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Mbeki, L.

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Chapter 6

Sickly slaves, soldiers and sailors.

contextualising the Cape's 18th-19th century

Green Point burials through isotope

investigation

This chapter has been published elsewhere with few alterations: Mbeki, L., Kootker, L.M., Kars, H., Davies, G.R., 2017. *Journal of Archaeological Science: Reports* 11, 480-490.

Introduction

The biogeochemical approach to the study of forced migrations has been applied to the Atlantic World in several instances, but still remains in its infancy. For example, carbon, nitrogen, strontium and oxygen isotopes have been used to “gain a more nuanced understanding of the slaves’ origin” at the Newton plantation in Barbados, in Saint Martin, Dutch Caribbean and in Brazil (Schroeder *et al.*, 2009; Schroeder *et al.*, 2014; Bastos *et al.*, 2016). Laffoon *et al.* (2012a, b) also employed a multi-isotope approach on dental enamel to investigate human mobility in the Caribbean Archipelago to determine possible places of origin (Greater Antilles, Meso-America or Africa). Some African slaves from the New York African Burial Ground (NYABG) were transported via the Caribbean to their final destination (Goodman *et al.*, 2009). Nystrom *et al.* (2011) performed a strontium isotope study of African-American individuals from the Newburgh (New York) free black cemetery to shed light on how manumission and industrialisation affected the mobility of the free black population. Isotopic work has also been performed on early 16th and 17th century burials in Campeche, Mexico (Price *et al.*, 2006, 2012). In combination with cultural markers, these data trace some of the individuals’ roots to West Africa.

In contrast to the varied body of work focussing on the New World slave trade, only three isotopic studies have been carried that focus on Indian Ocean World forced migration. These studies concentrate on the former Cape Colony as a node in the Indian Ocean forced migration circuit. Cox and Sealy (1997) determined that the individuals excavated at Fort Knokke (Cape Town, South Africa) were slaves from Mozambique transported by the Portuguese slaving brig *Pacquet Real*, which sank off the Cape coast in 1818. These individuals all experienced a dietary shift that the authors concluded probably coincided with their enslavement. Their previous diets were heterogeneous, suggesting different places of origins. Subsequent work on the dietary assessment of some of these individuals involved the measurement of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of different bone density fractions to determine when the dietary change occurred (Bell *et al.*, 2001). Cox *et al.* (2001) used stable isotope analysis together with cultural markers to determine the diversity of origins of 53 individuals from the Cobern Street burial ground in Cape Town, South Africa, in use from the mid-18th to early 19th century. This pioneering work led to further study on this population using strontium isotopes to identify locally born individuals from migrants and to determine the number of migration events experienced by the migrants before the age of *circa* 16 (Kootker *et al.*, 2016).

The current study focuses on a population from a mid-18th to mid-19th century informal burial ground at the present-day Victoria & Albert Waterfront Marina in the vicinity of Green Point, Cape Town, South Africa, located 500 metres from the Cobern Street burial ground.

To enable direct comparison with the Cobern Street population from a contemporaneous burial site, this population was treated in an identical manner in terms of sampling design and laboratory protocols (Cox *et al.*, 2001; Kootker *et al.*, 2016). Stable and radiogenic isotope and osteological data were used to identify first generation migrants to Cape Town in a changing social landscape, and to further contextualise the archaeological site.

Archaeological and historical background

In 1999, development at the Victoria and Albert (V & A) Waterfront Marina (**Figure 9**) unearthed a possible paupers' cemetery. This conclusion was based on unmarked and haphazardly arranged graves, the lack of coffins, the presence of prone burials and the fact that the burial ground was not officially recorded on maps. In addition to multiple scattered loose human remains, 57 complete primary burials were excavated, and a further 12-14 secondary burials were recovered showing evidence of being buried together in a box (Halkett, 2000). Based on inferences from the work of Mentzel (1921), Laidler (1926), Van Heyningen (1989), and a photograph showing the harbour and a walled enclosure which is believed to be the "old burial ground", mentioned on a plan of the harbour in circa 1899-1900 (Urban Conservation Unit: Surveyor General Compilation), it was deduced that the burial ground was in use from 1750 to 1850.



Figure 9. Map of modern-day Cape Town with archaeological sites and streets mentioned in the text

The Dutch East India Company (VOC or the Company) hospital was located at the corner of present day Adderly and Wale Streets, opposite the Slave Lodge, one of the oldest buildings in Cape Town. It was used by slaves and the lower echelons of the VOC, such as sailors and soldiers, who were prone to scurvy and malnutrition and were often ill on arrival at The Cape (Bruijn, 2011; Worden *et al.*, 1998). Slaves on sea voyages were particularly prone to illness as they were crammed below deck with little or no ventilation. These unsanitary conditions coupled with poor nutrition inevitably led to illness, even on relatively short voyages, such as between Madagascar and The Cape (Alexander, 2003). The Cape also experienced smallpox epidemics in 1755 and 1767. In 1755, the church was forced to request land from the VOC administration for a new graveyard at the foot of *Leeuwen Bil* (Lion's Rump) as the existing one could not accommodate the high volume of the dead (Cape Archives, Title Deeds 12, July 2nd, 1755). *Leeuwen Bil* refers to a part of the mountain formation that includes *De Rug* (the back) and the well-known Lion's Head.

A group of Company slaves were responsible for carrying the dead from the Company hospital to the outskirts of Cape Town (Schoeman, 2007, 2012). These individuals were thought to be taken to the area around Gallows Hill in present-day Green Point, which in the 18th and 19th centuries was a shrub-covered wilderness used for grazing livestock (Patrick and Clift, 2006). This was the site of many burials, both formal (e.g., Dutch Reformed and Anglican churches) and informal (e.g., Prestwich Place, Cobern Street and V & A Marina residence burial sites: Apollonio, 1998; Halkett, 2000). It is highly probable that the dead from the Old Somerset Hospital (1818-1845), located between the current Hospital and Prestwich Streets, were also interred in this area.

During the time that the Cobern Street and V & A Marina Residence burial grounds were in use (1750-1850), events unfolded that changed the experience of the unfree population at The Cape. By 1806, The Cape was firmly under British control. In 1808 the oceanic slave trade was outlawed by the British; however, slave ownership was still legal. The British Royal Navy was charged with policing the seas, and any illegally enslaved persons they encountered were captured as prizes and forcibly entered into a period of indenture (these individuals were known as "prize negroes"). The first Cape amelioration laws were passed in 1823 to not only improve the lives of the enslaved on humanitarian grounds, but to also prepare them to be compliant workers in a free labour market (Mason, 1994; Dooling, 2007). In 1834, slavery was abolished in most of the British Empire, although former slaves were obliged to remain in the service of their masters for a further four years. This 'apprenticeship' period was supposed to be used to train the former slaves in a trade, however, it was effectively another form of coerced labour. It ended in the final emancipation of Cape slaves in 1838.

