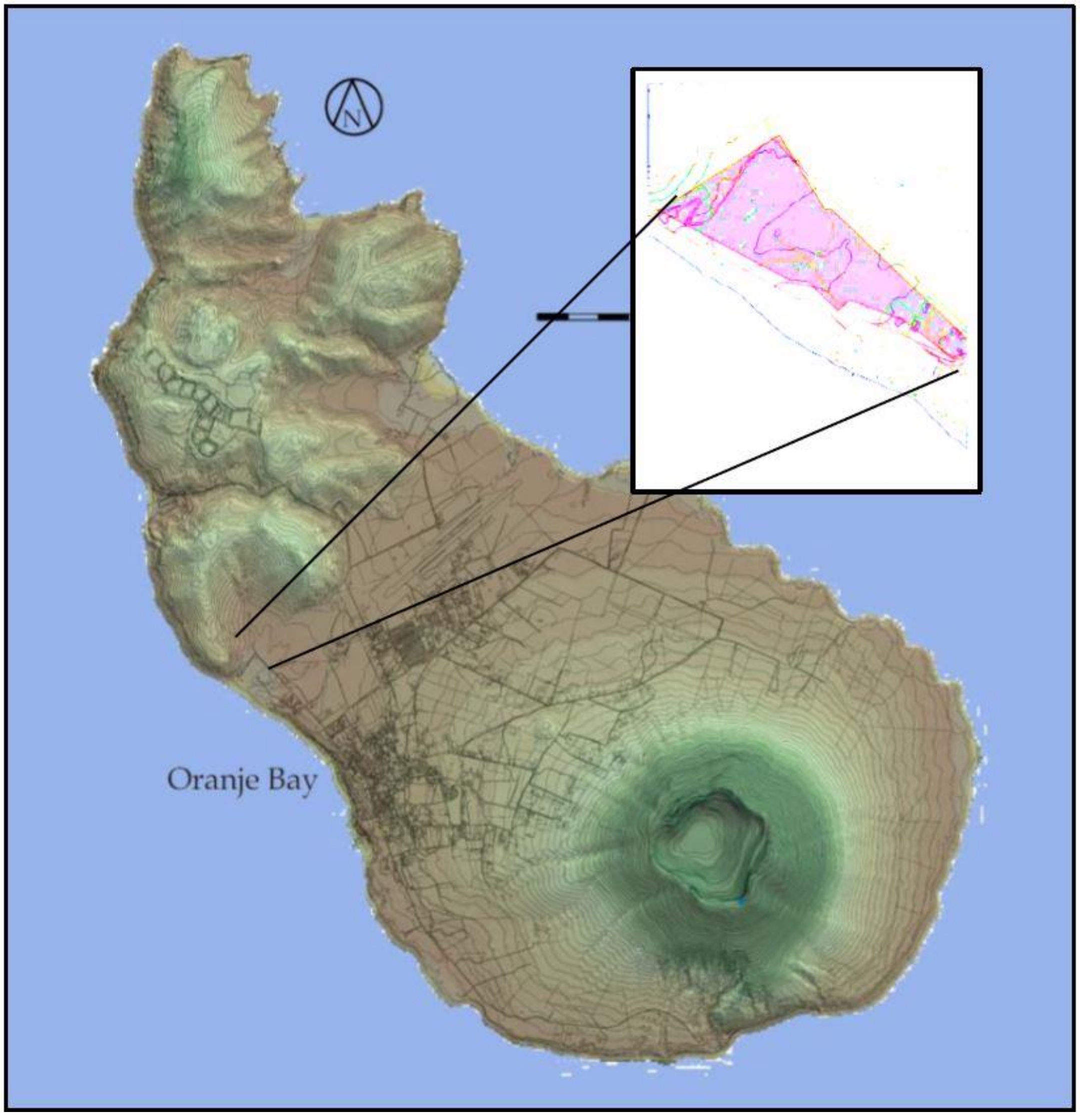

Figure 3. Godet Property Location on Statia (SECAR 2017).

The Godet Property

The goals of the recent archaeological investigations of the Godet Property were to address the threat of destruction to cultural resources through natural processes and as a result of construction and development (SECAR 2016, 2017). The Godet Property (Figure 3) is currently owned by the Van Zanten family and is located on the shoreline of Oranje Bay. The property is the location of several archaeological sites, including Fort Amsterdam, Godet Plantation, Lazaretto, Rotterdam Battery, Godet Cemetery, and a prehistoric site (SECAR 2016, 2017; Figure 4). Fort Amsterdam was an essential part of the trade port and was the official, then unofficial, depot for the Dutch West Indies Company (DWIC) slave trade during the 18th century. In addition to assessing threats to cultural resources, the report also produced a predictive model that indicates areas where there is a high probability for intact deposits. This report found that the most intact deposits were likely near the shoreline, which includes Fort Amsterdam and the Godet Cemetery.

Figure 4. Historic Map Showing the Godet Property (SECAR 2016). The blue star represents the Godet Cemetery (SE600).

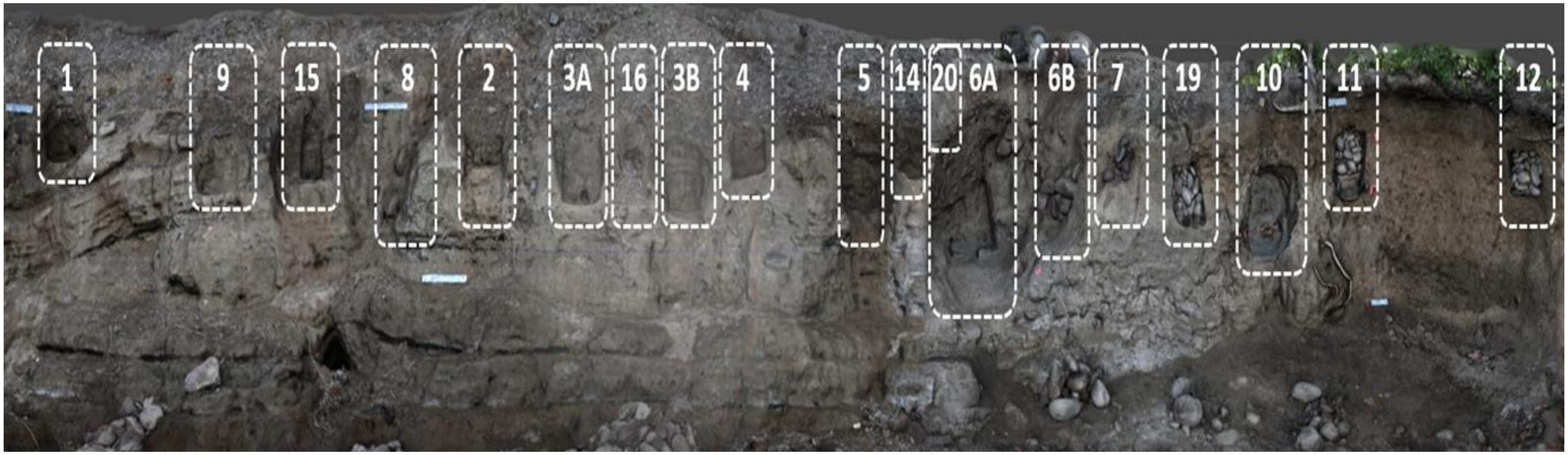

Figure 5. Panoramic of the Godet Cemetery (Stainton 2019).

The Godet Cemetery (SE600)

The Godet Cemetery (Figure 5) is located on the Godet Property, just north of Fort Amsterdam. The cemetery's location along the shoreline means that it is largely unprotected from destruction by natural causes, including tropical storms and hurricanes. The protection and preservation of these endangered cultural deposits is one of the reasons for recent excavations at the site. The cliffside, where the cemetery is located, has eroded heavily in the last few years due to wave action and sheet wash from tropical storms and hurricanes. This erosion has caused the burials to be exposed on the cliffside and washed away into the Caribbean Sea.

The first investigations at the Godet Cemetery were conducted by Morsink (2012) during October and November of 2012, when rescue excavations of eroding burials were undertaken. The archaeologists involved in this study hypothesized that the site was a slave burial site. These investigations examined the relationships between the buried individuals and Fort Amsterdam. Fort Amsterdam was a Dutch fortification meant to protect the island against naval attacks and served as a slave depot for the Dutch West Indies Company (DWIC). Statia played an important role in the Trans-Atlantic Slave Trade, and as many as 450 slaves were held at Fort Amsterdam at any one time. Initial investigations at the cemetery yielded unexpected results. Morsink (2012) suggests that individuals of both European and African ancestry were buried at the cemetery. Morsink (2012) claims that evidence of a coffin was distinctive of European burial practices, therefore the individuals buried in coffins must be of European ancestry. The assumed presence of both European and African remains at the cemetery caused Morsink (2012) to question previous views regarding African-European relations, as well as burial practices, cemetery use, and the social status of individuals buried at the site. It is generally thought that due to the prejudices that accompany slavery, society was extremely segregated. Individuals of African ancestry that were brought to Statia as slaves would not be expected to be buried in the same cemetery as Europeans.

Re-evaluation of the skeletal remains from the Godet cemetery have concluded that all of the individuals buried there are of African ancestry (Ashley McKeown, person communication, 2019; Felicia Fricke, Personal Communication 2019; Tucker 2019; Wanstead and Rogers 2019). These findings indicate that the cemetery was most likely associated with the Godet Plantation or the Slave Depot, rather than the Dutch occupied Fort Amsterdam. Though Statia was known to have an interesting social environment, the social hierarchy in place during the time of the Trans-Atlantic Slave Trade remains clear.

Due to various conclusions reached by different investigations into the Godet Cemetery, it is important to understand the cemetery's demographics and which groups were using the cemetery. Table 9 shows the what attributes about the cemetery would likely be present if a particular group was using the cemetery (McKeown 2019; Tucker 2019).

Table 9. Expected Demographics of the Godet Cemetery (McKeown 2019).

If…	**Dutch Military (1687-1724)**	**Slave Depot (1726-1781)**	**Godet Plantation (1690-1860)**
Then…	European Ancestry	African Ancestry	African Ancestry
	Adult Males	Both sexes, all ages	Both sexes, all ages
	Coffins	No Coffins	Possibly Coffins
	Artifacts consistent with time period	Artifacts consistent with time period	Artifacts consistent with time period

Additional research into the artifacts associated with the excavated burials by Tucker (2019) has documented the manufacture dates for the artifacts from each burial. The findings from this study are illustrated in Figure 6 and are helpful for determining the cemetery's age of use and association.

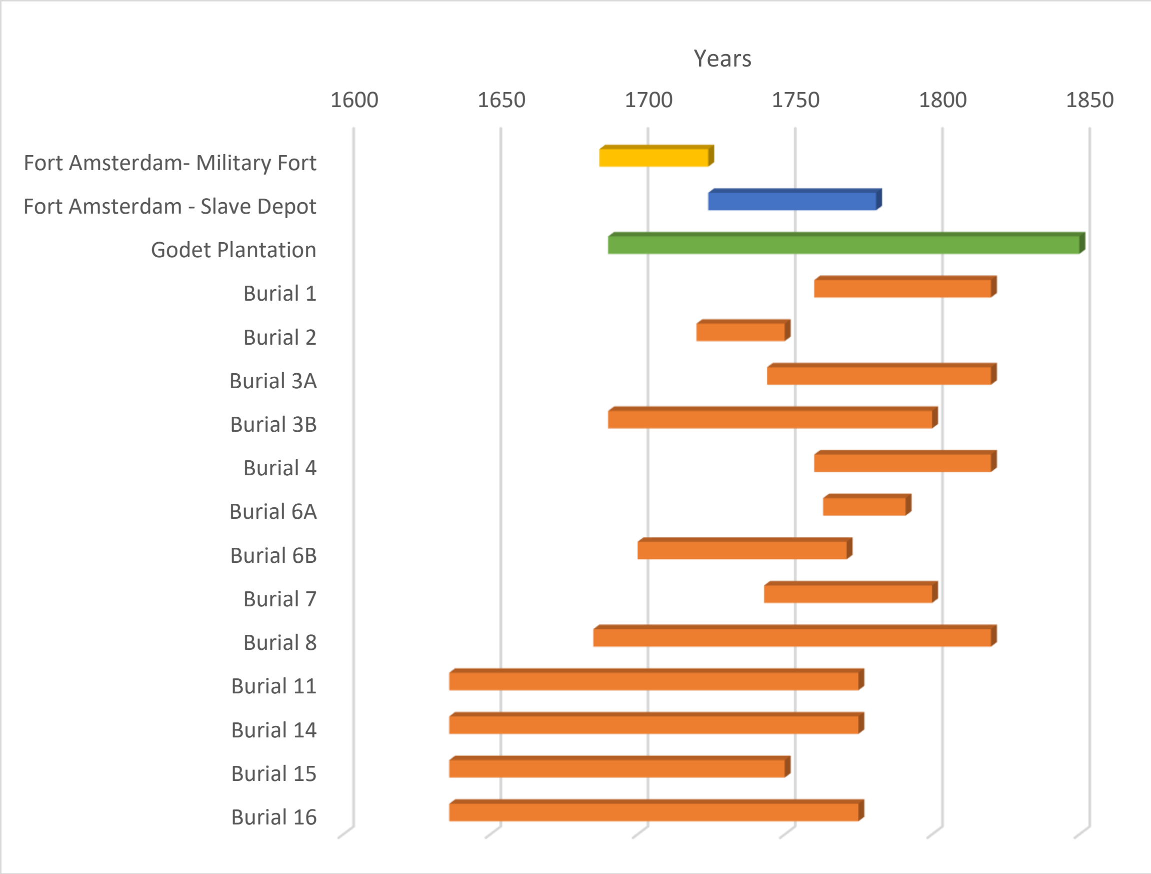

Figure 6. Manufacture Dates of Artifacts Associated with Godet Cemetery Burials (Tucker 2019).

