Exercise Magwitch, Rat Island 2020

Interim Archaeological Excavation Report

A Wicked Noah's Ark: Exercise Magwitch, Rat Island 2020. Interim Excavation Report Code BI20

By Richard Osgood, Chris Daniell, David Errickson, Mark Holloway and Richard Bennett

Non-Technical Summary

Further erosion at Burrow Island (known as Rat Island) – an MOD asset between Gosport and Portsmouth on the south coast of England – resulted in additional human remains being eroded from a cliff that had already been examined in 2014, 2017 & 2019. A team undertook recovery work in August 2020 to retrieve these remains and bones from a minimum number of seven adults and one infant (0-1 years of age) were found. These displayed various pathological traits. The finding of two bones of an infant was unusual; the first occasion that this project team has encountered remains of such a young individual. If the human remains represent burials of those who died upon the prison hulks of the 18th and 19th centuries (as most documentary sources seem to point towards), then this raises interesting questions about the incarcerated demographic. A radiocarbon programme placed the remains firmly in the Georgian Period (mid 18th - early 19th C) whilst isotopic assessments showed the individuals to have had a childhood consistent with being in southern Britain though an origin on the European mainland would also be consistent.

Contents

Introduction

The excavation report from the 2017 season at Burrow Island/ Rat Island (Osgood et al, 2017) concluded that 'there is a VERY HIGH likelihood of further human burials being present on the island, with the eastern and south eastern portion of the island especially sensitive. Indeed, fragments of wood, consistent with the elm coffins found in the excavations were visible close to a rubble wall in this area'. Erosion in the period between spring 2017 and summer 2020 did indeed reveal further deposits related to the burial ground on the island.

A recovery programme was established which also drew upon the skills of the Royal Military Police Special Investigation Branch (SIB) as part of a module in Body recovery training. This programme was codenamed Exercise Redcap Recovery and this team, combined with military veterans on Operation Nightingale (provided through Breaking Ground Heritage), archaeologists and forensics specialists from Cranfield Forensic Institute worked on site for a week on March 2019 to retrieve the remains. The report on that work stated that 'a series of burials, some partly eroded and lost already, were encountered with evidence for further burials still *in situ* being seen. The probability is that these too will erode BY spring 2020'. This proved to be the case and thus the 2019 work was followed by a further season with this RMP in August 2020. A Ministry of Justice exhumation license (19-0036 Burrow Island) was thus obtained. The report below details the results of the project.

Fig 1: Participants on Exercise Redcap Recovery (Photo Mark Holloway).

Research Objectives

The primary focus of the field week was to recover human remains eroding from the cliff and, in particular, to retain elements partly revealed in 2019 and join the components of the burials to retain skeletal integrity. Ancillary aims were to consider the potential for deeper stratigraphy of burial, to consider the possibility of chronological data and to assess all result to make further statements on the individuals interred on the island. The work also provided positive training opportunities for the SIB to work in partnership with forensics specialists and archaeologists.

Summary of the site archive

All paper archives are held by Richard Osgood at the Ministry of Defence. No small finds within securely sealed stratigraphic contexts were encountered, bar coffin nails and a clay pipe bowl. No environmental samples were taken. A photographic archive will be included with this report and deposited with the Hampshire Historic Environment Record. All human remains were held at the Cranfield Forensic Institute (an approved repository) prior to intended reburial. The Hampshire Historic Environment Record will be informed of any reburial in order to complete this record.

Potential of the data

Further analysis on the remains of these individuals' stable isotopes assessments and radiocarbon sampling would facilitate a greater understanding of this prison population, the ailments suffered and their place of origin. To this end, a programme of sampling was undertaken, and the results included here. The work in this report should be taken alongside that of the previous study (Osgood et al, 2017, 2019) to make any statements on the group buried on the island

Legislation, policy, and plans

Work on the Ministry of Defence (MOD) estate is guided by the Department for Culture Media and Sport (DCMS) Protocol for the care of the Government's Historic Estate and, specifically within Defence, Joint Service Publication 362 Leaflet 12 (Defence Lands Handbook). Rat Island is not covered by one of the MOD Integrated Rural management Plans (IRMPs) nor covered by a Regional Prime Contract (RPC) hence the funding for such work came from Defence Infrastructure Organisation and the Conservation Stewardship Plan. On this occasion, the fieldwork required one statutory permission – from the Ministry of Justice (Exhumation Licence 19-0036 Burrow Island)

Desktop Strategy

The work of 2020 drew upon all the assessments conducted prior to the 2017 and 2019 excavations and also the results of that programme. Following the initial site visit in 2014, the authors undertook a standard Desk-based assessment of the area – with map regression, air photographic examination, an interrogation of the Hampshire Historic Environment Record (HER), newspaper searches, any holdings within Ministry of Defence Files, and a search of local history literature. Discussions were also held with Abigail Coppins

– a leading expert on PoWs and prisoners of the period and curator of the English Heritage Prisoner collections at Portchester Castle.

After the fieldwork in 2014, and prior to the excavations of 2017, a Ground Penetrating Radar (GPR) survey of the area directly above the most concentrated areas of burials (Area A) by Peter Masters of Cranfield Forensic Institute. This survey was able to distinguish anomalies at some 2m below the surface of the made ground of the island which were perhaps further burials.

Location and Topography

The site is located between Gosport and Portsmouth in Hampshire (NGR SU62077 100790). It is an island connected to the mainland by a causeway (towards Priddy's Hard) which is submerged twice a day. The island is up to c3m in height with a series of dredged layers, building debris destruction layers, and beached shingles in clearly stratigraphically distinct laminated layers. The area has a coverage of foliage including holm oak and grasses. This is successful in preventing erosion to the west of the island but less so to the east.

Fig 2: Rat Island Grave Locations marked in red on Burrow Island (courtesy of Wessex Archaeology)

Documented History

This extensive history (and indeed details of documentary sources) was presented in a previous report on fieldwork (Osgood et al, 2017) and is by Chris Daniell.

There are two main sources for the history of the island: maps and newspapers. However, the search is complicated by the fact that the island has two consistent names: 'Burrow Island' and 'Rat Island'. There has been some speculation about the name Rat Island, which was either because of the rats living on the early 19th century prisoner hulks and coming ashore on the island, or because of the waste offal from Royal Clarence Yard which was washed up on the island which the rats then ate. The earliest example of the name Rat Island so far discovered was the name given on the 1812 painting by John Schetky (see below). Whilst 'Rat Island' has been consistently spelt, there are numerous variations of Burrow Island. The earliest recorded name is on two Tudor maps 'Barrow Island' (pers comm R Harper, who has suggested that the site may have been so called because of a Prehistoric barrow located on the island), and 'Baro' (1678).

There are several maps by De Gomme who proposed a fortification upon the island. His terminology included: 'The Barow Island', 'Redout upon the Little Island' (1688), 'The Eyland called the Bou… Gosport …'' A 19th century document records: 'Burrough Island bough of John Holt in 1679 for £22:10:0; deed dated 17th Sept 1679'. The spit joining the island at low tide to the mainland was known as Burrow Bank and in 1857 a portion was 'under removal' (*Portsmouth Times and Naval Gazette* 28 February 1857).

The earliest detailed maps of the area go back to the 17th century and the first map with any detail dates from 1678, which shows a small island and shingle back formed by the convergence of Forton Creek with Portsmouth Harbour. The Victorians speculated that the site had either a Roman or Medieval fort on it (*Portsmouth Times and Naval Gazette* 28 February 1857), but there is no independent evidence for this, though in 1871 the *Hampshire Telegraph* reported that dredging in the harbour had discovered Roman pottery at a depth of 16 feet. 'There is a legend that the fort was preceded by a Norman Castle. An old letter of 1847 which I have seen mentions 'the ruins of Borough Castle, traditionally ascribed to King Stephen,' (Note: Capt G Civil note in the English Heritage Monument Long Report, National Archive, Swindon. Capt Civil's letter no longer exists.)

The earliest known structure is a small fort called Fort James built by the famous Dutch defensive engineer Sir Bernard De Gomme in 1679. Fort James was part of a much bigger defensive scheme around Portsmouth harbour as the vulnerability of the naval dockyards had become apparent during the Second Dutch War (1672-1678). Fortunately a detailed set of plans have survived of Fort James, copies of which are in Portsmouth City Library. The plans show a strong rectangular two-storied fort with walls six feet thick with a platform for guns and a curtain wall, also six feet thick. Within the fort is a 'House for a Sargeant', two guns and various rooms, with corner turrets each as a 'sentry house'. (Portsmouth Map Collection, Dartmouth Collection James Forte).
However, within a few decades of the fort's completion it was un-used and falling into decay. In 1698 the drawbridge was said to be needing repair and ten years later in 1707/8 Admiral Sir George Byng noted that the fort was in poor condition (G H Williams, *The Western Defences of Portsmouth Harbour 1400–1800.* Portsmouth City Council 1979 . p. 19).

In 1742, an order was made to recover its 2 guns which were weed-covered (http://www.pastscape.org.uk/hob.aspx?hob_id=238752&sort=4&search=all&criteria=monckton&rational=q&recordsperpage=10). There was a scheme to rebuild it in 1750, but this was not carried out (Williams, ibid pp 21-22). During the 18th century the fort continued to decline.

There is a drawing of the ruinous fort in the National Maritime Museum collection, described as Rat Island 1812'' by John Schetky, which shows the fort and curtain wall before its demolition (National Maritime Museum PAI 0913). There are no windows or fixtures or fittings shown, but the walls look substantial, high and strong. There is also a small curtain wall running down to the sea and then turning parallel to the sea. The artist's location is not clear, but the most logical location is at Priddy's Hard looking across Forton Lake to Royal Clarence Yard (indicated by the buildings behind). That the view is of Forton Lake in the foreground is also emphasised by the small ships and the pencilled in small ship which appears beached in the immediate foreshore. It is also possible that the fort is shown on two other drawings.