After 1838 the workforce became mobile and many former “apprentices” moved to Cape Town seeking better prospects. This migration led to a significant population increase. Cape Town became an overcrowded city with densely populated slums and unsanitary conditions, a hotbed for epidemics that disproportionately affected the poor. This conclusion is supported by the outbreak of measles in 1839, closely followed by smallpox in 1840 (Watson, 2012). Together with a structural shortage of health professionals and malnutrition, this resulted in the high mortality within this vulnerable group.

Biogeochemical background

Carbon and nitrogen isotopes

The stable isotopes of nitrogen (N) and carbon (C) are well-established tools for the assessment of palaeodiet, as they provide information about sources of nutrients and food web relations (e.g., Hatch and Slack, 1966; Schoeninger and DeNiro, 1982. For applications see: Mays and Beavan, 2012; Privat *et al.*, 2002; Redfern *et al.*, 2010). The ratio $^{15}\text{N}/^{14}\text{N}$, or $\delta^{15}\text{N}$, can be used to assess the trophic position of humans and animals, to identify the (temporal) shifts in dietary regime, or shifts in feeding frequency due to prolonged nutritional stresses or metabolic diseases for example (see Leatherdale, 2013; Tykot, 2006; Wright and Schwarcz, 1998; Zazzo *et al.*, 2010; and references therein). The trophic level increase in $\delta^{15}\text{N}$ of the consumer relative to that of their diet can be attributed to nitrogen elimination through urea synthesis; a process that favours ^{14}N over ^{15}N . Water- or nutritional-stress results in the increase of urea concentration and the quantity of ^{14}N excreted, which forces the body to use ^{15}N enriched nitrogen for protein and tissue synthesis. Hence, an inadequate dietary intake of nitrogen results in an increase in $\delta^{15}\text{N}_{\text{collagen}}$ beyond the average $\Delta^{15}\text{N}_{\text{diet-tissue}}$ of 3-5‰ (Ambrose, 2002; O’Connell *et al.*, 2012; Schoeller, 1999;).

The proportion of ^{13}C in relation to ^{12}C of organic materials, or $\delta^{13}\text{C}$, is directly linked to the isotopic composition of consumed foods, but with an isotopic enrichment of on average 3 to 5‰ between $\delta^{13}\text{C}_{\text{diet}}$ and $\delta^{13}\text{C}_{\text{collagen}}$ due to metabolic processes (Lee-Thorp *et al.*, 1989; Ambrose and Norr, 1993; Bocherens *et al.*, 2000). The consumption of amino acids in foods, which are the building blocks of bone collagen, leads to their rapid incorporation into bone collagen (Brabaj *et al.*, 2005).

The $\delta^{13}\text{C}$ value in particular enables differentiation between individuals who consumed C_3 -based diets (temperate grasses and trees) from those with marine/ C_4 (subtropical grasses, e.g. maize in the New World and millet in Europe) based diets or a combination thereof (Ambrose, 1991; DeNiro and Epstein, 1981; Hedges and Van Klinken, 2000; Norr, 1995; O’Leary, 1981; Sealy *et al.*, 1987; Schwarcz, 2000; Schwarcz *et al.*, 2010). Digestive adaptations, age, sex and

nutritional and environmental factors may, however, also affect the isotopic relationship between $\delta^{13}\text{C}_{\text{diet}}$ and $\delta^{13}\text{C}_{\text{collagen}}$ (Hedges and Klinken 2000, Schwarcz 2000, Sealy *et al.*, 1987, Ambrose 1991).

Carbon isotope ratios can be obtained from both the organic (collagen) and inorganic (apatite) components of bone. The vast majority (75%) of the carbon content in bone collagen is derived from the intact amino acids in proteins, whereas $\pm 25\%$ of the carbon content in bone collagen is derived from carbohydrates and lipids (Ambrose and Norr, 1993; Fernandes *et al.*, 2012; Pestle *et al.*, 2015; Tieszen and Fagre, 1993). As a result, $\delta^{13}\text{C}_{\text{collagen}}$ is more representative of the protein portion of diet, as is evidenced by the high $\delta^{13}\text{C}_{\text{collagen}}$ - $\delta^{13}\text{C}_{\text{protein}}$ correlation. Whole diet on the other hand is reflected by bone $\delta^{13}\text{C}_{\text{apatite}}$ and isotopic spacing between bone apatite and collagen can yield information about the energy and protein sources in an individual's diet (Lee-Thorp *et al.*, 1989; Ambrose and Norr, 1993). Unfortunately, the high diagenetic susceptibility of bone and dentin hydroxyapatite may potentially compromise their isotopic integrity (Koch *et al.*, 1997; Jim *et al.*, 2004). As a result, the $\delta^{13}\text{C}_{\text{apatite}}$ values may be relatively unreliable and not reflect the biogenic carbon content. Therefore, in this study only collagen samples were used. Given the much higher protein content of meat/fish relative to plants, $\delta^{13}\text{C}_{\text{collagen}}$ is sensitive to variation/changes in non-plant contributions to diet.

Bone constantly remodels during life, resulting in changes in isotopic composition associated with changes in diet, geological loci and illness. The turnover rate of bone varies according to biological sex, age, type of bone, element and location within the bone (see e.g. Debono *et al.*, 2011; Hedges *et al.*, 2007; Klepinger, 1984). In contrast to bone, dentin, the organic component of dental elements, is unable to remodel. As it is formed during the first years of life, the carbon isotopic signature of primary dentin can be used to trace childhood diet (Nelson and Ash, 2010). In this study, carbon isotopes determined from dentin are used not only to assess palaeodiet, but also as a proxy for palaeomobility. Kootker *et al.* (2016) used a simple statistical method to determine the $\delta^{13}\text{C}_{\text{collagen}}$ range that was most likely representative of the local economic underclass diet. Based on 50 cancellous bone samples from individuals dating to 1750-1827, a tentative local $\delta^{13}\text{C}$ range of -18.8‰ to -13.5‰ was determined (see Figure. 3 in Kootker *et al.* 2016). Individuals who exhibited $\delta^{13}\text{C}_{\text{dentin}}$ values that deviated from this range were assigned as migrants. Such an approach is applicable to this era in South African history, as many enslaved persons came from C_4 dominated regions, particularly Mozambique (see e.g., Bastos *et al.*, 2016 for references). A limitation of this method, however, is the inability to identify non-locally born individuals who consumed a diet similar to that at The Cape.

Strontium isotopes

The strontium isotope of interest, ^{87}Sr , is a radiogenic isotope, derived from the radioactive decay of ^{87}Rb (Steiger and Jäger, 1977). Variations in the amount of ^{87}Rb in geological bedrock, and the age of the lithology result in the geographical variations in ^{87}Sr (Beard and Johnson, 2000; Bentley, 2006; Capo *et al.*, 1998; Faure and Mensing, 2005). The strontium from geological bedrock is released through erosion and incorporated in the food chain via water, vegetation and livestock (Bentley, 2006). Chemically, strontium behaves similarly to calcium, one of the principal building blocks of hydroxyapatite, and readily substitutes in the structure of bone and enamel.