Table 9 and Figure 6 were utilized by the author and other researchers for understanding cemetery usage and affiliation. Based upon the ancestry and sex estimation of individuals, presence of coffins, and Tucker's (2019) dating of the burials, the individuals are most likely associated with the Godet Plantation. Some of the most telling evidence to indicate the cemetery's association is the mention of the cemetery as a burial ground for enslaved Africans in a historical record from 1738 (Knappert 1932). A further discussion of the burial demographics is provided in Chapter V.

Statia Climate

Statia possesses a relatively low geological topography, significantly reducing rainfall amounts on the island (Gilmore 2013). The tropical climate of Statia is governed by its latitude. Weather is typically sunny with light Northeast Trade Winds bringing constant cool breezes and ample moisture (Allen 2017). Though these winds bring moisture, rainfall on Statia is inconsistent from year to year. Steep hillsides, thin soil layers, and cracked igneous rock prevent the natural catchment of rainfall. This inconsistent rainfall makes crop production inconsistent and the resulting drought can require the importation of water to the island (Allen 2017). The absence of streams, lakes, and aquifers on the island meant that rainwater must be stored, both presently and historically. Cisterns are used to collect this rainwater and are usually located adjacent to or underneath most buildings.

Statia Geology

The volcano on Statia, the Quill, was formed by the subduction of the North American plate and the eastern-most section of the Caribbean plate. Statia, along with the neighboring island of Saba, are the youngest islands in the Lesser Antilles chain (Allen 2017). According to Allen (2017), Statia's geology can be divided into three very different landscapes. The oldest of these landscapes is the northern hills, formed around 1 million years ago (Figure 7), and is made up of volcanic deposits like those that created the Brimstone Hill formation on the neighboring island of St. Kitts. The intermediate landscape is the Sugar Loaf-White Wall formation on the southern end of the island, which formed anywhere from 68,000 to 320,000 years ago (Figure 7). Finally, the youngest landscape is the Quill itself. The Quill is a pyroclastic volcano whose deposits

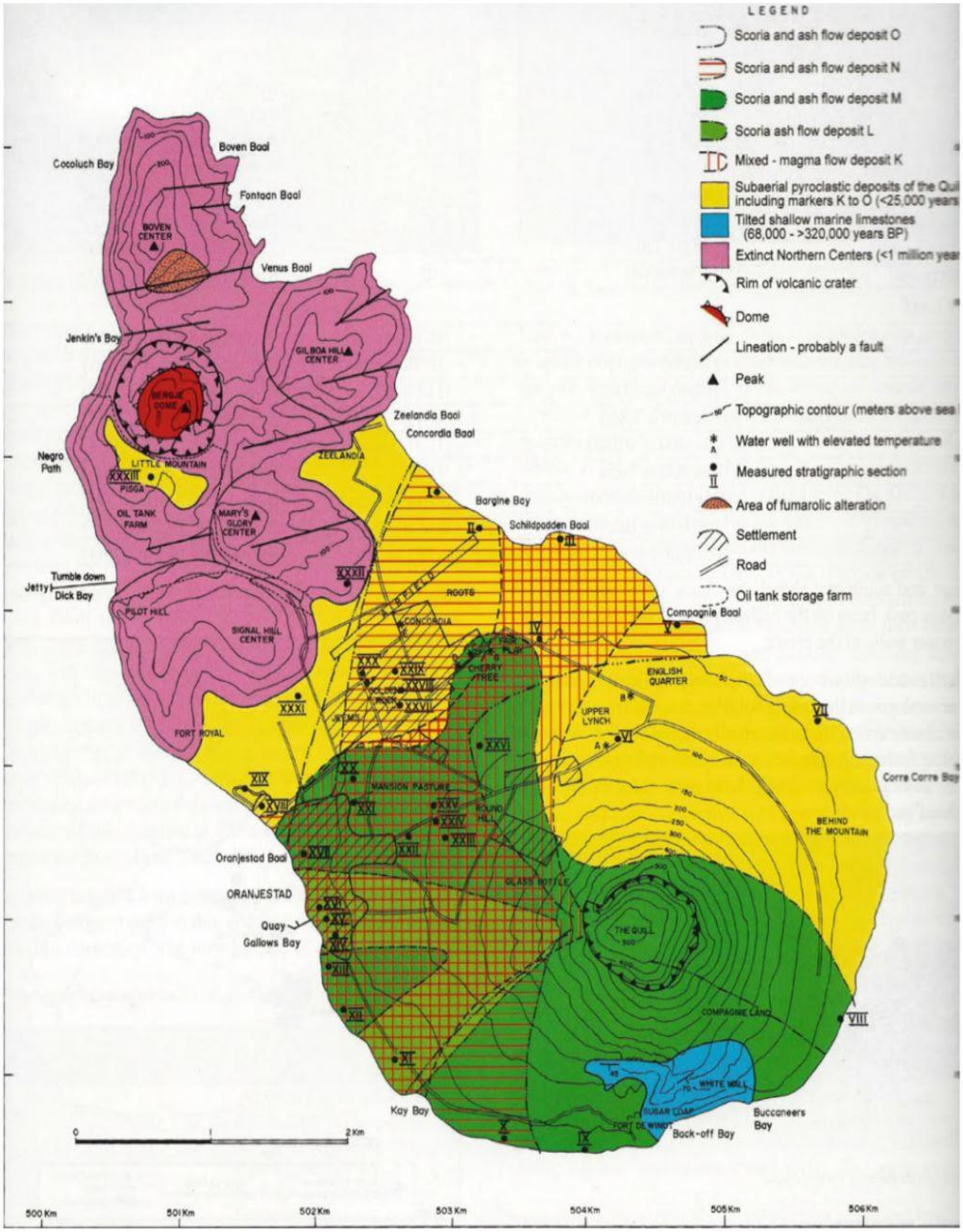

Figure 7. Geologic Map of Statia (Allen 2017).

formed the landmass between itself and the northern hills. This intermediate land mass was formed about 25,000 years ago (Figure 7; Allen 2017).

Water Procurement on Statia

As mentioned previously, Statia has little to no naturally occurring water; however, there is some ground water in a shallow aquafer. Wells were dug to reach this ground water but most water was found to be brackish and only used for animals and small-scale agriculture (van Keulen 2017). Due to the lack of success with obtaining potable ground water, most Statians relied on rainwater catchment, such as cisterns. Most cisterns on Statia and the neighboring island of Saba, have underground storage basins. These cisterns were typically built with some type of catchments for the collection of rainwater (Esperson 2013). People also collected roof runoff when it would rain with gutters in barrels and cisterns. Roof gutter runoff in barrels replenished more quickly than cisterns and in turn permitted the consumption of more water per person per day (Esperson 2013). The water in these barrels was more likely to go bad before the water in the cistern, meaning this water must be consumed quicker than cistern water (Esperson 2013).

Expected Isotopic Values for Statia

Previous isotopic studies conducted in the Caribbean have found that inter-island values show little variation (Laffoon et al. 2013) because Caribbean islands are relatively young landforms in comparison in other parts of the world. The expected results for this study are based upon the results from previous studies dealing with similar contexts and materials (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2013, 2018). Oxygen isotopic studies in the Caribbean have found that values do not deviate much from island to island, apart from Barbados. Laffoon et al. (2013) pooled the values from 46 sites in the Caribbean and obtained a mean $\delta^{18}O_{ca}$ value of -2.5‰ with a range of -3.4 to -1.1 (‰ PBD). The remains from the Newton Plantation in Barbados had a mean $\delta^{18}O_{ca}$ value of -5.8 with a range of -6.2 to -5.4 (‰PBD) for the seven African-born individuals. According to the Online Isotopes in Precipitation Calculator (OIPC) created by Dr. Gabriel Bowen (2019) at the University of Utah, the expected oxygen isotopic value for Statia is -2.6‰. This study will utilize the conservative methods used by Laffoon et al. (2013) to convert oxygen isotope values to $\delta^{18}O_{ca}$ (‰PBD) for comparison.

Studies of diet and nutrition in the Caribbean have found that free and enslaved Africans were typically consuming an intermediate diet of C_3 and C_4 plants and terrestrial and marine proteins (Varney 2003; Sparkes et al. 2012; Kelly and Wallman 2014; Wallman and Grouard 2017). Pure C_3 plant consumers typically have values around -21.5‰ for collagen and -14.5‰ for apatite. In contrast, pure C_4 plant consumers typically have values around -7.5‰ for collagen and -0.5‰ for apatite (Tykot 2004; Table 1). People who eat a mixed diet of a variety of C_3 and C_4 plants are expected to have intermediate values. It is expected that Statians' intermediate diets would fall solidly between these values because they are consuming considerable amounts of C_3 and C_4 plants.

Similarly, nitrogen isotopic values also give some insight into the diet of deceased individuals. Nitrogen values are indicative of protein content of the diet and where people were consuming marine or terrestrial proteins. According to Tykot (2004), human consumers of terrestrial plants and animals typically have bone collagen nitrogen values of 6-10‰ and human consumers of freshwater and marine fish, seals, and sea lions have collagen nitrogen values of 15-20‰. Varney (2003) suggests that populations that were significantly reliant on marine foods generally have nitrogen values of 11‰ or higher. Enslaved Africans on Statia are expected to have nitrogen values higher than 11‰ due to the reliance on imported salt fish and marine resources as a source of protein (Handler and Wallman 2014; Kelly and Wallman 2014; Wallman and Grouard 2017).

Deviations from the expected values for the diet of individuals on Statia could indicate the presence of malnutrition. It is well known that enslaved Africans were generally not afforded the same luxuries as planters, overseers, and other people of privilege. For this reason, it would not be unusual for slaves to be malnourished. Iotopic values for a malnourished individual will deviate from expected diet values. In someone who is malnourished, it is expected that these individuals will have lower carbon values and higher nitrogen values. This inverse relationship is due to the lack of proteins being consumed and an increase in trophic level from the body consuming its own proteins (Hatch et al. 2006; Mekota et al. 2006; Neuberger et al. 2013).

V. MATERIALS AND METHODS

To better understand free and enslaved African lifeways on Statia, 18 burials at the Godet Cemetery were examined for inclusion in this research. Individuals were excluded from the sample if they were classified as subadult, poorly preserved, comingled, or too fragmentary. The remaining individuals included in the research are classified as adults based on a biological profile completed by Dr. Ashley McKeown at Texas State University. Originally, incomplete remains were also to be excluded; however, upon excavation it became clear that most individuals encountered would be incomplete due to erosion and cemetery placement.

Remains recovered directly from the site were initially placed into brown paper bags. For transportation and storage, remains were placed into plastic bags and carefully packaged into plastic boxes. Upon arrival at Texas State University, remains were held at the Grady Early Building (GEB) until they were prepared for analysis.

Justification for Tissues Sampled

The selection of tissues is critical to isotopic studies and is dependent upon the study's research objectives. For this study, the primary objectives are: 1) diet and nutrition, 2) residential history in the years prior to death, and 3) how this compares to the social environment present on Statia from the 17th-19th centuries. These objectives require the sampling of bone collagen and bioapatite. Initially, enamel samples from each of the burials were going to be taken. However, due to the lack of suitable teeth available for analysis, bone collagen and bone bioapatite were utilized. Recent studies have also found that faunal samples can be a good baseline for bioavailable isotopic ranges (Price et al. 2010, Wright et al. 2010, Pederzani and Britton 2019). Faunal tooth enamel samples were chosen for analysis due to ease of collection and transportation. The decision to sample faunal tooth enamel was initially based upon the author's original plan to sample human tooth enamel. The decision to sample human bone was made after the collection of faunal tooth enamel on Statia.

Justification for Sample Exclusion

Burials excluded from this analysis and reason for the exclusion, based on the criteria mentioned above, are shown in Table 10. Subadults were excluded from this analysis because of their faster bone remodeling than the adults in the sample (Cox and Sealy 1997; White et al. 2004). This accelerated remodeling does not give an average signature over a long period of their life, rather it more strongly reflects later life stages.

Table 10. Godet Cemetery (SE600) Burials (McKeown 2019).