On a map of 1810 the fort is shown in outline, but with an additional feature stretching into Portsmouth Harbour. This could be a jetty which was used for transporting the stone away from the island. By the late 1820s the fort had been completely removed. English Heritage have a record from 1953 which states a 'letter of 1828 says "the walls of the Castle [ie Fort James] have lately been taken down" (Note: Capt G Civil note in the English Heritage Monument Long Report, National Archive, Swindon. The original letter no longer exists.) By the 1830s there was nothing left of the fort.

The first indication of a 19th Century military presence on the island is the report of an accident in 1833 (*Reading Mercury* 4 Nov 1833). A gun exploded on St Mary's Quay and the wadding was catapulted over to the island, severely injuring Master-gunner Ross. Thereafter there were frequent newspaper reports of plans or activities on Rat Island.
In 1846 the *West Kent Guardian* (14 February 1846) reported a planned scheme to make the island into a coaling station. A pier was to be created, on the end of which was a large coal store. This scheme was dropped in 1847 because of 'insuperable' objections, in particular because the jetty would lead to the 'unavoidable accumulation of muddy deposits' (*Morning Post*, 16 August 1847). *The Evening Chronicle* (31 August 1846) also reported on the proposed coaling station and there was the recommendation that Rat Island should be converted into a fort as it could sweep the entrance of the Harbour 'and be made useful than Blockhouse Fort'.

Possibly as part of the planned coaling station in May 1846 Lieutenant Richard Tylden of the Royal Engineers drew a plan and sections of the island (The National Archives MPHH 1/233/6). There is no trace of the fort on the plan and the island is devoid of any trees and only has two structures upon it, one of which is a building 46 feet long and 18 feet wide, and the other is a 6ft square structure. The length of the island is 348 feet and its width is 108 feet. Instead, in 1847, the Ordnance granted permission for the Admiralty to make the island into a drill-ground for HMS Excellent's men to drill with field-pieces (London Daily News 8 March 1847), whereas the *Shipping and Mercantile Gazette* (9 March 1847) stated that the officers and seamen would be exercised 'in field fortification, storming etc. Some heavy 60 pounders will be mounted on the island' in defence of the harbour and dockyards. Later in the year the Board of Admiralty visited the harbour, which included Rat Island 'where officers and men of the Excellent are instructed in the formation of field works etc and other kinds of fortifications' (*Morning Post* 11 August 1847). The *Dover Telegraph* (14 August 1847) added the detail that the Lords 'inspected the plans of Lieut. Savage, of the Royal Naval College, for Service Batteries, one of which is erected on the island'. In preparation for this thousands of tons of spoil from the excavated dockyard basins were dumped by convict labourers.

Rat Island was also used as a Victorian burning ground on occasion and on 16 September 1854 *The Hampshire Advertiser* reported that the St Vincent was towed into harbour and as a precaution 'a large number of the blankets and hammocks etc used by the Russian prisoners, supposed to have been infected by cholera (as she came into port with several cases on board), were burned on Rat Island in this harbour'. The *London Evening Standard* (12 September 1854) stated that the blankets belonged to the men 'who died on cholera' whilst on board and the *Evening Mail* (13 September 1854) quantified the burnt amount as 'several hundred beds and blankets'.

For the rest of the century the island had two main uses, the first as a drill ground and the second as a site of experimentation.

Drill Parade Ground

In 1847 the Ordnance granted permission for the Admiralty to use Rat Island as a drill ground for Excellent's men with field-pieces (*The Daily News* March 8 1847) and the function of the island as a drill ground was the island's primary role for the rest of the century. In the same year a high-ranking visitation visited the island where the officers and men of the Excellent are instructed in the formation of field work etc and other kinds of fortifications' (*West Kent Guardian* 14 August 1847).

In 1854 the 'newly raised men of the Excellent were drilled in musket and sword exercise …and the men of the ordinary were also exercised in the use of the floating engines' (which were not specified) (*Hampshire Advertiser* 29 July 1854). This use continued until the end of the century, but in 1900 the *Hampshire Telegraph* reported that Rat Island 'was formerly used as a drill ground for field gun practice by the seamen of the Excellent' (*Hampshire Telegraph* 22 September 1900). In an article, written in 1926, stated that field work took place on Rat Island 'and on one day a week the Marine Cadets were instructed … in field fortification work' (*Hampshire Telegraph* 27 December 1929).

However, this use unfortunately led to some accidents and even deaths, and the newspapers reported in 1862 the death of Robert Price, who was 21, who was an able bodied seaman on HMS Excellent. He was practicing drill and was moving a 12-pounder Armstrong gun when it overbalanced and crushed his head – causing instant death (*Portsmouth Times and Naval Gazette* 28 June 1828). In 1870 Henry Hicks, a leading seaman with HMS Excellent, also died on the island whilst practicing gun drill, this time because of a heart attack (*Hampshire Telegraph* 24 September 1870).

An odd occurrence happened in 1861 when a bullet was fired through the bread-room of Royal Clarence Yard. The police investigated and a number of men from the Excellent who 'were at rifle practice, with blank cartridge – and it is supposed the bullet was fired by one of those men thoughtlessly; it is, however, strange that it is not one as issued by the Government' (*Morning Advertiser* 18 Oct 1861).

However, the logistical difficulties were written about in the *Naval and Military Gazette* (10 February 1872): 'It is estimated that one hour of drill hour in every five is lost daily by drill parties in going to and from Burrow or Rat Island for field battery drill and laboratory processes etc'). The reference to a laboratory on the island is not elaborated upon. On the foreshore large fragments of crucibles have been found and these may have been part of experiments on the island.

Experimentation

The island was also used as a base for experimentation. In 1847 the officers and men of Excellent created a 'sand-bag battery' (*Shipping and Mercantile Gazette* 6 October 1847). In 1849 a series of experiments were undertaken to blow up a practice stockade. The reports were widely published in a variety of newspapers with one of the longest accounts given in the *Salisbury and Winchester Journal* (29 September 1849). A practice stockade was erected, from the recently broken up brig Curlew, with different amounts of gun powder being detonated against it. Whilst the 5lb and 10lb charges did not affect the stockade, when 5lb of powder in a flannel cartridge was used, with 120lb bag of sand over it three planks of the stockade were blown down with fragments being thrown in all directions. The experiment then stopped as a splinter hit the Commander in the leg and he suffered a considerable wound (*Lloyds Weekly London Newspaper*, 30 September 30th 1847) which turned out to be very heavy bruising (*The Daily News*, September 26 1849 page 7). Earlier in the year *London Evening Standard* (22 March 1854) reported that experiments were carried out on the island by the Royal Marine Artillery, in mining and blasting operations with the *Portsmouth Times and Naval Gazette* (25 March 1854) adding that the experiments were 'to try the effects of gunpowder in blasting stockheads'. The experiments were witnessed by Vice Admiral Sir Thomas John Cochrane amongst others.

As well as for military purposes Rat Island was also used for more general purposes. The 1852 various experiments concerning Phillipp's Fire Annihilator were reported on Rat Island. The experiments were described in detail by the *Illustrated London News* (23 October 1852) and the *North & South Shields Gazette and Northumberland* and *Durham Advertiser* (22 October 1852) and the *Liverpool Mail* (23 October 1852)), though there are some discrepancies between the accounts. The first experiment involved an 'immense quantity' of coal which was put into a trench and ignited. The next experiment involved twenty tar barrels which were put into a trough, or reservoir, forty or fifty feet by five feet in size, filled with wool, tar, naptha and 'other flammable materials' and then five empty tar barrels were filled with shavings and naptha and 'other flammable materials' poured on them and then they were set alight, and the third and last involved a purposefully built wooden building, twenty five feet long and high, was filled with combustible materials and set alight. The 'Annihilator' successfully put out all the flames and the experiments were deemed

successful. The *North and South Shields Gazette* describes the annihilators as 'portable engines. The largest goes on wheels, and is about the size of a small barrel'.
By the second half of the 19th century there was a considerable number of buildings on the northern end of the island. A detailed Admiralty map of 1891 shows the buildings and structures, which included: Officers' Mess Room; Mens' Mess Shed; Gun Shed; Gunner's Quarters; Signal Post; Observatory; Flagstaff; Practice Battery; Jetty and Derrick. The buildings were all single storey and are shown as part of a Portsmouth Harbour photographic panorama of 1881 and in a painting by the local artist Martin Snape. In 1892 tenders were invited to 'Remove Earth Closet Soil and Rubbish … and further to supply Dry Earth for use with closets' *(Portsmouth Evening News* 1892) showing that the area was still actively used.

On the 25 July 1896 the *Army and Navy Gazette* gave the first indication that homing pigeons were to be based on Rat Island as part of the Navy's messaging systems from ship to shire. The pigeons had previously been trained by the Commander of Whale Island entirely at his own expense, and the following month the proposed plan was mentioned in *the Illustrated Sporting and Dramatic News* (22 August 1896). The *Morning Post* in September (9 September 1896) mentioned that the 'pigeon establishment' had not been transferred to Rat Island yet. The plan was then changed, and the pigeon loft was being built near the Queen's private landing stage on Royal Clarence Yard (*Morning Post* 16 March 1897), but was changed again and on the 17 July 1897 the *Isle of Wight County Press* and South England reporter wrote that Rat island was 'an ideal spot in every way', and in November the *Army and Navy Gazette* (6 November 1897) wrote that the pigeon cote on Rat Island was 'comparatively new'. The *Belfast Newsletter* (28 July 1897) gave details of the new communications system of homing pigeons had been initially developed by individual officers, but the Naval Intelligence Department took notice and a pigeon cote had been built on Rat Island, 'an ideal spot in every way'. The pigeons were kept on board ship and then released up to 120 miles from shore where upon they would fly home with messages. The article reported that pigeons were even used on the Royal Yacht. However, under the main article was another with a cautionary tale – the Germans had flown homing pigeons from Dover, but the coast guard had found many dead, having been attacked and killed by British hawks.