Bone apatite is very susceptible to diagenetic alterations, irreversibly altering the biogenic $^{87}\text{Sr}/^{86}\text{Sr}$ signature (Kohn and Cerling, 2002). The large constituent phosphate crystals (up to 70 nm in width and 30 nm in thickness, and as much as 10 times larger than hydroxyapatite crystals in other tissues-Hand, 2014), and its compact structure make dental enamel far less prone to physical and chemical alterations; hence it is the preferred material in palaeomobility studies. The enamel of permanent teeth is formed during childhood and barely undergoes any change after mineralisation (Jussila *et al.*, 2013; Hand and Frank, 2014). Moreover, different dental elements mineralise at different times, capturing the isotopic signature for a discrete period in life, ranging from the peri-natal period (first molars, M1) to approximately 16 years of age (third molars, M3) in permanent dentition (Woelfel and Scheid, 2002; Reid and Dean, 2006; Nelson and Ash, 2010). A lag exists between the age of ingestion of strontium and age of incorporation of strontium into dental enamel. This *reservoir effect* is dependent on the physiology of the individual and his or her environment making it difficult to delineate (Montgomery, 2010). There is as yet no systematic manner in which to determine this time difference, therefore our study and others like it that assume that strontium incorporated into enamel was ingested soon before and during mineralisation may have to be revisited in future. Some headway has been made by Font and colleagues (2012) relating to this issue as they found Sr turnover in human hair to be rapid (Font *et al.*, 2012).

To enable the positive identification of migrants or non-locally born individuals, the strontium isotopes in tooth enamel can be compared to the $^{87}\text{Sr}/^{86}\text{Sr}$ signatures characteristic of the local environment. This so-called bioavailable strontium signal can be defined by measuring the $^{87}\text{Sr}/^{86}\text{Sr}$ of teeth of local (archaeological) animal species, or biosphere samples. Recently, a bioavailable strontium isoscape predictive geospatial model for the South African south-eastern coast was developed and published by Copeland *et al.* (2016). To date, however, such a predictive map is unavailable for the Cape Peninsula. Based on available modern and archaeological faunal strontium data from the south-western Cape, as well as the archaeological human data from the

Cobern Street burial site, a conservative local bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ range was proposed, varying from 0.7086 to 0.7179 (Sealy *et al.*, 1991; Balasse *et al.*, 2002; Kootker *et al.*, 2016).

Material and methods

Based on sample availability (presence of dental elements and ribs), twenty-seven of the 57 individuals from primary burials were selected for isotope analysis (18 males, 8 females, and 1 individual of indeterminate sex). Dentin (M1) and rib samples (cancellous or spongy bone samples), were taken for carbon and nitrogen isotope analysis, along with dental enamel samples of preferably the first, second and third molars for strontium isotope analysis. Most dentin forms during initial tooth growth (*i.e.*, primary dentin), but secondary and tertiary dentin form gradually throughout life after root completion (Nelson and Ash, 2010; Woefel and Scheid, 2002). Different dentin types are macroscopically indistinguishable and thus there may be a small volume of secondary and tertiary dentin altering the childhood signal (White and Pharoah, 2014). As a result of the slow growth of the secondary and tertiary dentin, however, we assume these samples are predominantly composed of primary dentin, thus the isotopic signature is predominantly a reflection of the childhood diet. Ribs were selected as target bones because of their high collagen turnover rate. The analyses of rib fragments, therefore, allow us to assess the palaeodiet during an individuals' last few months to years of life (Richards *et al.*, 2002; Szulc *et al.*, 2000; Tsutaya and Yoneda, 2013). Variations have been observed in the age at which dental enamel mineralises between European, Asian and African populations (Kajiyama, 1965; Reid and Dean, 2006 and references therein). The enamel mineralisation stages for Southern African populations are used as a reference (Reid and Dean, 2006).

Mechanically cleaned bone and dentin samples were crushed and 100-300 mg were subsampled. The fragments were demineralised in 0.6 M HCl at 7° C, which was replaced by new acid every 48 hours until CO₂ release visibly ceased. Samples were then rinsed with Milli-Q water and 0.001 M HCl (pH3) was added. The samples were then gelatinised at 80° C for 36 hours. Insoluble residues were removed using 5-8 µm Ezee filters (Elkay Laboratory Products). The frozen solution was then lyophilized for 48 hours. Between 0.9 and 1.1 mg bulk collagen was subsampled in tin foil cups. Stable isotopes were measured using an elemental analyser (NC2500; ThermoQuest) coupled to a Delta Plus ThermoQuest Finnigan isotope ratio mass spectrometer at the Department of Ecological Sciences, Vrije Universiteit Amsterdam. For calibration, USGS 40 and USGS 41 were used. The reproducibility of the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ analysis determined by repeated analysis of an internal standard (Bovine liver, NIST 1577c) was within 0.15‰ ($n = 3$). $\delta^{13}\text{C}$ is reported relative to standard Vienna PeeDee Belemnite (VPDB) and $\delta^{15}\text{N}$ relative to standard Ambient Inhalable Reservoir (AIR). The integrity of the collagen

samples was assessed by the atomic C:N ratio (2.9-3.6 - DeNiro, 1985; Brock *et al.*, 2012), the percentage nitrogen (11-16%) and carbon (>35% - Van Klinken 1999) and collagen yield (>2% wt - Ambrose, 1990; Van Klinken, 1999). The data were analysed using SPSS 22.0 (IBM SPSS Statistics for Macintosh, Armonk, IBM Corp.).

The enamel samples (M1-M2-M3 if available) were taken at the department of Human Biology, University of Cape Town. The enamel was mechanically cleaned using an HCl leached diamond-tipped drill bit until a dull white surface was exposed. Approximately 1-3 milligrams of enamel powder were collected and sealed in pre-cleaned polyethylene Eppendorf centrifuge tubes and transferred to the US Federal Standard Class 100 clean laboratory facility at the Vrije Universiteit Amsterdam for strontium purification. A full description of the strontium isotope isolation and analysis procedures are given in Kootker *et al.* (2016). Over the course of the research, NBS987 measurements gave mean $^{87}\text{Sr}/^{86}\text{Sr}$ values for the MAT262 mass spectrometer and Triton of 0.710273 ± 0.000009 (2 SE, $n = 3$) and 0.710282 ± 0.000008 (2 SE, $n = 4$) respectively. The individual measurements were all normalised to 0.710245 using the within run value of NBS987. Total procedural blanks were negligible: <100 pg strontium ($n = 8$).

Results and data interpretation

Strontium, carbon, and nitrogen isotope results are reported in **Table 8**. The strontium data vary between 0.70962 and 0.73567 (**Figure 10**). Both the M1 $^{87}\text{Sr}/^{86}\text{Sr}$ values of the females ($n = 8$) and males ($n = 16$) cluster around 0.714; however, the variation in male data (0.000031) is 2.4 times larger than in the female dataset (0.000013). Nevertheless, a Mann-Whitney U test revealed no statistically significant differences between the median M1 $^{87}\text{Sr}/^{86}\text{Sr}$ ratios ($U = 58$, $z = -0.367$, $p = 0.713$) of males ($^{87}\text{Sr}/^{86}\text{Sr}$: 0.71195) and females ($^{87}\text{Sr}/^{86}\text{Sr}$: 0.71322).