Burial #	Sex	Age (years)	Ancestry Estimation	Sampled (Y/N)	Year Excavated	Element Sampled	Reason for Exclusion
1	F	20-40	African	Y	2018	Metacarpal 5	-
2	?	?	?	N	2012	-	Subadult
3A	M	40-90	?	Y	2012	Proximal Hand Phalanx	-
3B	M	20-40	?	Y	2017	Metatarsal 3	-
4	?	1-4	?	N	2012	-	Subadult
5	M	20-40	?	Y	2012	Rib	-
6A	F	30-50	Possibly African	Y	2012	Rib	-
6B	M	40-60	?	Y	2017	Proximal Hand Phalanx	-
7	F	20-40	?	Y	2017	Rib	-
8	M	30-60	?	Y	2012	Metatarsal 2	-

Table 10. Continued.

Burial #	Sex	Age (years)	Ancestry Estimation	Sampled (Y/N)	Year Excavated	Element Sampled	Reason for Exclusion
9	?	?	?	N	2012	-	Too few remains
11	F	16-20	African	Y	2017	Rib	-
13	F	17-39	African	N	2017	-	Too few remains
14	n/a	4-5	?	N	2017	-	Subadult
15	F	20-40	?	Y	2018	Proximal Fibula Shaft	-
16	n/a	n/a	?	Y	2017	Rib	-
17	?	?	?	N	2017	-	Subadult/ Too few remains
18	n/a	10-14	?	N	2017	-	Subadult

Summary of Excavations

The remains from the Godet Cemetery were excavated from 2012-2019. Many remains recovered from the site were at risk of eroding into the ocean. The cemetery's precarious placement on a cliffside eroding into the Caribbean Sea caused most, if not all, of the burials to be fragmentary in nature. A biological profile of the remains recovered from the cemetery was completed by Dr. Ashley McKeown at Texas State University. Additional biological and enamel isotopic analysis has also been completed by Felicia Fricke from the University of Kent (Felicia Fricke, Personal Communication 2019).

Mortuary attributes for each of the burials at the cemetery were recorded systematically to better understand mortuary patterns. The understanding of mortuary attributes can yield important information regarding the lifeways of individuals buried at the cemetery. However, for the purposes of this study, the mortuary attributes are documented here to give more information regarding burials selected for this study in situ. Table 11 below illustrates the recorded attributes for the eleven burials submitted for isotopic analysis.

Table 11. Mortuary Attributes of SE600 Burials Selected for Analysis (McKeown 2019).

Burial #	Commingled (Y/N)	Disturbed (Y/N)	Burial Orientation	Head Orientation	Coffin (Y/N)	Coffin Shape	Preservation
1	N	N	E-W	West	Y	Rectangular	Poor
3A	N	N	E-W	West	Y	Rectangular	Poor-Fair
3B	N	N	E-W	West	Y	Rectangular	Poor-Fair
5	Y	N	?	?	N	?	Poor-Fair
6A	Y	N	?	?	?	?	Fair
6B	N	N	E-W	West	Y	?	Fair
7	N	N	E-W	West	N	?	Poor-Fair
8	N	N	E-W	West	Y	Rectangular	Fair
11	N	Y	E-W	West	Y	Rectangular	Fair-Good
15	N	N	E-W	West	Y	Rectangular	Poor-Fair
16	N	N	E-W	West	Y	Rectangular	Poor

Sample Collection

One bone sample was extracted from each of the eleven selected burials (Table 10). A Dremel Multi Pro, Model 285 was used during sample collection to cut sections of bone to be sent off for analysis. Samples were selected based upon completeness and amount of cortical bone present and available for analysis. Once selected, samples were handled using gloves to minimize cross contamination. Samples were placed into 4-mil plastic bags and labeled accordingly.

Faunal Sample Collection

One tooth sample was extracted from each of the eight selected faunal samples. As mentioned previously, the decision to sample bone apatite and bone collagen was made after collecting the faunal enamel samples on Statia. A total of 15 samples were collected, however, due to the large quantity recovered from the same location only 8 were submitted. Faunal samples were collected from modern, recently deceased fauna on Statia. The types of fauna sampled was based upon what fauna were encountered by the author for sampling. Fauna chosen and sampled were completely random and based solely on availability. Samples were handled using gloves to prevent cross contamination and initially placed into brown paper bags. Upon arrival at the Center for Archaeological Studies (CAS) at Texas State University, samples were placed in 4-mil plastic bags and labeled accordingly (Table 12).

Table 12. Faunal Samples Selected for Analysis.

Sample Number	Species	Collection Location
1	Goat/Sheep	Road to Zeelandia
2	Dog	Zeelandia Beach
5	Goat/Sheep	Boven Natl. Park
7	Goat/Sheep	Power Plant
10	Cow	Power Plant
12	Pig/Boar	Power Plant
13	Goat/Sheep	West Signal Hill
14	Goat/Sheep	Godet Waterfront

Sample Preparation

Samples were sent to the University of Georgia's Center for Applied Isotope Studies (CAIS) for analysis. Explanations of the processes used to prepare the samples in this study for analysis are directly from CAIS (2019).

Collagen

The sampling region of each bone was mechanically cleaned using a scalpel and wire bristle brush to remove surface contamination. Collagen was recovered following a modified Longin extraction (Longin 1971) as follows. Fragments were demineralized in cold (4˚C) 1N HCL for 20 minutes. The demineralized particles were rinsed with ultrapure (MilliQ) water to pH 4 (slightly acidic) and heated at 80˚C for 8 hours. The resulting solution was filtered through glass fiber filters to isolate the total acid insoluble fraction ("collagen") and freeze-dried.

A 1-mg sample of each collagen was weighed using a microbalance and encapsulated in tin for analysis. The C and N elemental concentrations and stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) were measured using an elemental analyzer isotope ratio mass spectrometer (EA-IRMS) housed at the University of Georgia Center for Applied Isotope Studies (CAIS).

Enamel/Bone Bioapatite

The sampling region of each bone or tooth was mechanically cleaned using a scalpel and wire bristle brush to remove surface contamination. Bone and enamel fragments were pretreated with acetic acid following Cherkinsky (2009) to remove secondary and diagenetic carbonates. The samples were mechanically broken into -1 mm fragments and reacted in 1N acetic acid overnight. The flasks containing the samples were evacuated and re-pressurized periodically, and when reaction ceased, the samples were rinsed repeatedly in ultrapure water and dried at 60˚C.

Approximately 1 mg of each pretreated enamel or bioapatite sample was reacted with 100% phosphoric acid in flushed exetainer vials to produce CO_2, and stable isotope ratios ($\delta^{13}C$ and $\delta^{18}O$) were measured using a Thermo GasBench II-IRMS.

Mass Spectrometry

The mass spectrometry analysis for bone and enamel samples was conducted in the Center for Stable Isotope Studies (CAIS) at The University of Georgia-Athens.

Explanations of the processes associated with the different types of mass spectrometry used to analyze the isotopic samples in this study are directly from Cook et al. (2017).

EA-IRMS

This technique is used when measuring organic carbon, nitrogen, and sulfur isotopic ratios. This elemental analyzer coupled with an isotope ratio mass spectrometer (EA-IRMS) utilizes a combustion device to completely convert organic substances to their primary combustion products. The gas chromatographic column contained within the elemental analyzer is used to separate these gases, which are then sent to the isotope ratio mass spectrometer for individual isotopic analysis.

Thermo GasBench II-IRMS

For the analysis of carbonates or apatite, a GasBench is coupled with an IRMS through an open-split interface. During sampling, the two-port needle adds a gentle flow of helium into the prepared sample vial, thus diluting a displacing the sample gas. Water is removed from the sample gas through diffusion traps. At the appropriate time, the sample in the loop is directed onto a GC column. Once the gas leaves the GasBench sampling system, it enters the source through an open-split interface. A reference gas injection system allows referencing of each sample aliquot to a CO_2 reference gas.

Statistical Analyses

Results are statistically compared to previous isotopic studies in the Caribbean. This analysis was performed to determine whether there are statistically significant differences between the mean isotopic values for different populations. To accomplish this task, a single factor analysis of variance (ANOVA) was performed to determine whether the means of the different populations was equal. If the results of the ANOVA indicate the means are unequal, a t-test was performed on each pair of means. Faunal samples were plotted on a bivariate scatter plot to compare these to the SE600 and Antillean populations. Statistical analyses were performed on both collagen and bioapatite isotope values because they are directly comparable to previously recorded study values (Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2013). The significance value for all statistical analyses is $\alpha=0.05$ or a 95% confidence interval. A Bonferroni Correction was applied to the alpha value because multiple comparisons are being made using different variables. The Bonferroni Correction lowers the alpha value to correct for Type I errors, the equation is as follows: α/n, where α is the original alpha value and n is the number of populations in the comparison.

Adjustments

Previous oxygen isotopic studies have converted PBD values to VSMOW. Laffoon et al. (2013) find that these conversions can be problematic due to the number of different regressions being utilized and the error associated with these regressions. With this uncertainty, Laffoon et al. (2013) do not convert values from PDB to VSMOW. To be consistent with Laffoon et al.'s (2013) data, the oxygen isotopic values in this study are not converted to VSMOW.

To account for inter-laboratory variability, sample isotope values are compared to previously compiled values for the circum-Caribbean (Varney 2003; Laffoon et al. 2013, 2018). The differences between the sample and expected values is then compared to established Minimum Meaningful Distance (MMD) values established by Pestle et al. (2014). MMD values establish a threshold by which results from two different labs may be compared. If the difference between sample and expected values is greater than the

MMD, this might indicate that there is a difference between the results of analyses from different labs (Pestle et al. 2014).

As mentioned previously in Chapter II, collagen yield can affect the results. Previous studies have suggested that the lowest acceptable collagen yield for analysis is 1-3.5% (Ambrose 1990; van Klinken 1999). Acceptable collagen yield values are determined based upon the study region and sample quality. For areas such as Africa, Ambrose (1990) uses a collagen yield of 3.5% as the lowest threshold. In contrast, for Europe van Klinken (1999) uses a collagen yield of 1% as the lowest threshold. For this study, the lowest threshold for collagen yield was 1%.

VI. RESULTS

The isotope analysis results of 11 human bone and 8 faunal tooth samples are shown in Tables 13 and 15. A statistical summary of $\delta^{13}C_{coll}$, $\delta^{15}N_{coll}$, $\delta^{13}C_{ap}$, and $\delta^{18}O_{ap}$ means and ranges are listed in Table 14. Laffoon et al. (2013) previously published $\delta^{13}C_{ap}$ and $\delta^{18}O_{ap}$ results from the Caribbean, these are displayed in Table 8. The isotopic results for each burial are recorded individually below. Results from the isotopic analysis of the faunal samples can be found in Table 15.

Table 13. SE600 Stable Isotope Results.

Sample	Element	Collagen				Bioapatite	
		Collagen Yield (%)	Atomic C:N	$\delta^{13}C$ (‰ PBD)	$\delta^{15}N$ (‰ AIR)	$\delta^{13}C$ (‰ PBD)	$\delta^{18}O$ (‰ PBD)
1	Metacarpal 5	21.3	3:2	-15.9	12.5	-10.5	-3.5
3A	Proximal Hand Phalanx	20.5	3:2	-16.5	11.4	-9.9	-4.0
3B	Metatarsal 3	15.2	3:2	-15.8	12.7	-10.2	-4.6
5	Rib	1.1	3:2	-19.4	12.6	-12.4	-6.5
6A	Rib	14.3	3:2	-14.8	13.8	-10.0	-4.5
6B	Proximal Hand Phalanx	17.8	3:2	-17.6	11.8	-9.5	-4.2
7	Rib	5.9	3:2	-20.1	11.6	-13.1	-5.1
8	Metatarsal 2	18.4	3:2	-16.4	11.9	-11.2	-4.4
11	Rib	18.6	3:2	-19.3	13.6	-15.3	-4.8
15	Proximal Fibula Shaft	19.3	3:2	-16.7	11.0	-11.4	-3.1
16	Rib	2.7	5:4	-20.6	14.4	-12.0	-5.1

Table 14. Mean and Range Values for SE600 Isotopes.

$\delta^{13}C_{coll}$	-17.3 (-20.1 to -14.8)
$\delta^{15}N_{coll}$	12.3 (11 to 14.4)
$\delta^{13}C_{ap}$	-11.3 (-15.3 to -9.5)
$\delta^{18}O_{ap}$	-4.5 (-6.5 to -3.1)

Table 15. Statia Fauna Enamel Stable Isotope Results.

Sample #	Species	Bioapatite	
		$\delta^{13}C$ (‰ PBD)	$\delta^{18}O$ (‰ PBD)
1	Goat/Sheep	-13.60	-1.93
2	Dog	-10.56	-4.11
5	Goat/Sheep	-6.66	1.16
7	Goat/Sheep	-3.68	-0.81
10	Cow	-0.47	-2.11
12	Pig/Boar	-8.96	-3.82
13	Goat/Sheep	-7.77	0.35
14	Goat/Sheep	-7.29	-3.56

Burial 1

The $\delta^{13}C$ (-15.9‰) and $\delta^{15}N$ (12.5‰) values for the extracted bone collagen are consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-10.5‰) and $\delta^{18}O$ (-3.5‰) values for bone bioapatite, relative to PBD, are consistent with the expected isotopic range for the Antilles (Table 4; Laffoon et al. 2013).