The Mindry Family

In the latter part of the 19th century the Mindry family lived on the island and through a range of records a reasonably detailed picture can be built up of the family. The reason for the family living on the island is probably that the father, Robert Mindry, was a caretaker for the whole site. In the 1871 Census Returns the husband, Robert, was 48 and living on Burrough Island. However, also in the 1871 census Robert was again included – a rare example of a 'double count' on the census – and this time the island was described as 'Rat Island Extra Parochial' and his family was included. The family consisted of Robert, the father, who was 47 and a Gunner 1st Class Royal Navy who was born in Gillingham Kent, his wife Mary Anne, 47, born in Devonport, Mary Jane, 21 born in Portsea, Frederick R, 13 born in Portsea, Henry H, 11 born in Portsea, Edith, 8, born in Portsea and Helena 2, who was born on Rat Island. Helena is the only known confirmed birth on the island. However, a birth announcement in the *Portsmouth Times and Naval Gazette* (6 April 1867) states that a

daughter was born on Borough Island – an alternative name to Rat Island - to the wife of Mr Henry Kuron, gunner RN and it maybe that the family were resident there before the Mindry family. Despite extensive searches no other reference has been found to the Kuron family and it maybe that the name was misspelt in the newspaper, made more likely by the lack of a birth certificate in 1867 with the surname Kuron. In 1881 Robert Mindry was away from Rat Island and his wife Mary remained with Henry, Edith and Helena. Mary was described as 'Gunner's wife RN' and her 20 year old son Henry was described as a 'Seaman RN'.
The most detailed record for Robert is his Physical and Service record (number 319657) which records that he was born on the 20th May 1821 at Gillingham in Kent. He had 'light' hair, blue eyes, a fair complexion and was 5 feet 81/2 inches tall and he could write. His only injury was a scar on his right leg. He was aged 25 when 'ticketed' and he first went to sea as a boy in 1836 and at the time of writing (20 May 1846) had served in the Royal Navy for 9 years. When not in the navy he resided in Hackney. In 1846 and 1847 he was on HMS Dasher, being discharged on 4 June 1847. HMS Dasher was a wooden paddle packet of 357 tons, launched at Chatham Dockyard on 5 December 1837 (https://www.royalnavy.mod.uk/dasher). He died in the last quarter of 1907 in Portsmouth.

The newspapers of the time revealed several tragedies which occurred to them. In 1873 the case of the young son of the Mindry's was reported. Two of the Mindry boys were sent to Gosport for medicine as their mother was ill. Whilst attempting to cross the water the '10 or 11 year old' fell overboard the boat and despite assistance being given he was drowned and his body could not be recovered (The *Hampshire Telegraph* and *Sussex Chronicle* March 5 1873). Although the boy is not named, given that Henry was 11 on the 1871 census, he is the most obvious candidate, but he appears on the 1881 Census, whereas Frederick does not, so Frederick (then aged 15) was presumably young looking for his age.

In 1877 the family again came to the attention of the press with a potentially tragic court case which was written about in the *Hampshire Telegraph* (Saturday 11 August 1877). The report told of an unnamed woman who lived on Rat Island (presumably the wife, Mary-Jane) applying to the Magistrates for the restitution of her six month old baby whom her husband had 'detained' over-night. As she could not breast feed the baby she was frightened that her baby might starve to death. He had been violent and aggressive towards her and had broken the Venetian blinds of the house where they lived. The Magistrate stated that the island was under naval control, so she had better apply to the commanding officer of the Excellent. The woman replied she had already done so and been referred by the commander to the civil authorities. The Magistrate said that if anything should happen to the baby the husband would render himself liable to serious indictment but he considered it a family quarrel and had no power to intervene. The outcome of the incident is not known. In the 1881 Census the family had moved off the island and the resident population on Rat Island was nil (*Hampshire Advertiser* 23 May 1883).

During the Victorian era the island formed a useful vantage point for cheering important guests or gun salutes – especially royalty. In 1858 the Coastguard fired for the Queen's Birthday and in 1874 the men from HMS Excellent 'were drawn up like sentinels on the crest of the grounds' of Rat Island with a 19 gun salute being fired (rather than the normal 21) 'signifying that formal honour was being paid, for the first time, to the new First Lord of the Admiralty.' (*London Daily News* 24 April 1874). Later in the same year Queen Victoria inspected the seaman and marines at Royal Clarence Yard and a large number of seamen stood on the side facing Royal Clarence Yard to welcome the Queen (*Hampshire Telegraph* 25 April 1874).

One of the last big events reported by the newspapers the transportation of Queen Victoria's coffin to her beloved Osborne House on the Isle of Wight. The men of the Excellent and boys from the training ship St Vincent manned Burrow Island as the coffin cadets lining the island as the coffin of Queen Victoria went past (*Portsmouth Evening News* 30 January 1900). Later in the same year Edward VII and his Queen visited Portsmouth and the men on Burrow Island 'added to the volume of welcoming acclamations'.

As a drill-ground Rat Island was no longer in use by 1900 but a scheme was reported in the *Hampshire Telegraph* (12 September 1900) to convert the island into the new naval coaling station. It was to be connected to the mainland by a railway so coal could be delivered by land and water. To enlarge the island material was going to be dredged from the harbour (*Hampshire Telegraph* 4 May 1900) This was the last major conversion scheme proposed for Rat Island but it was never carried out and in 1902 the scheme had been abandoned (*Hampshire Telegraph* 13 December 1902).

In the 20th century the island became less and less used. In 1904 tender notices were issued for the removal of earth closet soil and rubbish from Whale island and Burrow Island (*Portsmouth Evening News* 19 August 1904), and it may be that a decision had been made to formally reduce the use of Burrow Island. In the event this is what seems to have happened. During the 20th century from a previously bare patch of ground the vegetation began to take hold. Maps and aerial photography of the island show it vegetation-less until the 1920s and then slowly the trees began to grow. The maps and aerial photographs show the progressive growth of the vegetation.

It is only in the 20th century that a few mentions of beached shipping occur. In 1906 there was a mention of Rat Island in relation to a collision at sea when the Solent Queen, one of the harbour ferries collided with another ferry, the Frances, and was holed. The Solent Queen was first beached at Rat Island and the 'collision mats' were deployed. She later attempted to journey to Southampton, but took in so much water that she had to land at Gosport Hard (*Portsmouth Evening News* 4 December 1906). In 1946 the corvette Lupin was beached at Rat Island after springing a leak and in 1947 was to be towed to Portchester to be broken up, but owing to the bad weather had to be towed in the winter of 1947 (*Hampshire Telegraph* 29 August 1947, *Hampshire Telegraph* 14 November 1947). A large anchor structure, dated 1944, still survives at the southern end of the island and unless the tides have moved it, it is likely that the island was used in some way for D-Day, though this aspect is unrecorded.

The uses for the island in the 20th century were as a landing point for under-sea cables and also as a burning ground for unwanted fuel or munitions from Priddy's Hard. It was in order to carry the material to be burnt that a little tramway was built from Burrow Island to Priddy's Hard, the tracks of which can still be seen along the shingle bank. Today the island is completely overgrown with only the odd platform or object to be found on it. There are small portions of walls or re-vetting, especially on the eastern side. At present their uses and dates are unknown.

Note – There are several islands named ‘Rat Island’ which are reported on in the newspapers, notably Rat Island near Lundy, and on Jersey. In 1856 there is a single line entry about the building of barracks, which states ‘And Rat Island, for 13 officers and 378 men’ (Morning Chronicle 3 May 1856), but this is not the Rat Island in Portsmouth Harbour.

The Burials

The burials discovered on Rat Island have yielded radiocarbon dates inf the Georgian era (mid 18th – early 19th C), and there are a number of possibilities for their origin. The first is that they are prisoners of war from the American War of Independence or the Napoleonic Wars. If this is the case then they could be from a wide area of the globe, as fighting took place in North America, Caribbean, Europe, North Africa and the Middle East. Abigail Coppins has undertaken a large amount of research on the prisoners of war in Gosport, and there were large prisons at Portchester Castle and Forton Creek, as well as prisoner of war hulks in the harbour.

Whilst prisoner of war burials are possible, especially if there was a continuing tradition, there is more evidence for the burials being of convicts from the 1830s and 1840s from the prison hulks which lay in the harbour. Prison hulks were a common sight in Portsmouth harbour and were large decaying ships which were used to house prisoners, either as a ‘prison overspill’ system or for prisoners awaiting transportation to the colonies. An OS map of 1858 states that the south-eastern section of the island is the ‘convicts burying ground’ and in 1852 it was described as the ‘the convicts’ burial-ground’ (*Morning Chronicle* 18 October 1852). This was remembered after the burials had ceased and in 1891 a report of Queen Victoria’s visit to Portsmouth mentioned the previous convict ships ‘and any one will tell you the direction of Rat’s Island, where the prisoners were buried.’ (*London Daily News* 27 February 1891).

Dave Spencer, one of the veterans on the excavation team, located a map (reproduced in Williams 1979) which specifically refers to Burrow Island as being a ‘Convict burying ground’

Another tantalising reference is located in some lines from a tale written in *The Graphic* in the 5 January 1878 edition about the Portsmouth of the 1840s and 1850s. 'By Celia's Arbour' by Walter Besant and James Rice suggested that the burial of convicts was rudimentary though probably not dissimilar to many other inhumations in Portsmouth and Gosport at the time, and were at least with spiritual component:

"Brave and honest soldier – there is the roll of musketry over his grave – God rest his soul! Down below, creeping sluggishly along, go the gangs of convicts armed with pick and spade. No funeral march for them when their course is run; only the chaplain to read the appointed service; only an ignoble and forgotten grave in the mud of Rat Island"

However, there is one certain, named, burial on Burrow Island. In 07 February 1831 the *Reading Mercury* stated that Charles Morris Jones, a convict on the York prison hulk died and was buried on Rat Island. Earlier newspapers had charted the course of Charles's life and how he came to be on the prison hulk. The Abingdon court notices of October 24 1829 give a detailed account of how Morris came to be caught. Charles Morris Jones was born and lived in Aberystwyth and in his early 20s he moved to Abingdon where he was employed in the drapers shop owned by Mr George Shepherd. He was described as a 'genteel looking young man'. Shepherd strongly him of stealing money, so with some friends set a trap whereby two people bought some cloth with 'marked money'. Morris was searched and some marked money was found in his pockets. It also transpired that Morris had an accomplice in London (who was not named) who had received goods to the value of £30 from Morris.