All bone and dentin samples met the collagen quality criteria and were therefore reported in this study (**Table 8** below). The $\delta^{13}\text{C}_{\text{dentin}}$ and $\delta^{15}\text{N}_{\text{dentin}}$ values range from -20.3‰ to -6.6‰ (variance: 12.6‰) and 7.1‰ to 16.3‰ (variance 7.4‰) respectively, while the variation in $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$ values of the rib samples is less: -21.1‰ to -8.0‰ (variance: 5.9‰) and 9.8‰ to 16.5‰ (variance 2.8‰) respectively. The restricted variances in the rib collagen datasets indicate greater similarity in palaeodiet between the individuals during the last few years of life compared to their childhood diets. The male and female dentin and cancellous datasets do not differ significantly ($p > 0.05$), indicating comparable food resources for the males and females.

Table 8. Results of the isotopic analyses of enamel, cancellous bone (rib) and dentin samples.

ID	Sex	Estimated age	Dental enamel			Collagen						
			Element	$^{87}\text{Sr}/^{86}\text{Sr}$	$\pm 2\sigma$	Element	Yield (%)	$\delta^{15}\text{N}$	%N	$\delta^{13}\text{C}$	%C	C/N ratio
3	F	40-50	2.6	0.71196	0.00001	2.6	11	15.6	15.4	-15.7	42.0	3.2
			2.7	0.71194	0.00001	<i>costa</i>	5	15.4	14.9	-15.4	41.2	3.2
			2.8	0.71177	0.00001							
4	F	50+	2.6	0.71750	0.00001	2.6	16	12.7	14.6	-17.3	41.1	3.3
			2.7	0.71940	0.00001	<i>costa</i>	7	14.1	15.3	-16.4	42.4	3.2
			2.8	0.71711	0.00001							
5	M	35-45	2.6	0.71075	0.00001	2.6	14	9.9	15.8	-11.2	44.2	3.3
			2.7	0.70975	0.00001	<i>costa</i>	8	15.1	15.2	-14.8	42.6	3.3
			2.8	0.70962	0.00001							
7	F	18-35	2.6	0.71166	0.00001	2.6	10	12.8	15.4	-10.5	41.9	3.2
			3.7	0.71164	0.00001	<i>costa</i>	11	12.4	15.6	-9.6	41.8	3.1
			2.8	0.71188	0.00001							
8	F	45-55	4.6	0.71167	0.00001	4.6	16	12.0	14.7	-7.1	40.6	3.2
			4.7	0.71101	0.00001	<i>costa</i>	11	13.3	15.7	-14.7	43.2	3.2
			4.8	0.71156	0.00001							
9	-	-	-	-	-							
			4.7	0.71589	0.00001	4.7	9	9.7	15.3	-10.0	41.2	3.1
			4.8	0.71526	0.00001	<i>costa</i>	15	10.5	14.3	-7.8	39.5	3.2
10	M	18-35	-	-	-	3.6	8	9.8	14.6	-16.8	40.3	3.2
			4.7	0.73542	0.00001	<i>costa</i>	6	9.8	15.4	-17.1	43.0	3.3
			4.8	0.73567	0.00001							
20	F	-	3.6	0.71871	0.00001	3.6	14	8.8	15.8	-18.9	42.4	3.1
			3.7	0.72006	0.00001	<i>cranium</i>	5	13.6	14.6	-17.1	41.7	3.3
			1.8	0.71853	0.00001							
21	F	50+	3.6	0.71448	0.00001	3.6	18	14.2	15.5	-17.1	42.9	3.2
			-	-	-	<i>costa</i>	22	14.6	15.0	-16.1	40.5	3.2
			-	-	-							
25	M	25-30	4.6	0.71913	0.00001	4.6	16	8.7	15.7	-8.6	42.2	3.1
			-	-	-	<i>costa</i>	15	13.7	15.4	-14.3	42.4	3.2
			1.8	0.71536	0.00001							
26	M	50+	1.6	0.72053	0.00001	1.6	14	8.1	15.5	-16.7	42.3	3.2
			-	-	-	<i>costa</i>	5	14.6	14.3	-14.4	41.0	3.4
			1.8	0.71953	0.00001							

Table 8. Continued.

ID	Sex	Estimated age	Dental enamel			Collagen						
			Element	$^{87}\text{Sr}/^{86}\text{Sr}$	$\pm 2\sigma$	Element	Yield (%)	$\delta^{15}\text{N}$	%N	$\delta^{13}\text{C}$	%C	C/N ratio
28	M	30-40	-	-	-	3.6	14	14.5	15.3	-16.2	41.4	3.1
			3.7	0.71216	0.00001	<i>costa</i>	19	14.8	14.9	-15.5	41.6	3.3
			4.8	0.71180	0.00001							
29	M	40-60	1.6	0.71206	0.00001	1.6	11	16.3	15.7	-14.3	44.2	3.3
			2.7	0.71151	0.00001	<i>costa</i>	7	16.5	14.0	-14.9	40.4	3.4
			2.8	0.71150	0.00001							
31	M	20-30	1.6	0.71018	0.00001	1.6	16	10.6	15.9	-6.6	44.6	3.3
			3.7	0.71091	0.00001	<i>costa</i>	4	11.2	14.4	-8.0	40.6	3.3
			3.8	0.71114	0.00001							
32	M	50-60	4.6	0.71361	0.00001	4.6	17	11.8	15.1	-12.3	41.7	3.2
			3.7	0.71290	0.00001	<i>costa</i>	6	12.9	13.9	-14.4	39.0	3.3
			4.8	0.71725	0.00001							
33+	M	25-40	4.6	0.72883	0.00001	4.6	11	7.1	15.5	-12.9	41.7	3.1
			4.7	0.72972	0.00001	<i>costa</i>	5	14.8	14.4	-14.0	41.1	3.3
			3.8	0.72057	0.00001							
34	M	18-35	3.6	0.71033	0.00001							
			3.7	0.71047	0.00001	3.7	8	11.8	14.9	-18.8	41.5	3.2
			3.8	0.71078	0.00001	<i>costa</i>	5	11.9	13.3	-19.1	38.1	3.4
39	M	18	4.6	0.71998	0.00001	4.6	4	10.8	14.7	-20.3	40.7	3.2
			4.7	0.72052	0.00001	<i>costa</i>	7	10.9	15.0	-21.1	42.6	3.3
			4.8	0.72234	0.00001							
43B	M	40-60	1.6	0.71278	0.00001	1.6	16	14.3	14.9	-15.5	42.8	3.4
			4.7	0.71314	0.00001	<i>costa</i>	10	15.5	14.6	-15.4	40.5	3.2
			3.8	0.71248	0.00001							
45	F	40-55	4.6	0.71926	0.00001							
			4.7	0.72004	0.00001	4.7	15	11.1	14.8	-11.1	40.9	3.2
			4.8	0.71905	0.00001	<i>costa</i>	6	14.8	14.0	-15.5	39.8	3.3
46	M	25-35	2.6	0.71121	0.00001	2.6	14	15.3	15.7	-15.3	42.5	3.2
			2.7	0.71149	0.00001	<i>costa</i>	6	16.4	14.0	-14.9	39.3	3.3
			2.8	0.71131	0.00001							
48+	M	35-45	4.6	0.71183	0.00001	4.6	9	15.3	15.0	-16.0	40.7	3.2
			4.7	0.71162	0.00001	<i>costa</i>	5	14.6	14.8	-15.8	41.2	3.2
			4.8	0.71169	0.00001							

Table 8. Continued.