Burial 3A

The $\delta^{13}C$ (-16.5‰) and $\delta^{15}N$ (11.4‰) values for the extracted bone collagen are consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-9.9‰) value for bone bioapatite is consistent with expected values, while the $\delta^{18}O$ (-4.0‰) value for bone bioapatite, is not consistent with the expected isotopic range for the Antilles, both relative to PBD, (Laffoon et al. 2013).

Burial 3B

The $\delta^{13}C$ (-15.8‰) and $\delta^{15}N$ (12.7‰) values for the extracted bone collagen are consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-10.2‰) value for bone bioapatite is consistent with expected values, while the $\delta^{18}O$ (-4.6‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 5

The $\delta^{13}C$ (-19.4‰) and $\delta^{15}N$ (12.6‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-12.4‰) value for bone bioapatite is consistent with expected values, while the $\delta^{18}O$ (-6.5‰) value for bone bioapatite, both relative to PBD, are not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 6A

The $\delta^{13}C$ (-14.8‰) and $\delta^{15}N$ (13.8‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-10.0‰) value for bone bioapatite is consistent with expected values, while the $\delta^{18}O$ (-4.5‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 6B

The $\delta^{13}C$ (-17.6‰) and $\delta^{15}N$ (11.8‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-9.5‰) value for bone bioapatite is consistent with expected values, while $\delta^{18}O$ (-4.2‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 7

The $\delta^{13}C$ (-20.1‰) and $\delta^{15}N$ (11.6‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-13.1‰) value for bone bioapatite is consistent with expected values, while $\delta^{18}O$ (-5.1‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 8

The $\delta^{13}C$ (-16.4‰) and $\delta^{15}N$ (11.9‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-11.2‰) value for bone bioapatite is consistent with expected values, while $\delta^{18}O$ (-4.4‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 11

The $\delta^{13}C$ (-19.3‰) and $\delta^{15}N$ (13.6‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-15.3‰) value for bone bioapatite is consistent with expected values, while $\delta^{18}O$ (-4.8‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 15

The $\delta^{13}C$ (-16.7‰) and $\delta^{15}N$ (11.0‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-11.4‰) and $\delta^{18}O$ (-3.1‰) values for bone bioapatite, relative to PBD, are consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013).

Burial 16

The $\delta^{13}C$ (-20.6‰) and $\delta^{15}N$ (14.4‰) values for the extracted bone collagen is consistent with an intermediate diet consisting of both C_3 and C_4 plants and the consumption of both terrestrial and marine proteins. The $\delta^{13}C$ (-12.0‰) value for bone bioapatite is consistent with expected values, while $\delta^{18}O$ (-5.1‰) value for bone bioapatite, both relative to PBD, is not consistent with the expected isotopic range for the Antilles (Laffoon et al. 2013). Collagen yield for this burial has been deemed insufficient by the author and has likely been impacted by degradation that could be due to a variety of reasons. This is evidenced by the deviation of the atomic C:N ratio (Table 10). Therefore, this burial has been excluded from the statistical analysis.

Faunal Results

Results from the $\delta^{13}C$ and $\delta^{18}O$ isotopic analysis of faunal tooth enamel are shown in Table 12 above. The mean $\delta^{13}C$ value for faunal enamel bioapatite was -7.5‰, ranging from -13.6‰ to -0.47‰. The mean $\delta^{18}O$ value for faunal enamel bioapatite was -1.85‰, ranging from -4.11‰ to 1.16‰.

Results of Statistical Analyses

Statistical analyses were performed on the collagen and bioapatite results because they are directly comparable to previously recorded isotopic values for populations throughout the Caribbean (Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2013). A Bonferroni Correction was applied to each of the analyses to adjust for Type I errors. The correction equation for the bioapatite analyses was as follows, $\alpha=0.05/4=0.0125$, or a 98.75% confidence interval. While the correction equation for the collagen analyses was as follows, $\alpha=0.05/5=0.01$, or a 99% confidence interval.

Oxygen (Bioapatite)

An ANOVA test on the Antillean (Laffoon et al. 2013), Barbadian (Schroeder et al. 2009), African (Schroeder et al. 2009), and Godet Cemetery samples found there is a significant difference (F= 115.904, F crit= 3.862) between the mean oxygen isotope values of these populations. After it was determined that there was a significant difference in the oxygen isotopic means of these populations, a two paired t-test assuming unequal variance was conducted comparing the Godet Cemetery values with the other populations to determine which populations are significantly different from the Godet Cemetery population. There was a significant difference in the mean oxygen isotope values for the Godet Cemetery (M=-4.5) and Laffoon et al. (2013)'s Antillean (M=-2.44) populations; $t(10)= -6.664$, $p=0.000028$ and between the Godet Cemetery (M=-4.5) and Schroeder et al. (2009)'s African (M=-5.8, SD=0.315) populations; $t(12)= 4.332$, $p=0.000488$. There is not a significant difference in oxygen isotope values between the Godet Cemetery (M=-4.5) and Schroeder et al. (2009)'s Barbadian (M=-4.3) populations; $t(11)= -0.545$, $p=0.298$. This is concisely illustrated below in Table 16 and Figure 8.

Table 16. Two-Sample T-Test Assuming Unequal Variance Results for Oxygen Bioapatite. Numbers in bold are significant.

Population 1	Population 2	t	p value (one tailed)
SE600	Antillean	-6.664	**0.000028**
SE600	Barbadian	-0.545	0.298
SE600	African	4.332	**0.000488**

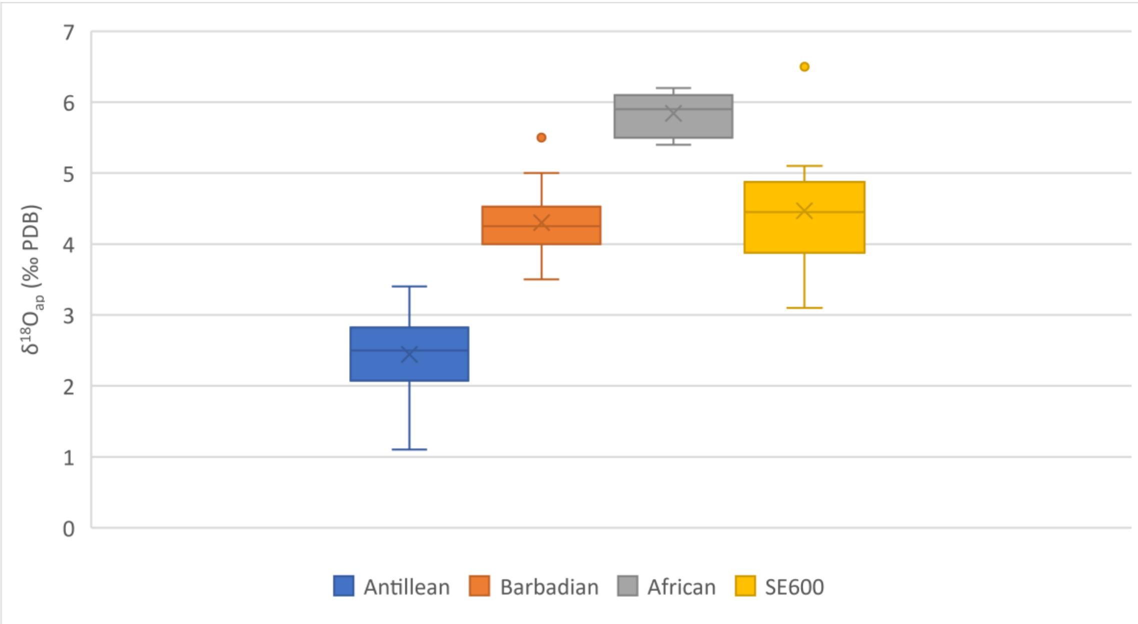

Figure 8. Mean and Range for Oxygen Bioapatite Values.

Carbon (Bioapatite)

An ANOVA test on the Antillean (Laffoon et al. 2013), Barbadian (Schroeder et al. 2009), African (Schroeder et al. 2009), and Godet Cemetery samples found there is a significant difference (F= 16.245, F crit= 3.862) between the mean carbon isotope values of these populations. To determine which populations had significantly different means, a two-sample t-test assuming unequal variance was calculated on population pairs. There is no significant difference between the mean carbon values for the Godet Cemetery (M=-11.3) and Laffoon et al. (2013)'s Antillean (M=-11.5) populations; t(12)=-0.303, p=0.384

and the mean carbon values for the Godet Cemetery (M=-11.3) and Schroeder et al. (2009)'s Barbadian (M=-10.6) populations; t(12)=1.253, p=0.117. There is a significant difference in the mean carbon values for the Godet Cemetery (M=-11.3) and Schroeder et al. (2009)'s African (M=-15.986) populations; t(8)=-2.763, p=0.0123. This is concisely illustrated below in Figure 9 and Table 17.

Table 17. Two-Sample T-Test Assuming Unequal Variance Results for Carbon Bioapatite. Numbers in bold are significant.

Population 1	Population 2	t	p value (one tailed)
SE600	Antillean	-0.303	0.384
SE600	Barbadian	1.253	0.117
SE600	African	-2.763	**0.0123**

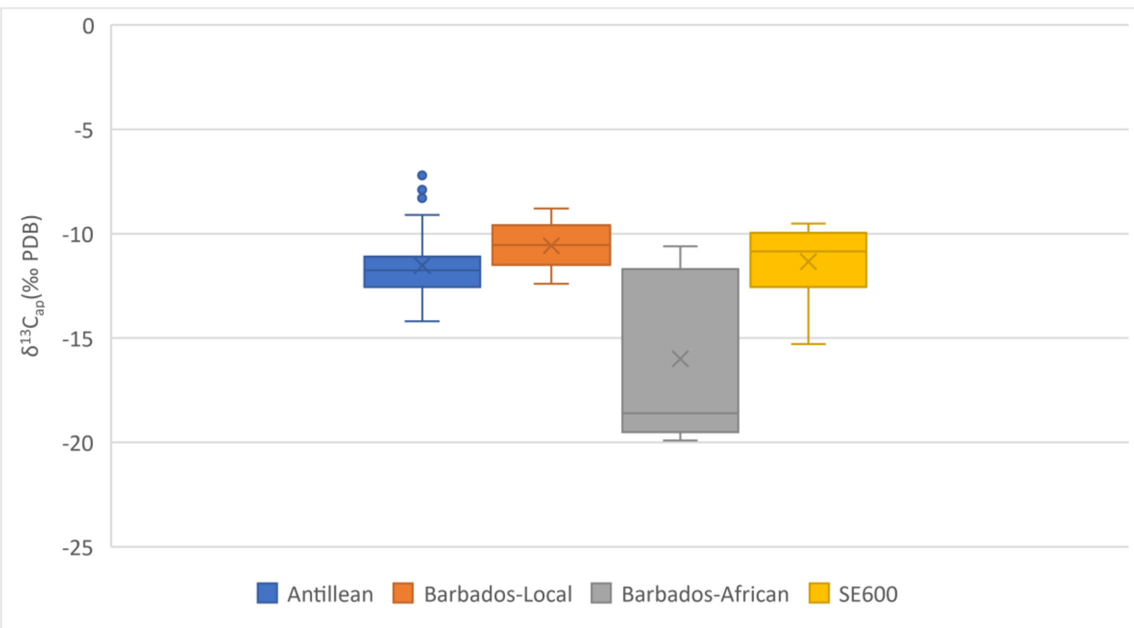

Figure 9. Mean and Range for Carbon Bioapatite Values.

Carbon (Collagen)

An ANOVA test on the Harney Site in Montserrat (Sparkes et al. 2012), Sainte-Marguerite site in Guadeloupe (Sparkes et al. 2012), Barbadian (Schroeder et al. 2009), African (Schroeder et al. 2009), and Godet Cemetery samples found there is a significant difference (F= 54.605, F crit= 3.485) between the mean carbon isotope values for bone collagen of these populations. To determine which populations had significantly different means, a two-sample t-test assuming unequal variances was conducted on population pairs. There is no significant difference between mean carbon values for the Harney Site (M=-16.15) and Godet Cemetery (M=-17.55) populations; t(19)=1.71, p=0.052. There was a significant difference between the mean carbon values for the Sainte-Marguerite site (M=-14.672) and Godet Cemetery (M=-17.55); t(12)=4.636, p=0.000287. There was a significant difference between the mean values for the Barbadian (M=-10.178) population and Godet Cemetery (M=-17.55); t(15)=11.099, p=0.00000000623. Finally, there was also a significant difference in the mean carbon values between the African (M=-10.871) and Godet Cemetery (M=-17.55) populations; t(16)=9.246, p=0.0000000404. This is concisely illustrated below in Figure 10 and Table 18.

Table 18. Two-Sample T-Test Assuming Unequal Variance Results for Carbon Collagen. Numbers in bold are significant.