The trial report ends ominously 'There will be little doubt that he will be committed on Tuesday next on a capital charge'. The expectation was that he would be hanged. On November 2 it was reported that Jones was not 'examined' by the magistrates owing to the fact that one of the witnesses from London failed to attend. The examination was reported in the November 7 Oxford Journal when the two London witnesses had arrived. They were named Owen and Jones and had received money and different sorts of cloth and a ticketed piece of lace, which proved it had come from Shepherd's shop. Morris had also written to Owen and boasted that he was doing very well 'at the rate of one pound a day!". Jones was again committed until the next Assizes. The actual trial was on the 3rd March 1830 and Morris was one of nine others found guilty of relatively minor theft – all were sentenced to death.

A long trial report was given in the Reading Mercury which includes a transcript of a letter from Morris to his cousin in Upper-Baker Street. The letters indicates that Jones was pretending to be a travelling buyer of cloth which he would then post via the Alert coach to Jones in London. Jones made no defence and was immediately found guilty with his counsel pleading that his life be spared. It was the jury that pleaded that his life be spared and the judge agreed – on the condition that he be transported for life. Sometime during the week of May 17 Jones and seven others were taken to the York hulk in Gosport, in the expectation that he would be transported for life. It was nearly a year later the Abingdon correspondent reported on the 3rd February 1831 that Charles Morris Jones ‘who was sentenced to 14 years transportation, lately died at the hulks at Portsmouth, and was buried on Rat Island’.

Fieldwork Methodology 2020

Rather like the 2019 work, the excavations could not take place in a horizontal plane because of the large overburden of the cliff and the need to recover the deposits quickly. On discussion with experts such as Jaqueline McKinley of Wessex Archaeology (author of CIfA guidance on work with human remains), the decision was taken to recover the remains in a horizontal plane; photographing this work and the location, and cataloguing the human remains with unique numbers in order to enable assessment and geolocation at a later stage. Conversely, this situation provided an excellent test of RMP skills as part of a training serial. One exception was **SK4** which was uncovered far enough from the eroding cliff to permit a traditional 1:10 drawn plan.

Further to the archaeological and location challenges, the project took place in the restrictive template of COVID19 precautions and hence social distancing was enforced on participants, with ‘swim-lanes’ demarcating areas for particular teams and with masks being worn at the cliff edge – as well as usual site safety equipment such as hardhats

Given the elements above, neither sections nor plans of the grave (or indeed a profile) were possible to draw (apart from SK4). This would have been unsafe given the nature of the collapsing cliff, part of which did indeed slip whilst we were one the island. The location of the burials is highlighted in the images below.

Fig 3: The cliff face section at Rat Island with various grave cuts exposed (Photo Harvey Mills Photography).

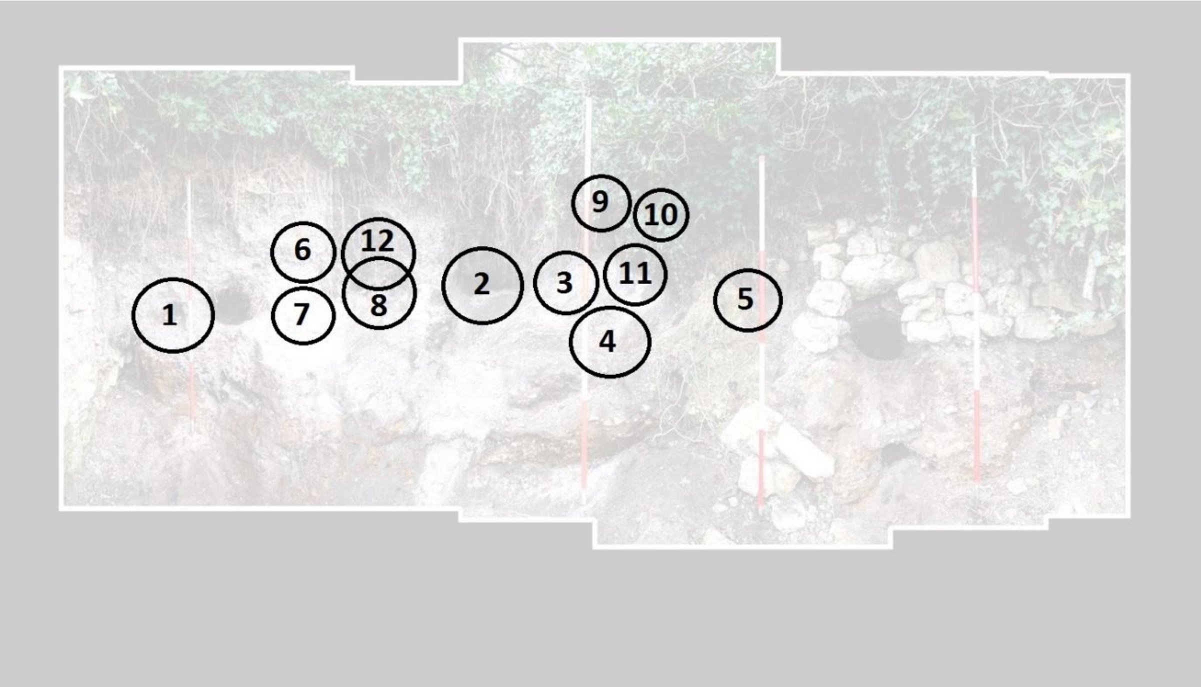


Fig 4: The cliff face section at Rat Island with the numbering of the various grave cuts exposed (those in circles represent the relative positions of the three more complete and other, more isolated, SK contexts.)

Skeletal recording forms were completed for all remains.

Results

The fieldwork yielded the remains of three more complete adults, and partial remains of at least nine other individuals in the cliff face to the immediate north of the ashlar wall that may represent part of the remains of James Fort. This confirmed the work of 2019 in highlighting that the burial ground extends further to the north than previously thought. What is also important is that these burials are also at greater depth and thus this raises the potential for far higher numbers of individuals being here.

In 2019, whilst digging area SK6, it became clear that there was the potential for a cliff collapse. Work was thus stopped in the area – the completion of the recovery of this person took place in 2020 and was indexed as BI20 SK02.

The work of 2020 confirmed that the burial ground is potentially far larger than first thought with burials stacked not only within the beach shingle, but also in the laminated layers above it.

As in earlier seasons, iron nails were seen *in situ* as part of coffin furniture. In 2019, we also noticed the presence of *in situ* copper alloy nails in some of the coffins – no other small finds were located in any of the burials - perhaps also adding to the argument that these were convict burials rather than Prisoners of War where items such as rosary beads, and military buttons have been located (see Cunliffe on nearby Portchester Castle). The 2020 season also confirmed the nature of multiple burials in a small location. This all contributes to the picture of stacked coffins located to the east side of the island. It should be noted that there may well be burials on the western, northern and central elements of the island but that these locations are not affected by erosion and thus not currently vulnerable or at risk. The scientific studies have been illuminating too – with Radiocarbon dates confirming that the individuals located in 2020 were buried from the mod 18th – mid 19th Centuries (see below). Analysis of the Stable isotopes showed that all of the burials were consistent with having early years in either southern England or perhaps the north European mainland such as France (see below)

Fig 5: Two sides of one of the coffins (holding Sk8) visible in the cliff cutting in 2020.

Conclusion

Erosion continues on Rat Island and the fieldwork has added at least a further 12 adult individuals to the list of human remains recovered from the site.

The work highlighted the problems of speedy recovery of remains from a collapsing cliff face and the limitations on traditional site recording potential (sections/plans). To this end, it provided good training to teams that are often very limited in the time that they can spend on site to recover remains. Priority was given to recovery of the remains themselves, with recording film and photography to document the work, and then to the analysis of the physical remains.

There will undoubtedly need to be further work undertaken here, as not all the components were retrieved.