ID	Sex	Estimated age	Dental enamel			Collagen						
			Element	$^{87}\text{Sr}/^{86}\text{Sr}$	$\pm 2\sigma$	Element	Yield (%)	$\delta^{15}\text{N}$	%N	$\delta^{13}\text{C}$	%C	C/N ratio
49	M	35-50	4.6	0.71116	0.00001	4.6	13	14.9	15.1	-15.9	42.2	3.3
			4.7	0.71145	0.00001	costa	5	15.0	14.9	-14.5	42.6	3.3
			4.8	0.71173	0.00001							
51	M	30-40	1.6	0.72249	0.00001	1.6	15	7.9	14.8	-12.0	41.3	3.3
			1.7	0.72847	0.00001	costa	5	15.0	13.7	-15.7	38.8	3.3
			2.8	0.71858	0.00001							
56	M	25-40	4.6	0.71162	0.00001	4.6	13	14.3	15.4	-15.8	41.3	3.1
			2.7	0.71188	0.00001	costa	7	15.6	15.1	-14.9	40.7	3.1
			1.8	0.71143	0.00001							
58	M	30-40	3.6	0.71039	0.00001	3.6	4	15.3	15.7	-14.5	42.8	3.2
			-	-	-	costa	9	15.2	14.6	-15.3	41.8	3.3
			-	-	-							
61	F	40-60	1.6	0.71051	0.00001	1.6	2	12.3	15.6	-12.2	42.3	3.2
			3.7	0.71074	0.00001	costa	5	14.9	13.9	-14.1	38.7	3.3
			-	-	-							

Key: Osteological data from Appolonia (1998). Dental element notation conforms to *Fédération Dentaire Internationale* (FDI). Key: + - lateral maxillary incisors filed to a point (Manyapelo, 2007); - - no data available/dental element absent.

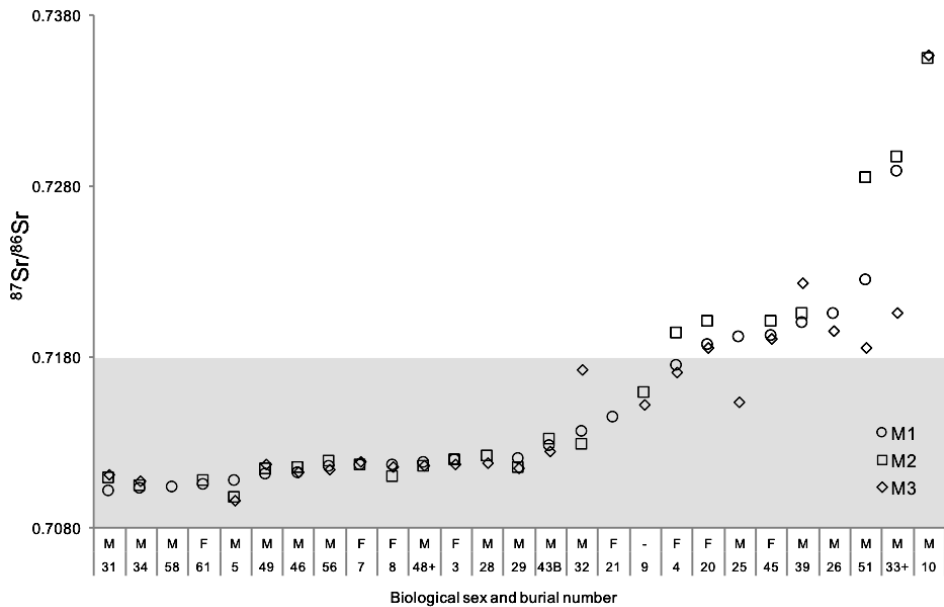


Figure 10. Multi-dental element strontium isotope data from 27 individuals from the V & A Marina Residence burial site in Cape Town, South Africa.

Key: The grey area marks the presumed local strontium range (0.7086 – 0.7179). Key: “+” next to sample number indicates the presence of cultural dental modifications. The standard errors in the analytical data are smaller than the plotted symbols.

Discussion

Local $^{87}\text{Sr}/^{86}\text{Sr}$ range

The wide range of human $^{87}\text{Sr}/^{86}\text{Sr}$ data indicates that the individuals came from diverse origins. Provenancing individuals to specific geological origins, however, remains challenging. Bioavailable modern and archaeological animal data and the statistical analysis of archaeological human data from the Colonial Cape led to the establishment of a conservative local $^{87}\text{Sr}/^{86}\text{Sr}$ range for The Cape of 0.7086 – 0.7179 (Kootker *et al.*, 2016). Inclusion of this study’s archaeological human strontium data in the basic statistical analysis ($n = 27$) does not alter this range substantially (**Figure 11**); therefore, it is also applied in this study.

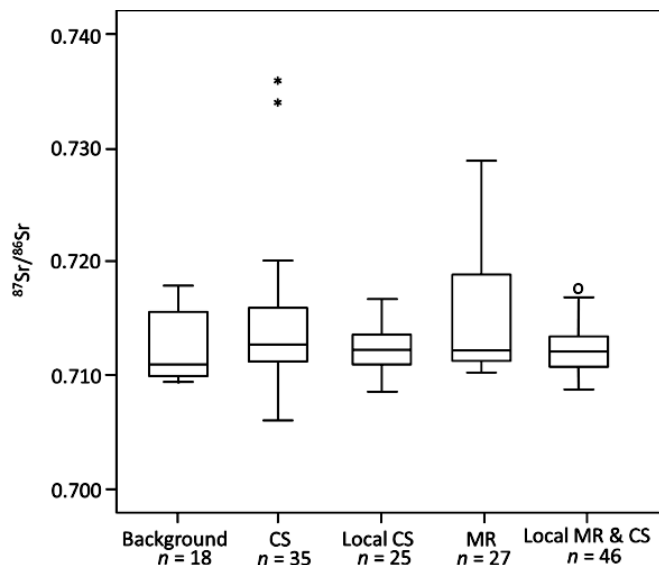


Figure 11. Tukey's schematic boxplot showing the variation in $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the background samples, the Cobern street (CS) M1 samples, the V & A Marina Residence (MR) M1 samples, the calculated local background based only on the Cobern Street data and on the combined Cobern Street and Marina Residence assemblages

Key: Total dataset excluding outliers resulting in normally distributed dataset as assessed by Shapiro-Wilk test, $p > 0.05$). The boxes represent the interquartile range (IQR: $Q3 - Q1$), the central line indicates the median. The whiskers represent $Q1 - 1.5 \text{ IQR}$ and $Q3 + 1.5 \text{ IQR}$. The circles represent mild outliers (>1.5 , but $<3 \text{ IQR}$), the asterisks extreme outliers ($>3 \text{ IQR}$).