Population 1	Population 2	t	p value (one tailed)
SE600	Harney Site, Monserrat	1.71	0.052
SE600	Sainte-Marguerite, Guadeloupe	4.636	**0.000287**
SE600	Barbadian	11.099	**0.00000000623**
SE600	African	9.246	**0.0000000404**

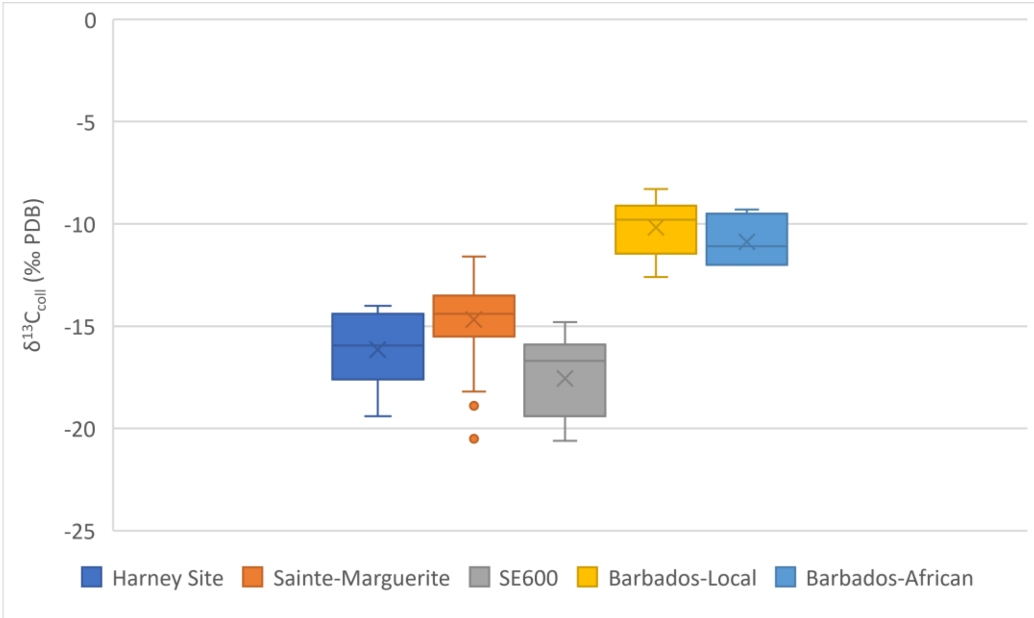

Figure 10. Mean and Range for Carbon Collagen Values.

Nitrogen (Collagen)

An ANOVA test on the Harney Site in Montserrat (Sparkes et al. 2012), Sainte-Marguerite site in Guadeloupe (Sparkes et al. 2012), Barbadian (Schroeder et al. 2009), African (Schroeder et al. 2009), and Godet Cemetery samples found there is a significant difference (F= 9.235, F crit= 3.485) between the mean carbon isotope values for bone collagen of these populations. To determine which populations had significantly different means, a two-sample t-test assuming unequal variances was conducted on population pairs. There is no significant difference between mean carbon values for the Harney Site (M=12.83) and Godet Cemetery (M=12.48) populations; t(18)= 0.669, p=0.256. There was a significant difference between the mean carbon values for the Sainte-Marguerite site (M=15.04) and Godet Cemetery (M=12.48); t(21)= 6.501, p=0.000000966. There was a significant difference between the mean values for the Barbadian (M=14.03) population and Godet Cemetery (M=12.48); t(15)= 4.222, p=0.00037. Finally, there was also a significant difference in the mean carbon values between the African (M=14.09) and Godet Cemetery (M=12.48) populations; t(15)= 3.479, p=0.00168. This is concisely illustrated below in Figure 11 and Table 19.

Table 19. Two-Sample T-Test Assuming Unequal Variance Results for Nitrogen Collagen. Numbers in bold are significant.

Population 1	Population 2	t	p value (one tailed)
SE600	Harney Site, Monserrat	0.669	0.256
SE600	Sainte-Marguerite, Guadeloupe	6.501	**0.000000966**
SE600	Barbadian	4.222	**0.00037**
SE600	African	3.479	**0.00168**

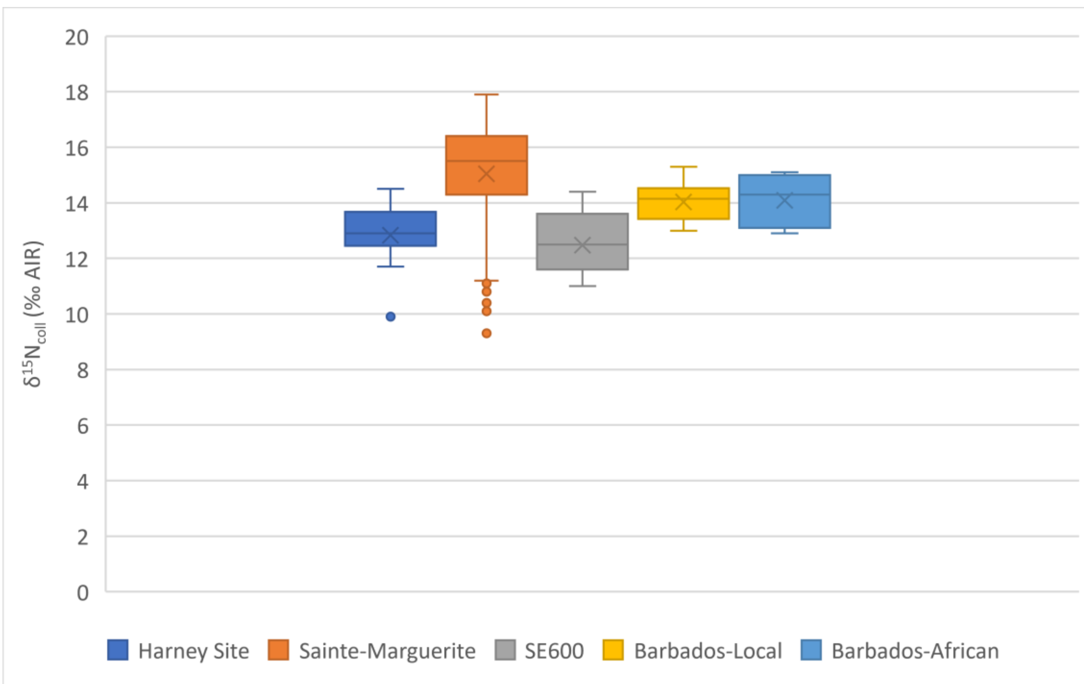

Figure 11. Mean and Range for Nitrogen Collagen Values.

Bivariate Scatter Plots

Additionally, bivariate scatter plots were created to illustrate were individuals were falling out relative to each other. It is important to understand the data on the individual level, in addition to the populational level. The scatter plots include both bioapatite and collagen of the populations being compared above, in addition to comparing the bioapatite values of the human population to the Statian faunal samples collected (Figures 12-14). An in-depth discussion and interpretation of the bivariate data can be found in the following chapter.

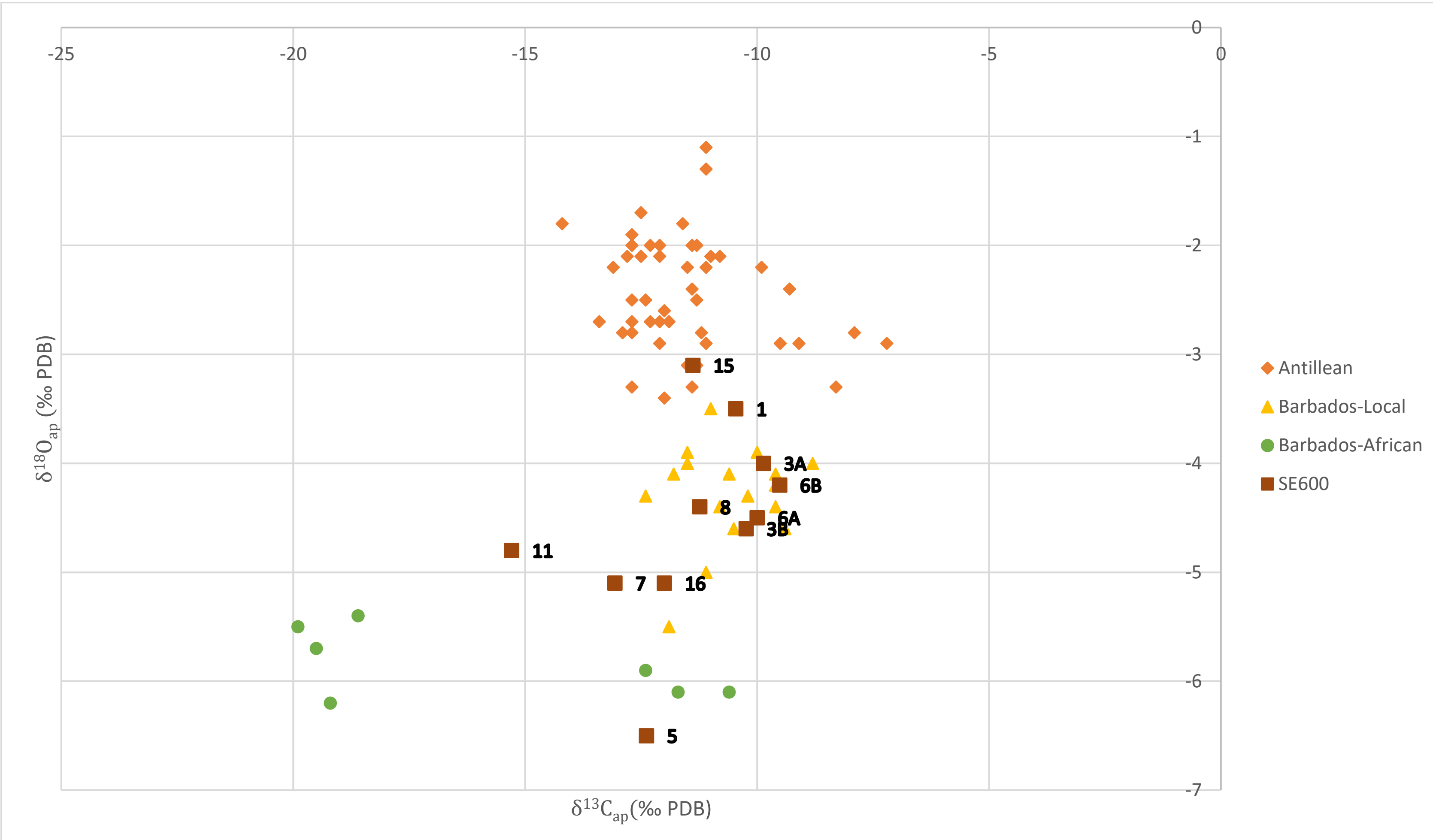

Figure 12. Bivariate Comparison of Carbon and Oxygen Bioapatite Values for Different Caribbean Populations (Schroeder et al. 2009; Laffoon et al. 2013).

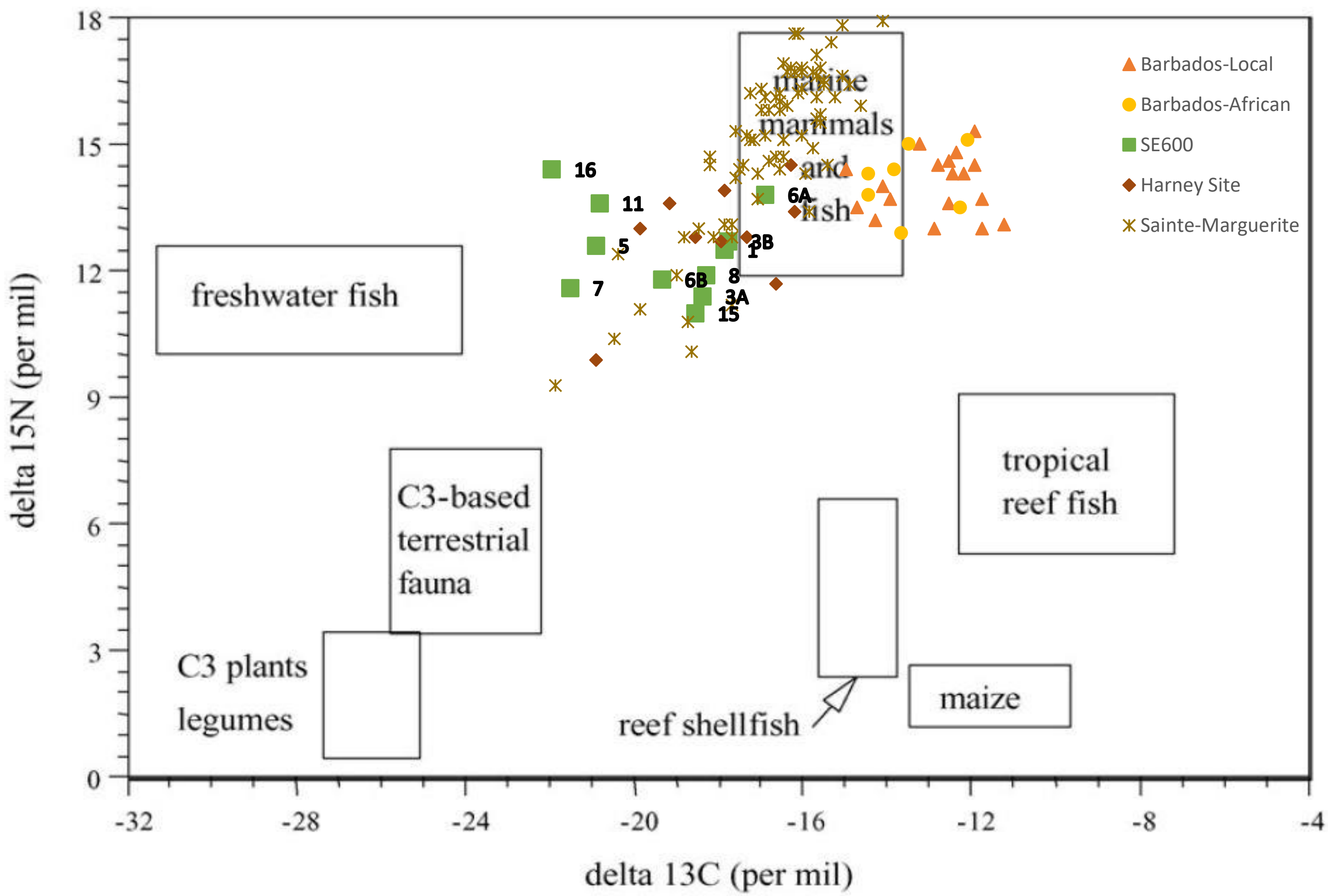

Figure 13. Bivariate Comparison of Nitrogen and Carbon Collagen Values for Different Caribbean Populations (Tykot 2004, 2006; Schroeder et al. 2009; Sparkes et al. 2012).