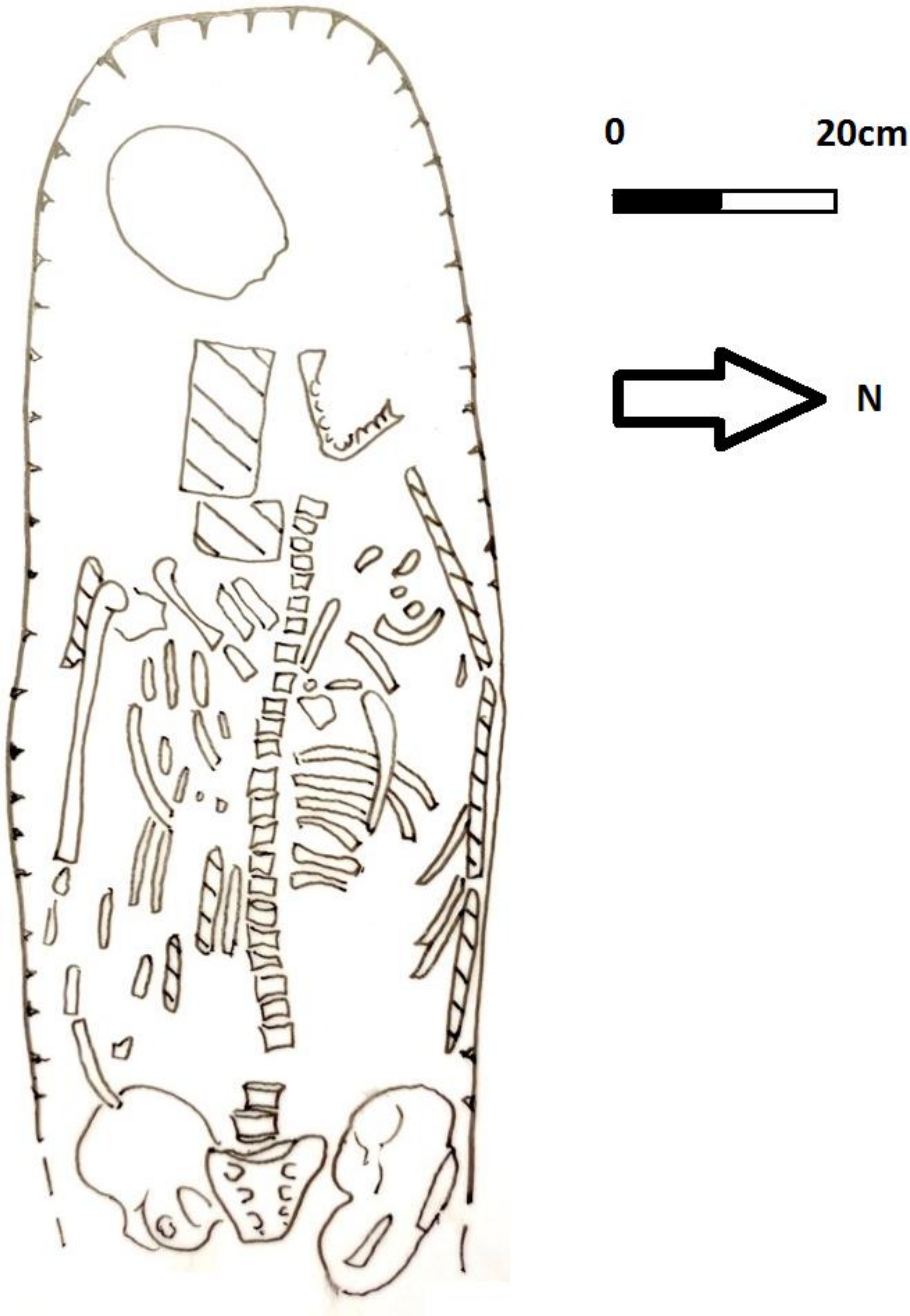


Fig 6: Grave plan of SK4 and coffin.

Recommendation for further work

The fieldwork was only for one week in duration. This was not long enough to examine all of the graves that have been exposed by erosion. At least two areas (both of which show either coffin wood or even human remains) need to be excavated as a matter of some urgency and thus a project to complete this phase in 2021 is essential.

Acknowledgements

Thanks to all the participants – Clare, Dave, Dickie, Giselle, Harvey, Jackie, Jackie, Jordan, Julian, Katherine, Kayleigh, Kevin, Kieran, Mark, Ryan, Sarah and the Explosion Museum.

To Professor Alice Roberts and the Channel 4 production team too.

References

Bass, W. M. 1995. Human Osteology: A Laboratory and Field Manual. Missouri Archaeological Society, Inc.

Boston, C., Witkin, A., Boyle, A. and Wilkinson, D.R.P. 2008. 'Safe Moor'd in Greenwich Tier'. A Study of the Skeletons of the Royal Navy Sailors and Marines Excavated at the Royal Hospital Greenwich. Oxford Archaeology, Oxford.

Branch-Johnson, W. 1957. *The English Prison Hulks.* Christopher Johnson, London.

Brickley, M. and McKinley, J. (editors). 2004. Guidelines to the Standards for Recording Human Remains. IFA Paper No. 7.

Brooks, S.T. and Suchey, J.M. 1990. Skeletal age determination based on the os pubis: a comparison of the Acsádi-Nemeskeri and Suchey-Brooks methods. Human Evolution, 5: 227-238.

Buckberry, J.L. and Chamberlain, A.T. 2002. Age estimation from the auricular surface of the ilium: a revised method. American Journal of Physical Anthropology, 119: 231-239.

Buikstra, J.E. and Ubelaker, D.H. 1994. Standards for Data Collection from Human Skeletal Remains. Arkansas Archaeological Survey Research Series No.44.

Caffell, A. 2016. Palaeopathology and Scurvy. https://sites.durham.ac.uk/scottishsoldiers/2016/08/26/palaeopathology-and-scurvy/

Chamberlain, P. 2008. *Hell upon Water: Prisoners of War in Britain 1793-1815.* History Press, Stroud.

Cunliffe, B. and Garratt, B. 1994. *Excavations at Portchester Castle. Volume V: Post Medieval 1609-1819.* Society of Antiquaries of London, London.

Garneray, L. 2003 (translated from 1851 original by Richard Rose). *The Floating Prison – the remarkable account of nine years' captivity on the British prison hulks during the Napoleonic Wars.* Conway, London.

Higgins, D., 1989 (April), 'A Pipe Made by Thomas Frost of Southampton', Society for Clay Pipe Research Newsletter, 22, 18.

İşcan, M.Y., Loth, S.R. and R.K. Wright. 1985. "Age estimation from the rib by phase analysis. White males". Journal of Forensic Sciences, 29: 1094-1104.

İşcan, M.Y., Loth, S.R. and R.K. Wright. 1985. "Age estimation from the rib by phase analysis: females". Journal of Forensic Sciences, Vol. 30, 853-863.

Mitchell, P.D. and Brickley, M. 2017. Updated Guidelines to the Standards for Recording Human Remains. CiFA/BABAO.

Osgood, R., Daniell, C., Márquez-Grant, N. & Bennett, R. 2017 (unpublished), *A Wicked Noah's Ark: Exercise Magwitch, Rat Island 2017. Excavation Report.*

Peacock, D.P.S. 1977 (ed). *Pottery and Early Commerce.* Academic Press, London.

Scheuer, L. and Black, S. 2000. Developmental Juvenile Osteology. Academic Press, London.

Suchey, J.M. and Katz, D. 1998. Applications of pubic age determination. In K.J. Reichs (ed), Forensic Osteology: Advances in the Identification of Human Remains. 2nd edition. Charles C. Thomas, Springfield. Pages: 204-236.

Trotter, M. 1970. Estimation of stature from intact long bones. In T.D. Stewart (1970)
Williams, G.H. 1979 (Dec). *The Western Defences of Portsmouth Harbour 1400 – 1800*. Portsmouth City Council, Portsmouth.

Appendices:

1 Contexts:

Please note that due to the immediate urgency of recovery, separate context numbers were not allotted to cut/fill of any deposits. Rather, a unique 'SK' number was given to each separate cutting, and the fill (including human remains/coffin wood/matrix) included within this allocation.

SK1: Located immediately to the north of the one surviving portion of the walls of James Fort in 2019 but not excavated that year. Parts of two femurs were visible in a grave cut through consolidated beach shingle, and coffin wood was also present. The burial was complete from femurs upwards and was lying extended and supine, aligned E-W with the skull at the Western end. Coffin nails were present and this burial location was both laser scanned and photographed in stages as the burial became exposed.

The burial was photographed at various stages of excavation and the coffin cutting was laser scanned by the RMP team.

SK2: This burial was located in 2019 and given the number BI19 SK6. Within the cliff face, coffin wood and several phalanges were visible. This area was located above and to the west of an older grave (BI19 SK3). This burial was in a wooden coffin, extended and supine, aligned W-E with the head at the western end. The skull was NOT recovered as the cliff face was deemed too unstable to attempt to retrieve it. This area was later affected by cliff collapse. When this face collapsed, further bones from even higher up the cliff (and kept separately as BI19SK9 and BI19SK10) were seen. We returned to this part of the cliff in 2020 and recovered what was left of the skull and mandible. This was accomplished by Professor Alice Roberts (and shown on C4 ‘Britain’s Most Historic Towns’) with the remains of BI19 SK6 and BI20 SK2 amalgamated as from the same individual.

BI20 SK2 being excavated in 2019 (as BI19 SK6)

SK3: Isolated femur – disarticulated.

SK4: Initially believed to be a pelvis and sacrum with the femurs and all bones below having eroded, on completion of excavation this was seen to be a c60% complete individual lying extended and supine in a wooden coffin, orientated E-W with the skull at the West end. The right arm lay upon the right pelvis. The top of the cranium was intact but the lower part of the skull including facial bones and maxilla less so. The mandible had rolled a short distance from the skull and lay to the NE of the cranium. The burial was photographed, scanned and planned at 1:10

SK5: disarticulated tibia N-S aligned.

SK6:

Stray (disarticulated) remains were located including an arm and rib, these were denoted as being SK6. Further into the cliff (to the West) a pelvis was found (SK7). Further bones were soon recovered – resulting in a more complete skeleton. Traces of coffin wood was seen.

SK7: A single Os Coxa was recovered close to (and to the west of) SK6

SK8: A clear coffin outline was seen at the interface of our Areas 2 and 3 (so-called 'swim lanes'). This coffin was carefully exposed for photography and laser-scanning before investigating elements within it. It was seen on cleaning to in fact be two stacked coffins in poor condition. The lower held the remains of an individual denoted as SK8, the upper another individual taken as SK12. The lid of the lower coffin had been pushed down into the earlier burial by the over-pressure and this decayed wood lay directly upon the bones of SK8. Iron coffin nails present on either side of both coffins. The coffin fill was sandy grey gritty soil with high numbers of water-worn pebble inclusion. Both burials were E-W aligned and extended/supine with the skull of SK8 at the West end. SK12 remains unexcavated but will presumably erode by 2021.

SK9: Single rib and two disarticulated vertebrae.

SK10: Single Tibia located in the area that had held the drystone wall seen in 2019 (holding BI19 SK4, BI19 SK5) which had subsequently collapsed and eroded to the foreshore. Aligned N-S and along with SK5 corroborated feelings that earlier burials had been disturbed by the insertion of later coffins – with the earlier remains then forming part of the grave backfill. There were further elements of drystone walling here adding credence to feeling that this structure had formed some sort of revetting to this part of the cemetery.

SK11: Another intact coffin base (foot end) was located at the end of the fieldwork week to the northern end of the site. Some toe bones were visible and were recovered as SK11 as they were loose. The intention is to recover the rest of the burial in 2021. Presumed E-W orientation and extended/supine with skull at West end.