Local dietary habits

A Pearson's product-moment correlation was run to assess the relationship between $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of the V & A Marina Residence dataset and to assist in the interpretation of the dietary isotope data. Preliminary statistical analyses identified several statistical outliers in both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ datasets (**Figure 12**). It is evident that these individuals consumed a diet inconsistent with that characteristic of The Cape. To enable a statistical assessment of the assumed local stable isotopes values, data from five individuals were excluded from the datasets. The Pearson's test showed no correlation between the $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of the V & A Marina Residence individuals ($r(21) = 0.063$, $p = 0.788$), indicating a non-linear and extremely weak to a non-existent relationship between the variables. Hence, knowledge of the value of one variable does not allow for the prediction of the value of the other. A positive and statistically significant (*i.e.*, linear) correlation would have reflected a diet consisting of a mixture of lower trophic level terrestrial, and higher trophic level marine foods. The absence of such a correlation indicates

the consumption of marine and terrestrial resources from a similar trophic level (Richards and Hedges, 1999).

Earlier work by Sealy *et al.* (1987), however, reported high $\delta^{15}\text{N}$ values for south-western Cape (terrestrial) herbivores (e.g., springbok (*Antidorcas marsupialis*) and steenbok (*Raphicerus campestris*)) ranging between 15‰ and 17‰, but low plant $\delta^{15}\text{N}$ values (1.3-2.6‰). This difference can be explained by factors such as aridity and differing metabolic processes in the animals. The $\delta^{15}\text{N}$ values of south-western Cape herbivores overlap completely with marine values (Sealy *et al.*, 1987). Consequently, in an arid environment, the absence of a correlation between $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ may not necessarily reflect a diet comprised of terrestrial and marine resources of similar trophic level but could also represent a diet consisting of foods with a similar isotopic signature. Hence, the statistical data presented here may well reflect a diet dominated by high trophic level marine foods, such as Cape hake (*Merluccius capensis*) and snoek (*Thyrsites atun*) and low trophic level terrestrial (domesticated) mammals.

This is consistent with the interpretation of the assumed local carbon and nitrogen isotope values. Prior research (Kootker *et al.*, 2016) suggested a local dietary signal of the lower rungs of Cape colonial society ranging from -18.8‰ to -13.5‰, as determined from the $\delta^{13}\text{C}_{\text{cancelous}}$ of 50 rib samples (Cox *et al.*, 2001). Inclusion of the Marina Residence dataset ($n = 27$) does not shift the isotopic endmembers considerably; consequently, the previously reported local range is adopted in this study (**Figure 12**). This local signature corresponds to a predominantly terrestrial C_3 diet, with additional contributions from C_4 plants (possibly seasonally dependent) and/or marine contributions (Ambrose and DeNiro, 1986b). The pre-VOC Cape was a C_3 dominated region, thus if the economic underclass at The Cape did consume indigenous vegetation, such as corms, their isotopic values would still reflect a preponderance of C_3 plants (Sealy, 1984). The C_3 component of the colonial Cape diet arose from wheat, rice and meat consumption, while maize was the C_4 component (Schoeman, 2007).

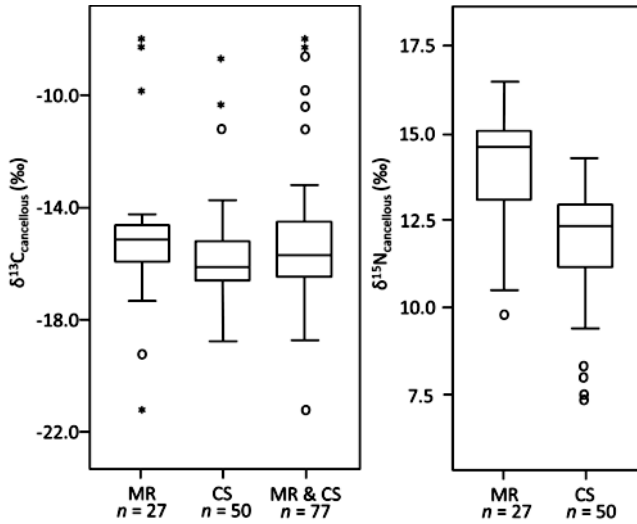


Figure 12. Tukey's schematic boxplot showing the variation in $\delta^{13}\text{C}_{\text{cancellous}}$ of the V & A Marina Residence (MR), the Cobern Street (CS) and that for the combined assemblages. $\delta^{15}\text{N}_{\text{cancellous}}$ values of the V & A Marina Residence and Cobern Street.

Key: The boxes represent the interquartile range (IQR: Q3-Q1), the central line indicates the median. The whiskers represent Q1 - 1.5 IQR and Q3 + 1.5 IQR. The circles represent mild outliers (>1.5, but <3 IQR), the asterisks extreme outliers (>3 IQR).

The V & A Marina Residence dataset

The greater variance in $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in the male dataset compared to the female dataset, also evident in the non-local Cobern Street sub-population (Kootker *et al.* 2016), may be attributed to males coming from a more geologically widespread catchment area of the Indian Ocean basin than females. Moreover, racial and sex preferences in the Cape slave market may have resulted in this difference (Shell, 1994). However, due to the limited sample sizes, this suggestion requires validation from further research.

In **Figure 13** M1 $^{87}\text{Sr}/^{86}\text{Sr}$ is plotted against M1 $\delta^{13}\text{C}_{\text{dentin}}$ and the local ranges of each isotope system are illustrated. Individuals who plot within the region of the figure defined by the overlap of the two local ranges are considered local to The Cape. Based on the defined local $^{87}\text{Sr}/^{86}\text{Sr}$ background signal, eight non-locally born individuals are identified: six males (individuals 10, 25, 26, 33, 39, and 51), and two females (individuals 20, and 45). Moreover, while the $^{87}\text{Sr}/^{86}\text{Sr}_{\text{M1}}$ ratio of individual 4, an adult female, is compatible with the local signal, her $^{87}\text{Sr}/^{86}\text{Sr}_{\text{M2}}$ is not. Although this female might have been born in the Cape region, she experienced a (forced) migration after the age of three, and subsequently after the age of eight to a region isotopically consistent with The Cape / the region in which she had spent the first years of her childhood. At least another four individuals, 20, 33, 39 and 51, experienced multiple migration events in

early life. Individual 51 for instance, a 30- to 40-year-old male, migrated to a more radiogenic region after the age of 3, before a subsequent migration to a location with a Sr isotope signature indistinguishable from The Cape after the age of *circa* seven. These multiple migrations may be related to the initial process of enslavement in indigenous slave networks or to being trafficked in the long-range slave trade by trading companies, such as the VOC. Migration to the Cape area at a very young age is also a possibility for individual 33, a 25- to 40-year-old male with aesthetic modifications to the maxillary medial incisors. His M1 and M2 $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (0.7288 and 0.7297) and the type of dental modifications (maxillary incisors filed to a point) are consistent with Mozambican origins (Manyapelo, 2007).