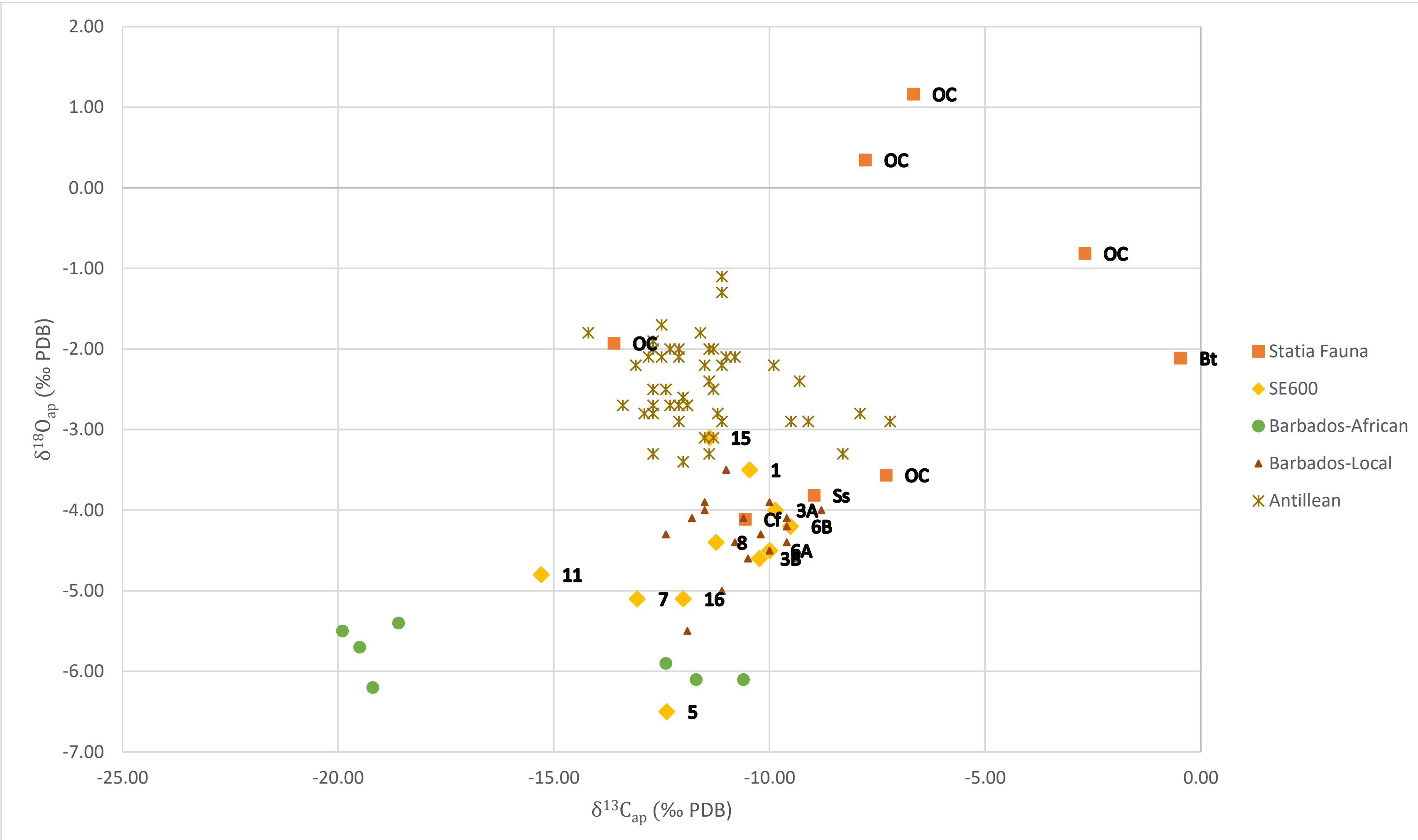

Figure 14. Bivariate Comparison of Carbon and Oxygen Bioapatite Values of Different Caribbean Populations and Statia Fauna (Schroeder et al. 2009; Laffoon et al. 2013).

VII. DISCUSSION

As discussed in Chapter V, results from the oxygen isotopic analysis of the bone bioapatite were not converted to VSMOW. Rather for comparability sake, these values remained in PDB so they can be directly compared to Laffoon et al.'s (2013, 2018) results. In addition to discussing the isotopic results, a table summarizing the interpretation of results (Table 20) and the meaning of results is below. Finally, a discussion of the assumptions, limitations, and implications is provided.

Table 20. Interpretation of SE600 Isotopic Results.

Burial #	**$\delta^{13}C$**	**$\delta^{15}N$**	**$\delta^{18}O$**
1	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Considerable consumption of marine proteins	Local
3A	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Consuming some marine proteins	Local
3B	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Considerable consumption of marine proteins	Local
5	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Considerable consumption of marine proteins	Possibly Non-Local?
6A	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Considerable consumption of marine proteins	Local

Table 20. Continued.

Burial #	δ13C	δ15N	δ18O
6B	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Consuming some marine proteins	Local
7	Primarily reliant on C3 temperate plants; some consumption of C4 tropical plants (i.e. maize)	Consuming some marine proteins	Possibly Non-Local?
8	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Consuming some marine proteins	Local
11	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Considerable consumption of marine proteins	Possibly Non-Local?
15	More reliant on C3 temperate plants; some consumption of tropical C4 plants (i.e. maize)	Consuming some marine proteins	Local
16*	Primarily reliant on C3 temperate plants; some consumption of C4 tropical plants (i.e. maize)	Large amount of marine proteins in diet	Possibly Non-Local?

* *indicates poor collagen yield*

Summary

The results of the isotopic analyses on remains from the Godet Cemetery indicate a reliance on marine proteins. This assertion is supported by previous isotopic and zooarchaeological studies of diet in the Caribbean (Varney 2003; Sparkes et al. 2012; Kelly and Wallman 2014, Wallman and Grouard 2017). It is likely that enslaved Africans were reliant upon provisioned salt fish, in addition to using local marine proteins to supplement the low protein diets provisioned to them. Additionally, the isotope data indicated that enslaved Africans were consuming a variety of C_3 and C_4 plants. The consumption of both types of plants is consistent with previous isotopic analyses and laws mandating resources to be provided to enslaved peoples (Higman 1984; Kelly and Wallman 2014).

In addition to dietary information, isotopic analysis of the Godet Cemetery remains provides insight into residential history in the years prior to death. The oxygen isotope results suggest that several of these individuals (n=4) were fairly recent migrants to Statia. The isotopic values associated with the “nonlocal” individuals at the Godet Cemetery were more similar to those recorded for locals from Barbados and 1st generation Africans on Barbados (Schroeder et al. 2009; Laffoon et al. 2013). A further discussion and interpretation of the isotopic results is provided in the following sections.

Faunal Samples as a Bioavailable Baseline

Eight recently deceased faunal tooth enamel samples were submitted for $\delta^{18}O$ and $\delta^{13}C$ isotopic analysis. For this study, the goal of submitting these samples was to establish a bioavailable isotopic baseline for the island of Statia. The individual results of the faunal analysis are found in Table 16 in Chapter VI. The mean $\delta^{18}O$ value for the faunal samples was -1.85‰, which is not significantly higher than the expected Statian value reported by the OIPC of -2.6‰. The mean $\delta^{13}C$ value for the faunal samples was -7.25‰. This value is significantly higher than the mean carbon value for individuals buried at the Godet Cemetery. These significant differences between the Statia Fauna and Godet Cemetery individuals can likely be attributed to the types of fauna selected for analysis. The majority of the fauna sampled in this study were Goats/Sheep (Oc). It is unlikely that these animals would be eating all the same foods as humans. However, the dog (Cf) and pig/boar (Ss) sampled had carbon and oxygen bioapatite values more similar those of the Godet Cemetery individuals (Figure 14). The similarity of the dog and pig values to human values is likely because they have similar omnivorous diets.

The results of the faunal analysis in this study have demonstrated the importance of sample selection. Sample selection in this study was limited to what was immediately available to the author for collection. Ideally, fauna such as dogs or pigs would be sampled because they are eating human food refuse or food scraps. Previous isotopic studies of faunal material have had much success with provenancing dog remains (Laffoon et al. 2014, 2017). These studies found that, like human remains, dog remains can be used to track residential history and understand diet. In turn, this makes dogs, and animals with similar diets, excellent specimens to use when developing a bioavailable isotopic range for a region (Guiry 2012; Edwards et al. 2017; Laffoon et al. 2017). As the background research and previous studies described in Chapter II and III indicates, dogs and pigs can be good proxies for humans in isotopic analysis. Though the present study only utilized one dog and one pig, future attempts to create a bioavailable isotopic range for Statia should utilize dogs and pigs or fauna with a similar diet.

Enslaved African Lifeways on Statia

Diet

This study gives insight into the lifeways of the enslaved Africans residing on the Godet Property. Isotopic analysis of enslaved African diet demonstrates a reliance on provisions provided by the plantation owner(s), their own provision grounds, and supplemented protein from local marine resources. The diet of enslaved Africans on Statia included an intermediate diet of both C_3 and C_4 plants, with a greater reliance on C_3 temperate plants, which is consistent with previous isotopic and archaeological research from the region (Varney 2003; Kidd 2006, Kelly and Wallman 2014; Wallman and Grouard 2017).

The protein intake of enslaved Africans on Statia was likely lower than the recommended amount of protein required for the type and amount of work they conducted (Kiple 1984; Higman 1984; Corruccini et al. 1987; Madrigal 2006). Nitrogen isotopic analysis indicates the consumption of a higher than expected quantities of marine or freshwater proteins in addition to expected terrestrial proteins amounts. The intake of marine proteins is well documented in previous research regarding on other Caribbean islands (Varney 2003; Wallman 2014; Kelly and Wallman 2014; Wallman and Grouard 2017). Marine proteins are also documented in the historical record as a provision required to be provided to enslaved Africans throughout the Caribbean (Higman 1984; Kelly and Wallman 2014; Wallman and Grouard 2017). It is likely that free and enslaved Africans on Statia were receiving salt fish provisions and fishing for additional marine protein sources during their free time. Enslaved Africans were likely also consuming a variety of terrestrial proteins (Ramsey 2011). A zooarchaeological study conducted on materials from enslaved Africans contexts on the island of Martinique found most terrestrial proteins were cow, pig, and goat (Wallman 2014). The availability of these proteins on Statia was dependent on provisions from slave owners and what animals the enslaved peoples had the time and money to raise themselves.

The enslaved Africans diet on Statia reflects their access to available resources. The diversity of C_3 plants thought to be associated with the provisioning grounds discussed in previous archaeological and historical studies of the Caribbean are supported by this study (Varney 2003: 24; Kidd 2006: 43; Byrd 2014: 42; Handler and Wallman 2014: 449; Figure 13). The consumption of primarily C_3 and some C_4 plants indicates a reliance on fruits and vegetables that can be easily grown on their own provisioning grounds and provisions of C4 plants, like corn and sorghum (guinea corn), required by law. Additionally, the consumption of a considerable amount of marine proteins indicates that enslaved Africans were likely reliant on provisions of salt fish and/or caught their own fish (Madrigal 2006; Ramsey 2011; Kelly and Wallman 2014; Wallman and Grouard 2017; Figure 13). It is also likely that enslaved Africans were also consuming terrestrial proteins such as cows, pigs, and goats (Wallman 2014; Kelly and Wallman 2014; Wallman and Grouard 2017).