SK12: On cleaning the coffin which held SK8 it was clear that a second coffin was present above it, pressing down onto the initial burial. Whilst this could clearly be seen to still contain remains, they remained unexcavated partly for reasons of time, partly as they were still lodged firmly – the feet having already eroded away. This burial was denoted as SK12 and was marked as a target for any recovery fieldwork in 2021. Presumed E-W orientation and extended/supine with skull at West end.

2 Finds

There were iron nails and fittings embedded in several of the coffins (which in 2017 were analysed as being of elm wood), and in 2020 a couple of copper alloy nails were also found still embedded in coffins. These were however only retained as proof of presence - not given small find numbers. No other *in-situ* small finds were made. No Illustrations.

3 Human Remains

By David Errickson

Anthropological Examination of Rat Island Skeletons, 2020.

Information and Introduction

This report outlines the anthropological analysis, isotopic sampling, and C14 dating that was undertaken on the human skeletal remains recovered from Rat Island in August 2020. This was under the direction of Richard Osgood, in collaboration with Breaking Ground Heritage and Cranfield Forensic Institute. The human remains were ethically recovered, and transported back to Cranfield's Forensic Institute, Cranfield University, Milton Keynes, where the anthropological examination was undertaken. Isotopic analysis was undertaken at Durham University under the direction of Joanne Moore, and C14 was acquired from Oxford's Radiocarbon Dating Laboratory.

Anthropological Examination

The anthropological analysis was undertaken at Cranfield Forensic Institute, Cranfield University, Milton Keynes. Dr David Errickson wrote this report and was assisted by the results obtained by Tooba Siddiqui, an MSc student at Cranfield University. The anthropological examination is outlined below and where possible information is provided on the sex, stature, and age-at-death. Likewise, any skeletal anomalies or pathological conditions were also recorded.

The anthropological methods employed are well accepted standards within the physical / forensic anthropological community and employed internationally. The methods are outlined below:

- The examination was carried out following guidelines established by Buikstra and Ubelaker (1994), Brickley and McKinley (2004) and Mitchell and Brickley (2017). Bone weathering followed the 2004 scales from 0 to 5+ by J. McKinley (see Brickley and McKinley 2004).

- Where possible, the estimation of age-at-death included assessing the stage of skeletal and dental maturity (Scheuer and Black, 2000). In addition, the morphology (shape) of the sternal end of the right fourth rib where possible (İşcan et al., 1984, 1985) and the auricular surface (Lovejoy et al., 1985; Buckberry and Chamberlain, 2002) of the pelvis were also employed where possible. One of the most reliable indicators, the pubic symphysis (Suchey-Brooks method; Brooks and Suchey, 1990;

Suchey and Katz, 1998), was also employed. A note on cranial suture closure and degenerative joint disease was also made although these indicators only serve as complementary methods to the others.

- Estimation of biological sex was based on the morphology (shape) of the pelvis and the skull, complemented by post-cranial measurements. This estimation was based with reference to the criteria in Buikstra and Ubelaker (1994) and Bass (1995).

- Stature was obtained where possible by applying long bone measurements to the 'White Male' formulae devised by Trotter and Gleser (Trotter,1970). Wherever possible, the femur was the preferred bone to be measured.

- Remains were excavated and analysed with all due respect and dignity and taking into account a number of ethical issues surrounding the excavation, analysis, retention and publication of human remains.

The Burials

The fieldwork for 2020 yielded three articulated human remains. These were labelled SK1, SK4, and SK6. In addition to these, several disassociated bones were recovered and given individual numbers respectively. These were SK3, SK5, SK7, SK8, SK9, SK10 and unstratified individuals labelled as U/S. Most unstratified individuals were recovered from the shoreline and were not in context. Furthermore, partial remains that were articulated were recovered or exposed, however these were not fully excavated due to time constraints and are scheduled for 2021. The elements that were recovered or exposed were labelled as SK11 and SK12. Finally, in 2020, skeletal elements were assigned to SK2, however this individual was largely recovered in 2019. These elements were reassociated with the body of BI19-SK6.

Fully Articulated Burials

SK1

Skeleton 1 was located in 2019, but not threatened at that time by coastal erosion. Upon evaluation in 2020, it was determined that this individual should be excavated due to the imminent threat to the remains. SK1 was East-West aligned and located in area 1. The skeletal remains were laser scanned *in situ* prior to their recovery.

Although the skeletal elements that were recovered were in good condition, some weathering and taphonomy change can be observed on the bone's surface (classification of Grade 1). The recovered bone elements from this individual comprise between 50% - 75% of the skeleton. Primarily, the lower limbs, some ribs, parts of the cranium and the upper vertebrae are missing. Four metatarsals were recovered that were 'associated to SK1', however upon anthropological analysis, the taphonomic staining is very different on these bones and therefore were subsequently disassociated.

There were no duplication of bones and no inconsistencies with age or sex that may suggest more than one minimum number of individuals. The individual was male, as assessed by the pelvic traits that could be observed, and the metric and visual assessments made on the humerus, cranium and mandible supported this also. The estimated age-at-death of the individual was between 25 and 35 years based primarily on skeletal maturation – S1 was unfused. Unfortunately, some useful skeletal elements for estimating age-at-death were not present. Using the left humerus, stature calculations were observed as, white male 171.47 +/- 4.05, or black male 169.03 +/- 4.43. Ancestry was not assessed.

There was no observable degenerative joint disease and no infectious disease present (with exception to dental caries). Some lipping was observed on the posterior aspect of the sacrum which could be attributed to activity. Pitting was present on the cranium; however, this is taphonomic in nature.

Most of the damage present on the skeleton appears to be post-mortem. The M2 from the left side of the mandible was submitted for isotopic analysis and one rib fragment was submitted for C14 dating.

SK4

SK4 was located in area 4. Although the skeletal elements recovered were in good condition, weathering and some taphonomic change can be observed on the bone's surface (classification of Grade 1). The recovered bone elements from this individual comprised between 50%- 75% completeness. Like SK1, the lower limbs of this individual were not present (femora – foot phalanx), and in this case, no right-hand bones were present, and from the left hand only six carpals and two metacarpals were present.

The individual was assessed as probable male overall, and all bones appear to be from the same individual except one os coxa. Three os coxa were associated with this individual, however using anthropological visual pair matching, and observing the stage of fusion on the iliac crest, one os coxa was able to be eliminated and assigned a new skeleton number (SK7). The estimated age-at-death of this individual was between 35-55. This was based upon the pubic symphysis, cranial suture closure, the clavicle, and the overall development of the skeleton. Using the right radius, stature calculations were made at 175.02 +/- 4.32 for a white male, or 168.43 +/- 4.30 for a black male. Ancestry was not assessed.

On the orbital roof, porosities can be observed and attributed to Cribra Orbitalia. There is also some osteophytosis (lipping) on the articular facers of some vertebrae, as well as the posterior aspect of the sacrum. Finally, a lytic lesion can be observed on a vertebral body – possibly an aneurysmal bone cyst.

Fig 7: The lytic lesion

Bone remodelling can be observed on the ribs, indicative of a traumatic incident earlier in life that has since healed. In addition, there is some woven bone on the long bones – specifically the radius. Further discussion on this is placed under 'health' below.

Most of the damage present on the skeleton appears to be post-mortem. The 2nd pre-molar from the left maxilla was submitted for isotopic analysis and one rib fragment was submitted for C14 dating.

SK6

SK6 was recovered from area 2. SK6 was in very good condition with most of the skeletal elements present (classification of Grade 1). The recovered bone elements from this individual comprised of >75% completeness. Only the cranium for this individual was not present.

The individual was assessed as possible male overall, and all bones appear to be from the same individual exception an additional foot bone. However, using anthropological visual pair matching one of these was eliminated and placed as unstratified human skeletal material. The estimated age-at-death for this individual was 18-25 years. This was based upon the skeletal maturation of the individual (specifically on the pelvic girdle), and tooth eruption.

Using the right femur (43.5cm), stature calculations were made at 164.94 +/- 3.27 for a white male, or 162.14 +/- 3.94 for a black male. Ancestry was not assessed.

Fig 8: Early age-at-death assessment for Skeleton 6

There was no observable degenerative joint disease. There was evident pathological presence of Schmorl's Nodes on three vertebrae (L1-L3) and lipping to the posterior aspect of the sacrum. Interestingly, woven bone was prevalent on the distal ends of both tibiae, fibulae, the shaft of both femora, the distal ends of the ulnae and radius, and both sustentaculum tali that is located on the calcaneus. For further discussion on these lesions please refer to the section on 'heath' below.

Fig 9: Woven bone observed on the distal femur highlighted by the arrow.

No cranium was associated with this individual, and thus no maxillary teeth. On the mandible, there were four incisors, two canines, four premolars and two molars. None of the other teeth were lost post-mortem, and the mandible exhibited signs of ante-mortem tooth loss where teeth were not present.

Very little post-mortem damage is present as the skeleton was well excavated. The left 2nd premolar from the mandible was submitted for isotopic analysis and one rib fragment was submitted for C14 dating.

Disarticulated Skeletons and Individual Skeletal Elements

SK3

SK3 was recovered from area 3. This was an isolated right femur. There is some woven bone at the distal end, however no further information can be attained from this single bone.

SK5

SK5 is an isolated left tibia. This was in north-south alignment. No other specific characteristics can be attained from this single skeletal element.

SK7

SK7 was mistakenly attributed to SK 4. It is a single os coxa and it is extremely unfortunate that this is the only skeletal element currently located from this individual as the os coxa is unusually flat. No further information can be obtained from this bone.

SK8

SK8 was recovered from area 3. This was an assortment of bones and included the distal end of a right femur, a clavicle, several ribs, a single proximal hand phalanx, and a fragment of a scapula.

SK9

SK9 is a single isolated right rib and two vertebral bodies. These were recovered from area 3 / 4 but are un-associated to any other individuals.

SK10

SK10 is a single isolated right tibia.

Unstratified Remains

Two thoracic vertebrae and several animal bones were recovered from the surface of area 2. Likewise, several animal bones and human ribs fragments were recovered from across the shoreline.