The fact that these individuals potentially arrived at The Cape at a young age is noteworthy. Early 18th-century VOC slave sale documents seem to suggest that the average “optimal” age of a slave migrant labourer at The Cape was 24 years of age with a range of 11 to 40 years of age (Cape Archives, Cape Title Deeds 1/84, March 1703-March 1704). The origins of an 18 to 35-year-old male (individual 10) may also be traced to Mozambique ($^{87}\text{Sr}/^{86}\text{Sr}$: 0.7354); however, he experienced residential stability at least until the age of *circa* 16.

Utilisation of the stable carbon and nitrogen isotope systems allows for the identification of a further seven non-local individuals. In addition to the eight non-locals identified by $^{87}\text{Sr}/^{86}\text{Sr}$, three males (burials: 5, 31, and 32), three females (burials: 7, 8, and 61), and one individual of indeterminate sex (burial 9) can be identified as non-local to The Cape. Individual 32, a 50- to 60-year-old male, experienced a significant change in geological residence after the age of 8. This change falls within the assumed Cape range and may be a result of (regional) mobility. A less probable reason for the isotopic change could be that the individual relied on food sourced from outside the Cape region after the age eight. One male (burial 48) exhibits local strontium, carbon and nitrogen isotope signals, but displays culturally modified teeth (filed into a diamond shaped), associated with foreign origins (Manyapelo, 2007). Assignment of these two individuals as non-locals brings the total number of migrants to 17 (63% of the total investigated population). Ten individuals show no isotopic and/or cultural evidence of mobility (burials: 3, 21, 28, 29, 34, 43B, 46, 49, 56, and 58) and hence may be second or subsequent generation slaves.

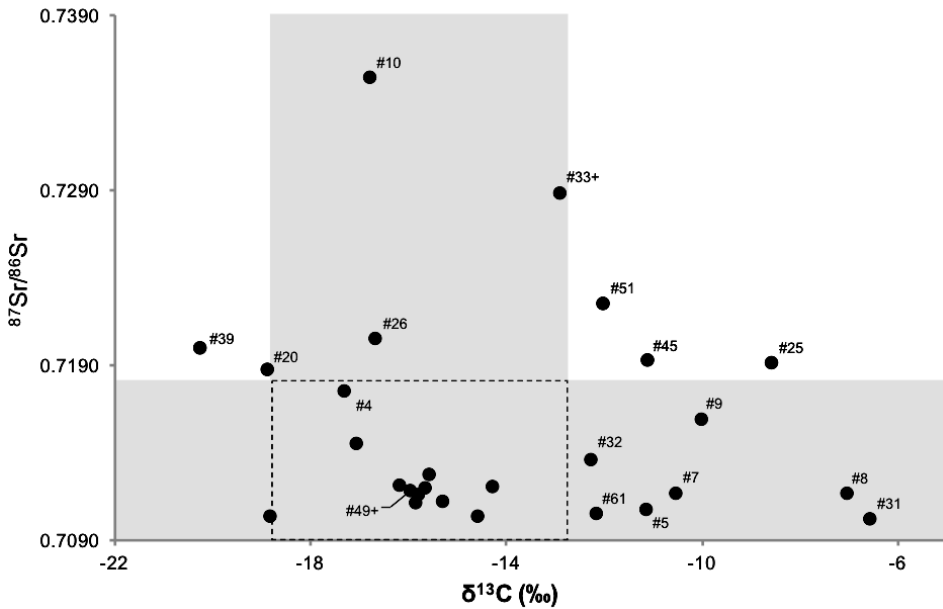


Figure 13. $^{87}\text{Sr}/^{86}\text{Sr}_{\text{MI}}$ ratios in dental enamel (hydroxyapatite) versus $\delta^{13}\text{C}_{\text{dentin}}$ data from the same dental element.

Key: The horizontal grey band marks the assumed local $^{87}\text{Sr}/^{86}\text{Sr}$ range. The vertical grey band marks the assumed local dietary $\delta^{13}\text{C}$ signal. All individuals who plot within the marked box show no isotopic evidence of migration, except for one. Individual 4 exhibits a local M1 $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.7175, as depicted in this figure), but a non-local M2 $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (0.7194). Moreover, individual 49 exhibits intentional dental modification alien to The Cape, bringing the total number of non-local individuals to 17. The standard analytical errors are smaller than the plotted symbols.

Contextualising the Marina Residence burials – a tale of two populations

In an effort to contextualise the V & A Marina Residence burials, a comparison was made between this study and the available archaeological and isotopic data from the contemporaneous burial site at Cobern Street (Apollonio, 1998; Cox *et al.*, 2001; Kootker *et al.*, 2016). A smaller majority (54.5%) of the individuals investigated from the Cobern Street burial site are foreign born (Cox *et al.*, 2001; Kootker *et al.*, 2016) compared to the 63% non-locals from the V & A Marina Residence. Both sites were predominantly in use post-creolisation (1760s), the point in time at which the number of locally born slaves surpassed the number of imported slaves. The Marina Residence burial ground was, however, still in use when Cape slaves gained their freedom in 1838.

The archaeological evidence led to the conclusion that the Cobern Street individuals were buried with care: in coffins with personal items and according to religious beliefs (Apollonio, 1998; Halkett, 2000). This suggests that these individuals either belonged to or were quickly

absorbed into an established community. The haphazard nature of the V & A Marina Residence burials indicates hasty burial without observance of any rituals and implies a population that did not belong to a well organised community. These individuals could have been newcomers to The Cape, in a weakened state from long sea journeys and the associated malnourishment, which would have resulted in relatively high $\delta^{15}\text{N}$ values. Equally, they could have died from one of the epidemics at The Cape. Such circumstances would be consistent with the hasty and careless manner of burial. We put these speculations to the test by comparing the archaeological data to $^{87}\text{Sr}/^{86}\text{Sr}$, $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$ isotopic data.

Statistical evaluation of the isotopic data illustrates a difference between the Cobern Street and Marina Residence populations. The palaeodiet of the Marina Residence population seems to be more restricted than the Cobern Street population, as can be seen from **Figure 12**. Exclusion of the statistical outliers, results in a carbon isotope range of -17.1‰ to -14.0‰ ($\Delta 3.1\%$) in the Marina Residence data, and -18.8‰ to -13.5‰ ($\Delta 6.0\%$) in the Cobern Street data. The Cobern Street population may have had access to more diverse food sources or may have spent a shorter time at The Cape before dying resulting in incomplete reflection of local dietary habits in the skeleton. Moreover, a non-parametric 2-independent samples Mann-Whitney test reveals statistically significant differences ($p \leq 0.05$) in median $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$ values between the Cobern Street and Marina Residential populations (**Figure 14**). The higher median $\delta^{15}\text{N}_{\text{cancellous}}$ (14.6‰ vs. 12.4‰) and median $\delta^{13}\text{C}_{\text{cancellous}}$ (-14.9‰ vs. -16.2‰) values in the Marina Residence population may be explained by various scenarios, of which three are proposed below.