Nutrition

In addition to diet, the analysis of carbon and nitrogen isotopes also give some insight into the health of the individuals being studied. The isotopic values associated with individuals from the Godet Cemetery do not show evidence for malnutrition or starvation that is often associated with enslaved and free African populations in the Caribbean. Carbon and nitrogen isotope values for all individuals are within the expected range for the Lesser Antilles and Africa. Consumption of considerable quantities of fish can account for the high nitrogen values in these individuals, rather than the reuse of body proteins. Additionally, individuals experiencing malnutrition or starvation are expected to have higher carbon values because they are not consuming the necessary nutrients (Mekota et al. 2006; Neuberger et al. 2013). The Godet Cemetery individuals are not expressing these high values and show evidence for an intermediate diet with several plant foods, primarily C_3 plants, contributing to the diet.

Residential History

The understanding of childhood residential history and adult residential history prior to death is important for understanding the lifeways of enslaved Africans in the Caribbean. The forced migration of people to Statia is well documented in the historical record (National Archives, The Hague; Fred van Keulen and Dr. Ruud Stelten, Personal Communication 2019). For this study, due to the unavailability of teeth for analysis, oxygen isotopic analysis was conducted on bone bioapatite to understand recent residential history. Most of the individuals in the study had results that were inconsistent with the expected value for the island of Statia (-2.6‰) and the Lesser Antilles (-2.5‰). However, upon examination of the bivariate plots, it becomes clear that four individuals are likely nonlocal to the island (Figures 12-14). The remaining seven individuals had results consistent with the individuals residing on Barbados and the Lesser Antilles for a substantial period of time prior to death (Schroeder et al. 2009; Laffoon et al. 2013; Figures 12-13).

This study suggests that there is a possibility that four of the buried individuals at the Godet Cemetery are nonlocal to the Lesser Antilles. The bivariate plots for both collagen and bioapatite isotopic analyses support the suggestion that individuals in Burials 5, 7, 11, 16 were nonlocal to Statia (Figures 12 and 13). In both bivariate plots, these four burials are separated from the local Caribbean population indicating they were not consuming all of the same resources. The nonlocal individuals in the Godet Cemetery population have diets and residential histories more similar to individuals from Barbados and Africa (Schroeder et al. 2009; Laffoon et al. 2013; Figures 12 and 13). Additional support for the nonlocal origins of enslaved Africans on Statia comes from original shipping records dating to 1787-1789 provided by the St. Eustatius Center for Archaeological Research (SECAR). These records document what each ship brought to Statia, including the number of slaves on board. An analysis of these records found that over this three-year period, an estimated 40% of enslaved peoples brought to Statia were on ships coming directly from Africa (Table 21; Figure 15). This likely under documented number of enslaved peoples coming to Statia on ships embarking directly from Africa increases the likelihood that the individuals buried at the Godet Cemetery could have recently resided in Africa for a substantial amount of time prior to death.

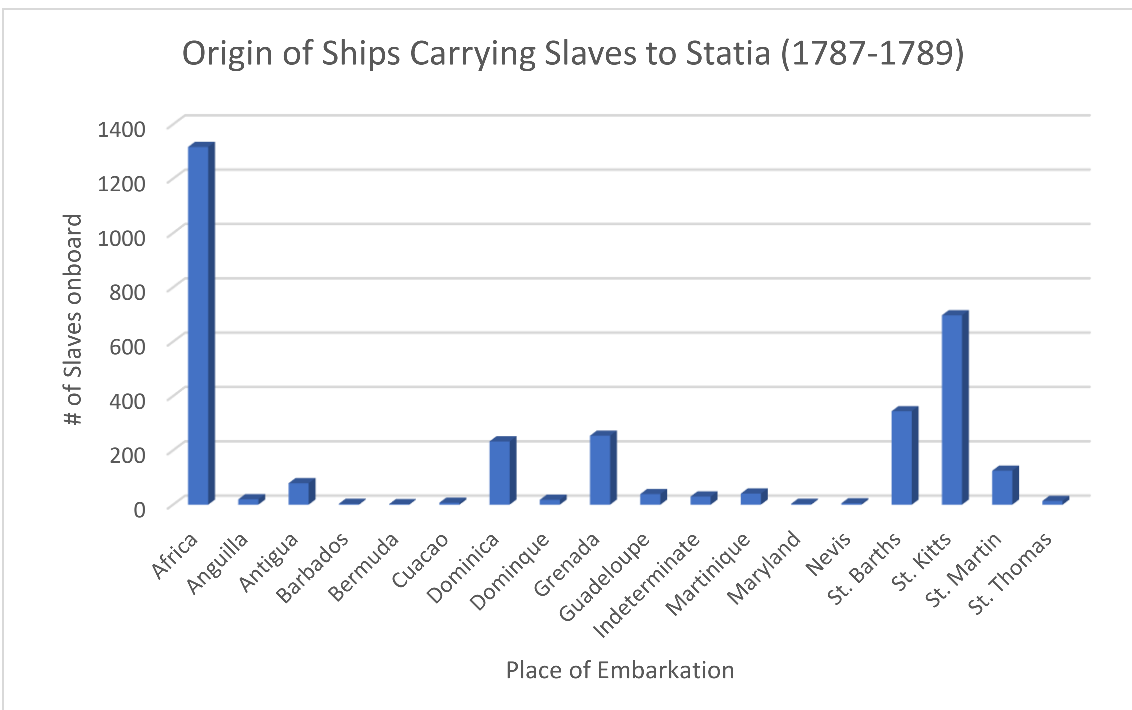

Figure 15. Origins of Ships Carrying Slaves to Statia (1787-1789).

Table 21. Ships Carrying Slaves to Statia (1787-1789).

Place of Embarkation	# of Slaves Onboard	% of Total
Africa	1317	40.76
Anguilla	20	0.62
Antigua	79	2.45
Barbados	3	0.09
Bermuda	2	0.06
Cuacao	7	0.22
Dominica	233	7.21
Dominique	18	0.56
Grenada	254	7.86
Guadeloupe	39	1.21
Indeterminate	30	0.93
Martinique	41	1.27
Maryland	3	0.09
Nevis	5	0.15
St. Barths	344	10.65
St. Kitts	697	21.57
St. Martin	125	3.87
St. Thomas	14	0.43
Total	**3231**	

Inter-Island Dietary Comparisons

When mean isotope values for bone collagen for the Godet Cemetery and other historical Caribbean cemeteries are compared, some patterns are evident. There is a distinct dietary similarity between enslaved African populations on different islands. Table 22 lists the mean and range of carbon and nitrogen isotopic analysis for 3 sites on 3 different islands

Table 22. Comparison of Carbon and Nitrogen Isotopic Values for 3 Sites (Sparkes et al. 2012: 5).

Site	n	Mean $\delta^{13}C$ ‰	Range	Mean $\delta^{15}N$ ‰	Range
Harney site, Monserrat*	10	-15.5	-14 to -18.2	13.2	11.7 to 14.5
Sainte-Marguerite, Guadeloupe*	76	-14.7	-11.6 to -20.5	15	9.3 to 17.9
Godet Cemetery, St. Eustatius	10	-17.3	-14.8 to -20.1	12.3	11 to 14.4

*From Sparkes et al. (2012)

A comparison of carbon and nitrogen isotopic analysis suggests that enslaved Africans at the three sites are consuming similar foods. The carbon values make it apparent that C_3 root crops and temperate grasses were a substantial part of the diet and enslaved Africans were less reliant upon C_4 crops. Nitrogen values from the three sites indicate a reliance on marine proteins, such as provisioned salt fish and supplementary locally caught fish. The comparisons here illustrate that the diet of the Godet Cemetery individuals was typical of enslaved Africans in the Caribbean. A statistical analysis between the carbon and nitrogen isotopic values for the different populations was presented in the previous chapter (Figures 10, 11, 13; Table 19 and 20). This statistical analysis illustrated that though these populations were consuming similar foods, there was a statistical difference between the Godet and Guadeloupe populations. The Guadeloupe population was more reliant on C_3 crops and marine resources than the Monserrat and Godet populations. Though there was a greater reliance on these resources in the Guadeloupe population, they are still utilizing the same resources. This reliance on particular resources, C_3 crops and marine proteins, shows the importance of these items to enslaved communities in the Caribbean.

Assumptions

In Chapter I, a series of assumptions are made about the water and food sources of enslaved Africans and expected isotopic ratios. In this section, the applicability of these assumptions is assessed and explained.

Assumption 1: African Ancestry

The first assumption made was that all individuals buried at the Godet Cemetery were of African ancestry. A biological profile, conducted by Dr. Ashley McKeown, found four of these individuals to be of African ancestry. The remaining individuals are likely of African ancestry based upon demographic information (Table 9), mortuary attributes (Table 11) and dating of the burials completed by Sydney Tucker (2019; Figure 6). Additional support for this assumption is through historical records from 1738 that mention the cemetery as a burial ground for enslaved Africans (Knappert 1932). The first excavations at the site by Morsink (2012) made the assertion that individuals of European ancestry were buried at the Godet Cemetery. Morsink (2012)'s support for this argument was the presence of coffins. It was previously believed that enslaved Africans would not have been buried in coffins. However, the social environment on Statia, the biological profiles, and demographic information contradict this finding. Enslaved Africans on Statia made their own money and could have accumulated enough personal wealth to bury their loved ones in coffins. The isotopic analysis completed for this study also supports the notion that these individuals are likely not of European decent. The oxygen isotopic values for the individuals buried at the Godet Cemetery are much higher than the expected values for individuals of European ancestry, specifically for Dutch and English individuals (Bowen 2019; IAEA/WMO 2019).

Assumption 2: Associated with the Godet Plantation

The second assumption made in this study was that all individuals buried at the Godet Cemetery are associated with the Godet Plantation. This assumption is supported by the artifacts found associated with the burials. An analysis of these artifacts by Sydney Tucker (2019) was done to date the cemetery and determine if it was associated to Fort Amsterdam, the Slave Depot, or the Godet Plantation. The results of this analysis dated most of the burials at the Godet Cemetery were dated from the early 1700s to 1850. These dates coincide well with the documented dates of the Plantation from 1690-1850 as well as the Slave Depot at Fort Amsterdam from 1724-1781 (Tucker 2019). Additional evidence for the cemetery's association with the Godet Plantation is the tendency for artifacts associated with burials to favor the late 18th to early 19th century. The results of the analysis are further supported by the 1738 mention of the cemetery in historical records as a burial ground for enslaved Africans (Knappert 1932).

Assumption 3: Similar to Faunal Values

The third and final assumption of this study is that the results of the isotopic analysis on the human remains from the Godet Cemetery will be similar, yet enriched, to local fauna. After submitting samples for isotopic analysis, this assumption was determined to be partially incorrect. As mentioned in the section above, the mean $\delta^{18}O$ value for the modern, recently deceased fauna was significantly different than the values from the cemetery. Though it was considerably higher than the values from the cemetery, it was not significantly different from the expected value for Statia. $\delta^{18}O$ is more accurate for comparison between human and faunal values in this study than $\delta^{13}C$. The faunal $\delta^{13}C$ values are significantly higher than those of the cemetery samples. As mentioned previously, this is likely due to the fauna selected for analysis. Though the mean $\delta^{18}O$ and $\delta^{13}C$ values for fauna were significantly different from the Godet Cemetery individuals, the dog and pig values stood out individually (Figure 14). These faunae had $\delta^{18}O$ and $\delta^{13}C$ values similar to those of humans due to the likelihood they are consuming human food refuse or scavenging human foods (Guiry 2012; Guiry et al. 2012; Edwards et al. 2017; Laffoon et al. 2017). In the future, isotopic studies like the one presented here would benefit from selective sampling of dogs, pigs, or fauna with similar diets.

Limitations

Isotopic analysis has several well documented limitations. These limitations can be both natural and chemical. In this section, the limitations of this study will be discussed in detail.

Equifinality

The first limitation to be discussed is the issue of equifinality. As mentioned previously, equifinality occurs when two geographic locations share similar or the same isotopic values. Equifinality is especially an issue when discussing residential history but is not as much with diet or nutrition. This is because residential history is dependent on the isotopic composition of the soil and water. The issue of equifinality is addressed using multiple isotope approaches to determine residential history. Typically, both strontium and oxygen isotope analysis are used to determine where an individual has lived previously because it is more unlikely, though still possible, that both values will experience issues with equifinality (Laffoon et al. 2013). Due to the unavailability of certain skeletal elements for analysis, only bone collagen and bone bioapatite were available for analysis. Strontium isotopic analysis is generally not recommended for collagen and bone bioapatite analyses due to the high rate of turnover in these tissues (Cox and Sealy 1997). For this reason, strontium analysis was excluded from this analysis and oxygen was the primary isotope relied upon for residential history analyses.