SK11

SK11 is to be recovered in 2021. SK 11 was from area 4 and is located within a coffin. A full set of both left and right feet with the exception to several distal phalanx was recovered. Further, an additional fragmented ulna was recovered also, however it is apparent from the taphonomic staining of this bone that it does not belong to SK8. Therefore, this was placed as an unstratified skeletal element. There are no unusual features associated with these bones.

SK12

Another skeleton (SK12) was found towards the end of the excavation. The distal ends of the tibiae and fibulae were uncovered and photographed; however, no recovery was undertaken.

Discussion

A total of twelve individuals were identified, however the number is much larger due to the unstratified, and un-associated remains found on the foreshore. In 2020, all remains were either probable or possible males where sex estimation could be undertaken. Likewise, age-at-death estimation gave a small range of young adults for all individuals – between 25 and 55 years old. For a summary of the skeletal elements recovered, please refer to the table below.

Table 1. An overview of the articulated skeletal remains.

Burial Area No.	% Complete	Sex	Age	Height	Comments
SK1 Area 1	50% - 75%	Male, Possible Male	25 - 35	171.474 +/- 4.05	None
SK4 Area 4	50% - 75%	Male, Probable Male	35 - 55	175.022 +/- 4.3	Cribra Orbitalia, lytic lesions on vertebrae
SK6 Area 2	> 75%	Male, Possible Male	18 - 25	164.94 +/- 3.27	Schmorls nodes, woven bone

Discussion on Pathological Conditions and Anomalies

Some pathological changes were observed on Skeleton 6. Much of this was woven bone, a formation of new bone, which is initially bone that is laid down in response to illness or injury. The presence of woven bone on the skeleton indicated that the person was suffering from something that was active at the time of death. In appearance, woven bone is disorganised, porous, and looks brown or grey against the bone's surface. This typically sits atop the bone's surface as a plaque like formation.

For people, Vitamin C is obtained by eating fresh fruit and vegetables, and for those who do not eat enough Vitamin C for substantial periods of time will develop scurvy. This is a condition associated historically with long sea voyages (Cafell 2016).

The locations associated with woven bone on Skeleton 6 are consistent with metabolic deficiency, most likely vitamin c deficiency commonly known as scurvy. The distribution of lesions is consistent with known areas of inflammation associated with Vic C def. This is due to Vit C def causing haemorrhaging which results in inflammation, and thus periosteal new bone formation. This is perhaps particularly pertinent given our suspicion that these were sea fearing individuals, possibly of low status, and an amalgamation of factors including long sea voyages, lack of fresh fruit and veg (or other vit c containing food stuffs), as well as perhaps a long-standing poor diet.

On skeleton 4, cribra orbitalia was identified on the orbital roof. Although this is currently being debated, this pathological condition has to date primarily been associated with iron deficiency and anaemia. However, current discussion suggests that cribra may be a result of further metabolic changes or deficiency.

From two of the skeletons recovered, although further scientific analysis is recommended, it could be argued that the individuals from Rat Island were not getting the required nutrients needed to maintain the health of their skeleton. Given our suspicion that these individuals are military personnel, the health may have been further compounded if these indeed these then became pow, and nutrition was withheld as a result.

Carbon Dating

Carbon dating has been undertaken by Oxford's Radiocarbon Dating Laboratory. In total, twelve samples were taken for radiocarbon dating, however due to the availability of adequate skeletal elements (rib fragments), samples were acquired from additional recovery years.

Table 2: Summary of the C14 dates.

Sample Number	Skeleton Number	Associated Year	Date	Calibrated Date (Likelihood as a %)
Sample 1	Skeleton 1	2020	184 ± 15 BP	1664-1686 (19.7%) 1732-1785 (50.7%) 1793-1805 (8.1%) 1927- (16.9%)
Sample 2	Skeleton 2 / Skeleton 6	2020 / 2019	181 ± 15 BP	1664-1688 (19.2%) 1730-1785 (49.6%)

				1793-1807 (8.4%) 1925- (18.2%)
Sample 3	Skeleton 2	2019	125 ± 15 BP	1686 – 1733 (23%) 1805 – 1928 (72.5%)
Sample 4	Skeleton 4	2020	177 ± 16 BP	1665-1690 (18.4%) 1728-1785 (48.0%) 1793-1809 (8.9%) 1922- (20.1%)
Sample 5	Skeleton 4	2019	166 ± 15 BP	1666-1695 (18.0%) 1725-1784 (44.8%) 1794-1813 (10.3%) 1916- (22.5%)
Sample 6	Skeleton 6 / Skeleton 10	2020 / 2019	185 ± 16 BP	1662 – 1687 (20.2%) 1731 – 1806 (58.8%) 1926 – (16.5%)
Sample 7	Skeleton 7	2020	193 ± 17 BP	1660 – 1685 (22.5%) 1733 – 1805 (60.1%) 1927 – (12.8%)
Sample 8	U/S Area 3	2020	239 ± 17 BP	1641 – 1669 (65.9%) 1781 – 1798 (29.6%)
Sample 9	Skeleton 9	2020	157 ± 17 BP	1668 – 1697 (16.4%) 1723 – 1781 (35.7%) 1796 – 1814 (10.5%) 1837 – 1879 (10.7%) 1914 – (22.2%)
Sample 10	Skeleton 8	2020	176 ± 17 BP	1665 – 1691 (18.5%) 1727 – 1785 (47.4%) 1792 – 1809 (9.2%) 1921 – (20.3%)
Sample 11	U/S - Area 3	2020	219 ± 17 BP	1645 – 1680 (42.2%) 1741 – 1753 (3.5%) 1762 – 1800 (49.1%) 1940 (0.7%)
Sample 12	U/S – Shoreline	2020	TBC	TBC

The skeletons recovered from Rat Island have often been associated to the Napoleonic Wars. Analysing the C14 data, it is demonstrated that there is a large date range associated with most skeletal samples. The highest probability for dating lies with Skeleton 2 from 2019 with a 72% likelihood that it dates between 1805 and 1928. As the Napoleonic Wars is attributed to 1803 – 1815, this date supports the initial hypothesis. Nevertheless, samples from area 3 (Sample 8 and Sample 11) give almost a 95% likelihood that some individuals date between 1641 – 1800, thus pre-dating the Napoleonic Wars. Interestingly, the three articulated individuals from 2020 also may pre-date the Napoleonic Wars: SK1 (77% likelihood to date

1664 - 1805), SK4 (74% likelihood to date 1665 - 1809) and SK6 (78% likelihood to date 1662 - 1813) however, these dates do encompass the beginning or some of the Napoleonic Wars and therefore may suggest that they died as a prisoner of war.

Nevertheless, caution must be sought when ascertaining a date for these individuals, and it could be argued that the site of Rat Island was a burial ground long before the Napoleonic Wars but was in continuous use until the first half of the 19th century.

AIPRL

Archaeological Isotope and Peptide Research Laboratory

Isotopic Analysis:

Specialist Report: Multi isotope analysis of three individuals from Burrow (Rat) Island, Portsmouth.

November 2021

Report and interpretation written by:

Joanna Moore[1] and Janet Montgomery[1]

Data measurements by:

Geoff Nowell[2], Chris Ottley[2], Darren Grocke[3], Steven Brookes[4]

[1]AIPRL, Archaeology Department, Durham University, DH1 3LE

[2]Arthur Holmes Laboratory, Earth Sciences, Durham University DH1 3LE

[3]SIBL, Archaeology Department, Durham University, DH1 3LE

[4]ISO Analytical Ltd, The Quantum, Marshfield Bank Business Park, Crewe, CW2 8UY

Summary

Prepared for

Dr. Dave Erikkson
Cranfield Forensic Institute
Cranfield University
College Road
Cranfield
MK43 0AL

Prepared by

AIPRL
Department of Archaeology
Durham University
South Road
Durham
DH1 3LE

Summary

This report presents the results of an isotopic study into the diet and mobility of three individuals from Burrow (Rat) Island, Portsmouth. The carbon and nitrogen isotope data suggests a predominantly terrestrial C_3 diet with the inclusion of a small amount of marine protein, which is consistent with other 19th century populations from southern England. The strontium, oxygen and lead isotope characteristics seen in the three individuals from Burrow Island are largely consistent with a childhood spent in Britain; however, these values are not unique and can be found in other regions of Europe such as France.

***Note:** The isotope background sections of this report are based on a template adjusted to suit the specifics of this particular project. Much of the wording is therefore reproduced for other projects. These sections are therefore suitable for unpublished and general reporting but may require omission or adjustment for full publication*

1. Introduction

This report presents the results of multi-isotope analysis of three 19th century individuals recovered from Burrow (Rat) Island, Portsmouth. Teeth and rib fragments from three inhumation burials were analysed for lead, strontium, oxygen, carbon, and nitrogen isotopes to reconstruct diet and childhood mobility. The results have been interpreted and discussed in context with previously published data from contemporaneous burials.

Dietary Reconstruction

2.1 Carbon and nitrogen stable isotope analysis

Isotopic analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) is a well-established technique for the reconstruction of diets in past populations using archaeological teeth and bones (DeNiro and Epstein, 1978; Schoeninger et al., 1983; Kohn, 1999; Richards et al., 2006). Within these two tissue types, collagen is the predominant protein present and provides a rich source of averaged $\delta^{13}C$ and $\delta^{15}N$ values. The composition of these $\delta^{13}C$ and $\delta^{15}N$ values reflect the isotopic composition of the foods consumed during the tissue's formation. This is due to the metabolism and reuse of dietary proteins acquired from the plant and animal products consumed during collagen synthesis. Therefore, once metabolic fractionation has been accounted for, these $\delta^{13}C$ and $\delta^{15}N$ values can be used to garner insights into not only the types and quantities of food resources utilised by a population, but also the socioeconomic and cultural influences surrounding the dietary practices of groups as well as individuals.