The consumption of more and/or higher trophic level marine resources - This scenario would account for the significantly higher $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values exhibited by the Marina Residence population (e.g., Schoeninger *et al.*, 1983; Schoeninger and DeNiro, 1984). The V & A Marina Residence burial ground was still in use for approximately 12 years after the final emancipation of Cape slaves. During these years those who were newly freed could have consumed more fish, a cheap source of protein, than during the days of slavery when their slave masters/mistresses were responsible for their diet and wellbeing. Hence, it could be that the adaptation to freedom is reflected isotopically. Fish, such as snoek, and mutton were the major protein sources exploited by the poor at The Cape (Markell *et al.*, 1995). Due to its abundance and affordability, snoek, whether salted or fresh, was consumed mainly by the lower rungs of society (Graf, 1996; Leibbrandt, 1896; Norton, 2013). Stable isotope ratios for the flesh of Cape hake (*Merluccius capensis/paradoxus*), Cape anchovy (*Engraulis capen*) and roundherring (such as the *Etrumeus whiteheadi*) caught off the coast of Cape Town range between -17.5‰ and -14.5‰ for $\delta^{13}\text{C}$ and between 12.0‰ and 16.2‰ for $\delta^{15}\text{N}$ (Sholto-Douglas *et al.*, 1991; Van Der Lingen and Miller, 2014). Although the isotope ratios for Cape snoek are not known, the abovementioned ranges for

Cape hake and anchovy are considered indicative for Cape snoek, given their similar carnivorous diets. These values are consistent with the observed $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$ values for the Marina Residence individuals.

The consumption of more salted foods (meat and/or fish) - The VOC written records have numerous examples of the Company providing salted meat and fish to its European employees and slaves. In the journal entry of January 7th, 1700, it is specifically stated that the vessel “Amy” was sent to Saldanha bay to catch fish for the Company slaves and the hospital (Leibbrandt, 1896). The intake of salted foods induces a form of water stress causing the body to respond by increasing the rate of urea excretion (Ambrose and DeNiro, 1986a; Nevo *et al.*, 1989). As organisms favour the excretion of ^{14}N over ^{15}N , recycling of existing nitrogen results in ‘increased $\delta^{15}\text{N}$ values with decreased nitrogen availability’, possibly overshadowing a diet-induced nitrogen enrichment (Adams and Sterner, 2000).

Illness, nutritional or water stress - Inadequate intake of hydrates and nutrition forces the body to recycle the existing internal nitrogen resources, resulting in the excretion of ^{15}N depleted urea (Ambrose and DeNiro, 1986a; Hobson *et al.*, 1993; Adams and Sterner, 2000). This observation could support the hypothesis that the population under investigation is associated with the Somerset hospital and/or the Company hospital and suffered for example from ailments associated with seafaring or the unsanitary conditions at The Cape (Halkett, 2000; Friedling, 2007; Schoeman, 2007, 2012). Moreover, this hypothesis is supported by the archaeological and osteological data, such as the presence of prone and disturbed burials, the impression that the dead were hastily disposed of, and the evidence of medical procedures (e.g., autopsy and amputation: Halkett, 2000).

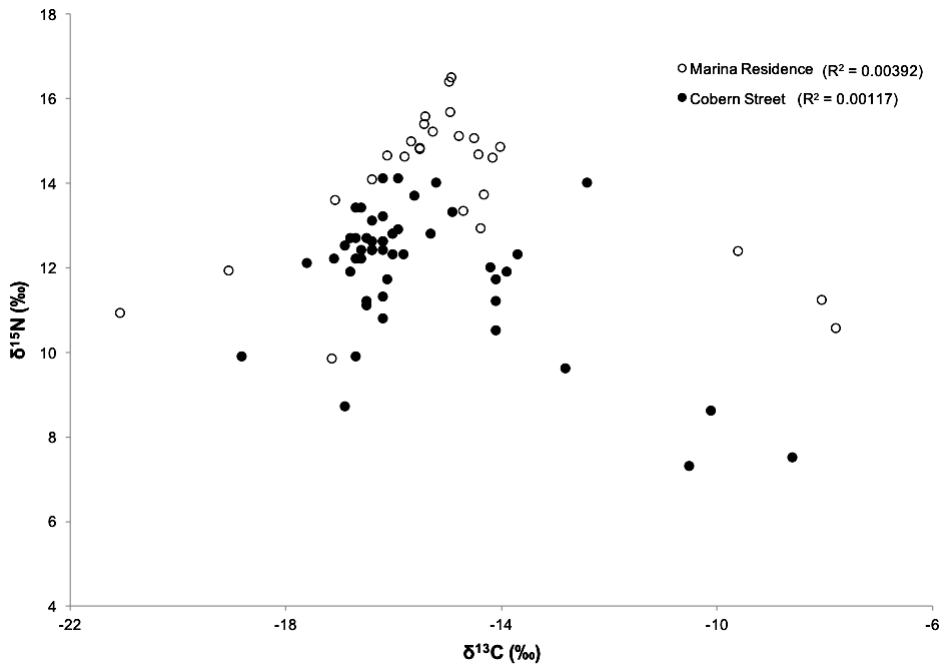


Figure 14. $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$ values of the V & A Marina Residence individuals and the Cobern Street individuals ($n = 27$ and $n = 50$ respectively).

Key: Cobern Street data from Cox *et al.*, 2001). The R^2 values are calculated with outliers as assessed from boxplots (*i.e.*, non-local diets) excluded (see figs. 3 and 4). The standard analytical errors are smaller than the plotted symbols.

Conclusions

The study of Indian Ocean slavery is currently predominantly dependent on the written record of early trading companies such as the VOC. It goes without saying that these sources are heavily biased in favour of the Company. Although historians attempt to read between the lines and against the grain, it remains extremely difficult to extract the life histories of slaves from such sources. Viewing the human body as an archive in its own right allows for a less subjective interpretation of the enslave experience. The study presented here adds valuable biogeochemical data to complement the body of historical work already in existence. Moreover, this approach aids in contextualising the mass of graves in the Green Point area. Despite the small sample size and the associated issues of representativeness, this study gives meaningful insight into Indian Ocean slavery as experienced by Cape slaves.

Using coupled Sr-C-N isotope ratios, and dental modifications as proxies for migration, a total of 17 out of 27 individuals (63%) at the V & A Marina Residence were identified as non-locally born. This majority of non-locally born individuals, from a site that was in use post-creolisation, supports the hypothesis that the V & A Marina Residence burial site is linked to the hospital/s that catered to the highly diverse and mobile lower rungs of VOC society, comprising slaves, soldiers and sailors. This theory is also supported by the elevated $\delta^{15}\text{N}_{\text{cancellous}}$ values of the Marina individuals relative to the contemporaneous Cobern Street individuals.

Another possible theory that explains the statistically significant elevated $\delta^{13}\text{C}_{\text{cancellous}}$ and $\delta^{15}\text{N}_{\text{cancellous}}$, is that the V & A Marina individuals exploited more marine resources, which were cheaper and more abundant than terrestrial ones. These two possibilities are not mutually exclusive. We have shown that a bioarchaeological approach to burial sites can elucidate social nuances, and in this case, make the precarious existence of The Cape economic underclass more tangible.