Preservation and Recovery

Another limitation of this study was the preservation and recovery of remains. The placement of the Godet Cemetery on a cliffside eroding into the Caribbean Sea means that the preservation of the remains was not optimal. Tropical storms and hurricanes have caused the continuous erosion of the cliffside and the loss of provenience information and remains. The loss of provenience information makes potentially useable samples unusable because they no longer have the necessary information to associate them with the Godet Cemetery. Additionally, the loss of the remains themselves means that potentially usable skeletal samples and the information they could have provided are now lost forever. The remains that are available for examination are highly fragmented and incomplete due to soil conditions and placement. In addition to the remains' highly fragmented nature, much of the skeletal material being recovered are the torso and lower limb bones. This is likely due to the direction of the burials and the likelihood that erosion would expose the lower limbs first. The low number of complete crania and teeth suitable for analysis makes it difficult to assess childhood residential history and diet. The lack of suitable teeth for analysis is the primary reason for the focus of this study on the bone collagen and bioapatite.

There are also potential issues with the recovery of collagen and bioapatite from the bones submitted for isotopic analysis. The importance of collagen yield to obtaining accurate isotopic results was discussed previously in Chapter V. Low collagen yield tends to cause the isotopic results of bone collagen to be inaccurate. This inaccuracy is due to the degradation of the collagen through natural or chemical processes (Ambrose 1990; van Klinken 1999). Preservation and integrity of the bone collagen for the Godet Cemetery individuals was generally good, except for Burial 16. The collagen yield of Burial 16 was low, 2.7%, and had an atomic C: N of 5.4, which is different from the atomic C: N of the remaining burials (3.2). It is likely that degradation of the collagen of Burial 16 has occurred due to natural processes associated with the placement of the cemetery on a cliffside and exposure to the elements.

Comparable Data Availability

For this study, the material being used for comparison is primarily derived from Laffoon et al. (2013) and Schroeder et al. (2009). Though other isotopic studies have been done in the Caribbean (Varney 2003, Laffoon et al. 2018), there is still not much material for comparison. The material that is present for comparison is primarily prehistoric (Laffoon et al. 2013) and this distinction could make a difference when using this data set. There is a possibility that prehistoric individuals procured water in a different way than historic peoples. There has been little investigation into the possible differences in the isotopic values of Caribbean prehistoric and historic peoples. The primary study analyzing oxygen isotopes in historic enslaved populations is Schroeder et al. (2009)'s Newton Plantation study in Barbados.

Barbados is different geologically and hydrologically because it is outside of the Lesser Antillean chain. This geology and hydrology make Barbados different isotopically, giving the island much lower oxygen isotope values than the rest of the Lesser Antilles (Schroeder et al. 2009). The work at the Newton Plantation is the some of the only isotopic work in the Caribbean done on a historic population. It is also one of the few works to definitively parse out 1st generation Africans. For these reasons, the Newton Plantation individuals have become a standard for isotopes in the Caribbean. However, Barbados' geology and hydrology make it difficult to compare local Antillean populations. Though the Newton Plantation individuals are not as helpful when trying to determine local individuals, it is helpful for comparison of individuals thought to be non-local from Africa.

Inter-laboratory Variation

Stable isotope analysis has long suffered from various issues regarding the validity of comparisons of isotopic values between labs. A previous study conducted by Pestle et al. (2014) confirmed that there are potential issues with the direct comparison of materials analyzed in different labs. The goal of Pestle et al. (2014)'s study was to test inter-laboratory variation by replicate testing of samples at a variety of different isotope labs. The results of this study found that collagen values are directly comparable, however, this is not the case for bioapatite. The study found that there was often a significant difference in the oxygen values of bioapatite between labs. The authors attribute this difference to the differences in oxidation treatment between the different labs. The difference in oxidation treatment only seems to influence oxygen values and not carbon (Pestle et al. 2014).

The issues associated with directly comparing oxygen isotopic values for oxygen could be affecting the results of this study. The mean oxygen isotopic value for this study was significantly different from the published expected value for the Lesser Antilles (Laffoon et al. 2013). This significant difference could be due to differences in residential history; it is also possible that these differences are due to inter-laboratory variation. As the study by Pestle et al. (2014) indicated, the variation in the values from this study and those from around the Caribbean could be attributed to differences in oxidation treatment.

Implications

The implications of this study regarding applicability of stable isotope analysis to the exploration of free and enslaved African lifeways on Statia are as follows. The present study suggests that enslaved Africans buried in the Godet Cemetery were consuming foods they were provisioned and could likely procure for themselves. The diet of these individuals is indicative of the social environment present in colonial Statia where enslaved Africans participated in Statia's trade economy and had the opportunity to buy foods not provisioned to them by slave owners or grown in their own provision grounds. Historical records have documented an inadequate protein intake among enslaved Africans throughout the Caribbean (Kiple 1984; Higman 1984; Hall and Higman 1992). However, isotopic analysis of the individuals buried at the Godet Cemetery indicate that the individuals did not have nutritional protein stress and relied on fish as a major source of protein. Salt fish was likely given to enslaved Africans as provisions or procured by the enslaved Africans. The fish caught by the enslaved Africans could have also been sold at local fisheries and used to make money to buy their freedom or other goods they may have needed such as cloth, lumber, or spices. The opportunity to make money by selling the fish they caught was a good incentive for enslaved Africans to catch and consume marine proteins. There is also monetary as well as personal incentive to raise terrestrial proteins such as cows, goats, pigs, and chickens on the provisioning grounds provided to enslaved Africans. They could also sell these animals at the market for profit. The ability for enslaved Africans to participate in the trade economy was important to the lifeways of these individuals. Enslaved Africans on Statia had access to goods and services not typically available to enslaved Africans throughout much of the Caribbean. The isotopic analysis of diet conducted for this study is supported by the availability of these food items.

The isotopic analysis of the residential history prior to death is also potentially indicative of Statia's position in the global economy. This is evidenced by the isotopic oxygen isotopic analysis indicating that the Godet Cemetery individuals are non-local from Barbados or Africa. As mentioned previously, Fort Amsterdam on the Godet Property was at one time the official, then unofficial, slave depot on Statia. Hundreds and likely thousands of slaves would come to the island before being sold and transported to other islands. The influx of ships bringing enslaved Africans to Statia raises the likelihood that the slaves on Statia could have been non-local to the island. This suggestion can also be supported by historical shipping records documenting the forced migration of enslaved people on ships disembarking in Statia (National Archives, The Hague; Fred van Keulen and Ruud Stelten, Personal Communication 2019). The possibility that a substantial portion of enslaved Africans residing on Statia were not local to the island would not be unusual considering how important Statia was to the global economy.

The isotopic analyses performed for this study support the interesting social environment on Statia. The analysis showed where people were potentially coming from and what foods they had access to. The position of the island in the global economy during the 18th and 19th centuries meant that ships from all over the world would disembark on Statia. The disembarkation of ships on Statia brought thousands of pounds of goods to the island, in addition to enslaved Africans. Globalization on Statia was on full display with local and non-local free and enslaved Africans participating in the trade economy to buy and sell foods and other goods previously thought to be unavailable to them.

VIII. CONCLUSIONS

Stable isotope analysis is an effective methodology to analyze the lifeways of past individuals and populations. Isotopic studies have been infrequently conducted in the Caribbean (Varney 2003; Schroeder et al. 2009; Sparkes et al. 2012; Laffoon et al. 2012, 2013, 2014, 2016, 2018) and remain underutilized when analyzing Caribbean populations. The present study sought to add to the present knowledge and contribute to the already tiny sample of isotopic studies conducted in the Caribbean.

Summary

The primary goal of this research is to explore and understand the lifeways of the enslaved Africans buried at the Godet Cemetery. To address this goal, 11 human bone collagen and bioapatite samples and 8 faunal tooth enamel samples were submitted to the University of Georgia's Center for Applied Isotope Studies (CAIS) for analysis. The analysis results are compared to previously analyzed samples from the Caribbean with special attention to the Lesser Antilles and Barbados (Laffoon et al. 2013; Schroeder et al. 2009). Oxygen isotopic values often face issues of equifinality, so reliance solely on oxygen for residential history determination is not recommended (Price et al. 2012; Laffoon et al. 2018). Oxygen isotope values are often not recommended as the only factor when assessing residential history due to equifinality; however, oxygen isotope values can provide preliminary information whether an individual is nonlocal to a region. Oxygen isotope values in this study suggest that four of the Godet Cemetery individuals were nonlocal to Statia. It should also be noted that these results could possibly be affected by sample degradation, diagenesis, or inter-laboratory variation; however, there is little indication that this is the case.

Carbon and nitrogen isotope analyses are more successful in assessing diet by distinguishing the types of plants and proteins consumed by the enslaved and freed Africans buried in the Godet Cemetery. The nitrogen analysis shows that marine resources were an important protein component in the diet of free and enslaved Africans, and they were likely consuming considerable amounts of marine proteins. Salt fish was frequently given to enslaved Africans as a provision by slave owners (Kiple 1984; Higman 1984; Hall and Higman 1992; Varney 2003; Ramsey 2011; Handler and Wallman 2014), and it is also possible that they supplemented their diet with additional marine proteins procured for themselves through fishing. It is possible enslaved Africans also fished for their families and/or used money they earned to buy fish from local fisheries (Madrigal 2006). This study also examines the types of plant foods being consumed by enslaved Africans at the Godet Cemetery. Carbon isotopic analysis indicates evidence for an intermediate diet with the consumption of a variety of both C_3 and C_4 plants.

Conclusions

This study demonstrates the applicability of carbon, nitrogen, and oxygen stable isotope analyses to explore the lifeways of enslaved Africans on Statia. This study is useful in understanding the types of foods that were consumed by enslaved Africans. In addition to learning more about what resources were available to enslaved peoples on Statia, this study also gave some insight into the possible origins of the enslaved people. Understanding the origins of the people being forcefully brought to Statia also demonstrates Statia's role in the Trans-Atlantic Slave Trade and the position of the island in the Caribbean as a hub for people and activities.

This study demonstrates the usefulness of isotopic analysis for understanding the diet of historic populations. The results are a good method for fact checking historical records documenting the types of plants and proteins provisioned to and grown by enslaved peoples. This analysis is helpful for interpreting diet but is less conclusive in assessing residential history. As mentioned previously, the reliance on oxygen isotope values alone to determine residential history is generally not the best practice (Laffoon et al. 2018). This study suggests the possibility that four individuals buried at the Godet Cemetery are non-local to the island.

Finally, the analysis results analysis supports some assertions previously made about the Statia's social environment during the 18th and 19th centuries. Previous research into the Statia's social environment during this time found enslaved Africans on the island had the opportunity to participate in the Statian trade economy. Participation in the trade economy allowed these individuals access to resources and sources of monetary gain that were unavailable to enslaved Africans on other Caribbean islands (Gilmore 2008, 2013, 2016). The isotopic analysis performed in this study demonstrates the self-sufficiency of enslaved Africans and the access to several plant resources that they grew themselves, traded for, or bought. Additionally, the evidence for a considerable amount of marine protein in the diet supports the idea that they likely utilized their personal time to supplement their historically low-protein diet by fishing for themselves (Madrigal 2006) and could have sold surplus to local fisheries to make their own money. The results of this study support Statia's position in the global economy and are indicative of the island's important trade position in the Caribbean.

Suggestions for Future Research

Isotopic Testing of Statian Water Sources

The analysis performed in this study yielded interesting results when compared to previous research. Nine of the eleven of the burials from the Godet Cemetery population had oxygen isotope results significantly lower than the expected oxygen values for the Lesser Antilles. The expected oxygen isotopic value for Statia is -2.6‰ according to the OIPC (Bowen 2019) and previous isotopic research in the Caribbean (Laffoon et al. 2013). Future research on this project would benefit from the isotopic testing of different water sources around the island. Oxygen isotopic analysis of the water sources used by historic peoples could give some insight into the validity of the oxygen isotope results of the present study. If Statian water samples have oxygen values more like those of the Godet Cemetery individuals, this could indicate that the estimated value from the OIPC is sometimes incorrect. It could also mean that there is a difference in the sources and procurement of water between prehistoric and historic peoples in the Caribbean.

Strontium Isotopic Testing

Due to various constraints on this project, strontium isotopic analysis was not run on the present samples. Strontium analysis would assist with the determination of locality and alleviate some of the issues associated with equifinality. The strontium signature of an individual reflects the signature of the soil and water where the element was derived. Because strontium is incorporated from the environment this means that strontium values are different in different environments and locations making it ideal for studies of migration and residential history (Wrobel et al. 2016). Though the oxygen isotope analysis performed in this study was able to suggest non-local origin, it was unable to make a definitive estimation of locality due to issues of equifinality and potential inter-laboratory variation. The results of the oxygen isotopic analysis in this study would benefit greatly from the additional analysis of the strontium isotopic composition, not only to further help estimate locality, it would also help determine the presence or absence of inter-laboratory variation. Additionally, strontium isotopic analysis would validate the use of faunal samples as a bioavailable reference standard. There have been previous studies that have successfully used faunal samples to help establish local expected strontium and oxygen values (Price et al. 2010, Wright et al. 2010, Laffoon et al. 2014, 2016; Pederzani and Britton 2019).

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