The variations that arise in $\delta^{13}C$ values result from differences in ecosystems (marine vs. terrestrial) and the photosynthetic pathways (C_3 and C_4) used by plants in their manufacture of carbohydrates (Lee-Thorp, 2008; Mays and Beavan, 2012). As such, variations in $\delta^{13}C$ values allows differentiation between the relative contribution of C_3 or C_4 plants and the animal products based on these plants, to diet (Ambrose et al., 1997; Camin et al., 2008; Beaumont et al., 2013). In temperate regions, such as Britain, plants tend to use the C_3 pathway. Therefore, isotopic evidence of dietary proteins based on C_4 plants (e.g. maize or millet) not native to Britain, would suggest a foreign influence on diet within a British population.

Variability in $\delta^{15}N$ values reflects the balance between biological nitrogen fixation, biosphere recycling and nitrogen release (Robinson, 2001). This variability facilitates the visualisation of terrestrial and marine food source input into diet as marine based food sources tend to be more enriched in ^{15}N than land-based food sources. In addition to this, $\delta^{15}N$ values also vary with trophic level due to metabolic fractionation, creating a 2–6 ‰ enrichment with every trophic level shift (Schoeninger and DeNiro, 1984). This shift is most noticeable in marine food consumers as aquatic food sources have high $\delta^{15}N$ values owing to the relatively long food chains compared to those observed in terrestrial food sources (Tykot, 2004). Combining the analyses of $\delta^{13}C$ and $\delta^{15}N$ values can facilitate the interpretation of plant, animal and marine protein contributions to past diets. This allows distinctions to be made between broad categories of food groups, such as herbivore vs. carnivore or marine vs. terrestrial input and any potentially non-local influence on diet (Ambrose and Katzenberg, 2000).

2.2 Materials and methods

Bone and dentine samples were collected from each individual and cleaned and abraded to a depth of >100µm using a tungsten carbide dental drill. Collagen extraction was carried out using O'Connell and Hedges (1999) method, briefly summarised here: bone and dentine samples (c. 200mg) were demineralised in refrigerated 0.5M HCl for several weeks and then thoroughly washed in Millipore Alpha Q (MQ) water before gelatinisation in a pH 3 solution of HCl at 70°C for 48 hours. The samples were then filtered, frozen and freeze-dried before being weighed into tin capsules and analysed in duplicate using a Thermo Scientific Delta V

Advantage isotope ratio mass spectrometer in the Stable Isotope Biogeochemistry Laboratory (SIBL), Durham University. Calibration using internal reference samples (e.g., Glutamic Acid, Glycine, SPAR and Urea) and international reference standards (e.g., USGS 24, USGS 40, IAEA 600, IAEA N1, IAEA N2) determined a standard deviation of ±0.1‰ (1σ) for collagen carbon and nitrogen isotopes. Replicate analysis of collagen samples averaged a standard deviation of ±0.2‰ (1σ).

2.3 Results and interpretation

The $\delta^{13}C$ and $\delta^{15}N$ data from the dentine and rib samples are presented in Table 1 and Figures 1 and 2. The $\delta^{13}C$ and $\delta^{15}N$ data from the permanent 2nd premolar represent the dietary protein consumed between the ages of 3.5 to 11.5 years, while the rib data represent an average of the diet consumed during approximately the last 5 years before death. The mean $\delta^{13}C$ and $\delta^{15}N$ values from the Burrow Island individual's collagen samples are presented in Figure 1, together with published human and faunal data from other post-medieval populations in southern England (Roberts et al., 2012; Dhaliwal et al., 2020). The results show that the Burrow Island individuals had long-term diets predominantly based on mixed terrestrial C_3 resources with a minor marine food contribution. The $\delta^{13}C$ enamel data (see section 3.2 below) which represents whole diet supports this interpretation of a predominantly C_3 terrestrial based diet. All three Burrow Island individuals exhibit a trophic level shift from the comparative faunal baseline, with a mean increase of $\delta^{13}C$ and $\delta^{15}N$ values of 2.4‰ and 5‰ respectively. This indicates that the Burrow Island individuals were also eating animal protein (meat, cheese, milk etc) and marine protein (e.g., fish, seabirds, seabird eggs, marine mammals). This diet is consistent with other 19th century populations from the south coast of England (see Fig. 1).

Incremental dentine profiles for the Burrow Island individuals are presented in Figure 2. The incremental dentine from SK1's permanent 2nd molar exhibits very little variation in $\delta^{13}C$ with less than 0.5‰ change in values throughout the formation of the tooth. Apart from the period between approximately 3 and 5 years of age, SK1's dentine profile remains relatively flat and consistent with the $\delta^{13}C$ and $\delta^{15}N$ values from their rib, indicating a stable childhood and adulthood diet. SK2 shows more variation in their dentine profile with what appears to be with two dietary shifts. The first begins around the age of 5 years, here a concurrent increase in $\delta^{13}C$ and $\delta^{15}N$ values indicates a period of increased marine protein consumption. This individuals' diet then reverts to one predominantly based on terrestrial C_3 protein, evident by the concurrent decrease in $\delta^{13}C$ and $\delta^{15}N$ values from the age of 7 years. From the age of ~10.5 years SK2 exhibits an increase in $\delta^{15}N$ values and a co-occurring decrease in $\delta^{13}C$

values, this type of opposing covariance is likely to be an indication of physiological or nutritional stress. Finally, the dentine profile from the 2nd premolar of SK4 reveals a wealth of information about the early life of this individual. There is a decrease in $\delta^{15}N$ values from the age of 4.5 to 5 years; this is thought to be a sign of physiological growth, as it occurs around the time of an early childhood growth spurt (Kendall et al., 2021; Tanner, 1988). This individual also shows signs of two periods of physiological or nutritional stress, with increasing $\delta^{15}N$ values rise alongside corresponding decreases in $\delta^{13}C$ values between the ages of 5 – 6.5 years and again from the age of 11 years.

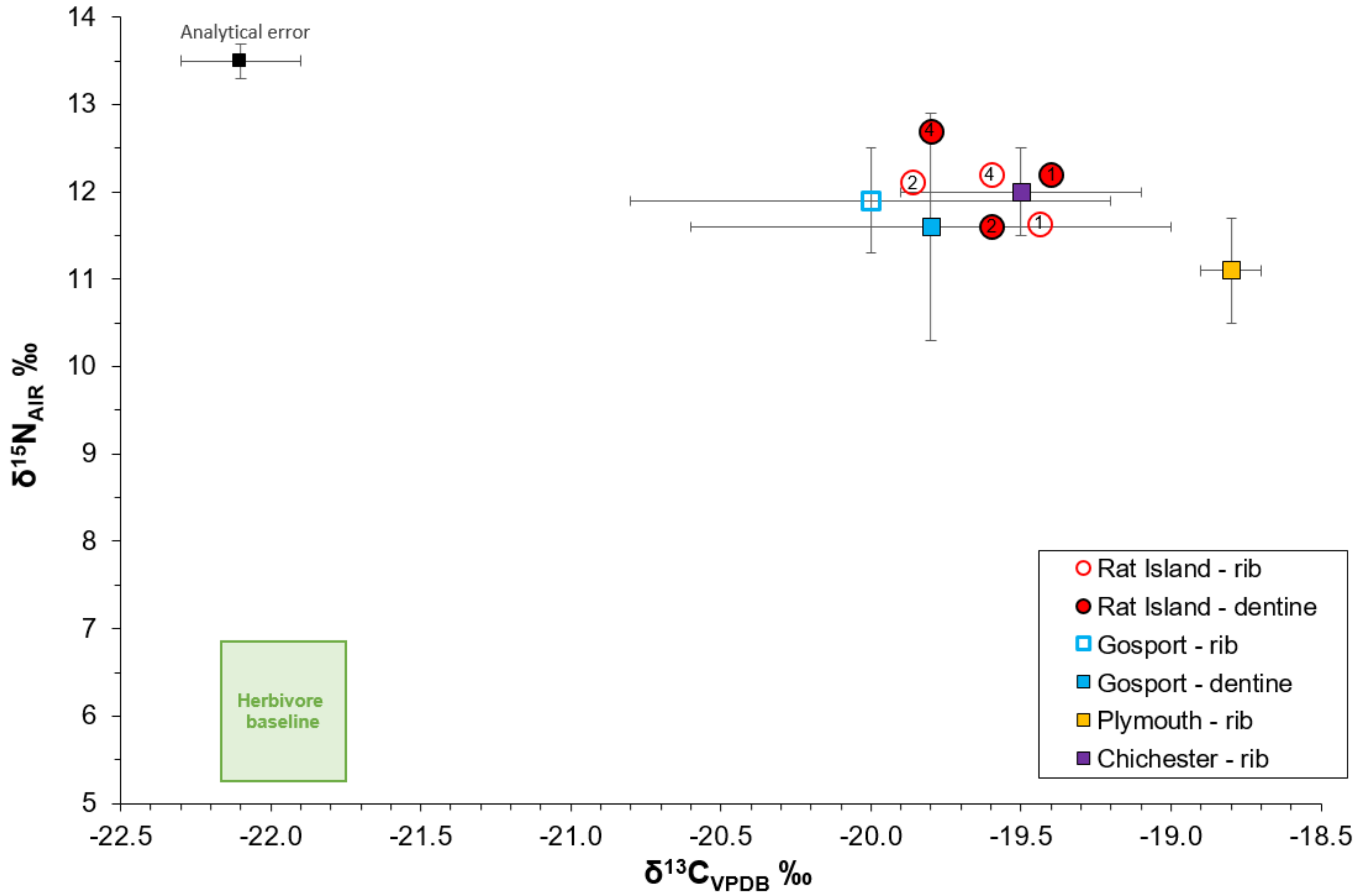


Figure 1 – Burrow (Rat) Island $\delta^{13}C$ and $\delta^{15}N$ data shown alongside published comparative human and animal data from Sussex. Published data from Roberts et al., 2012 (Gosport and Plymouth), and Dhaliwal et al., 2020 (Chichester and herbivore baseline). Analytical error is shown to 2 sd.

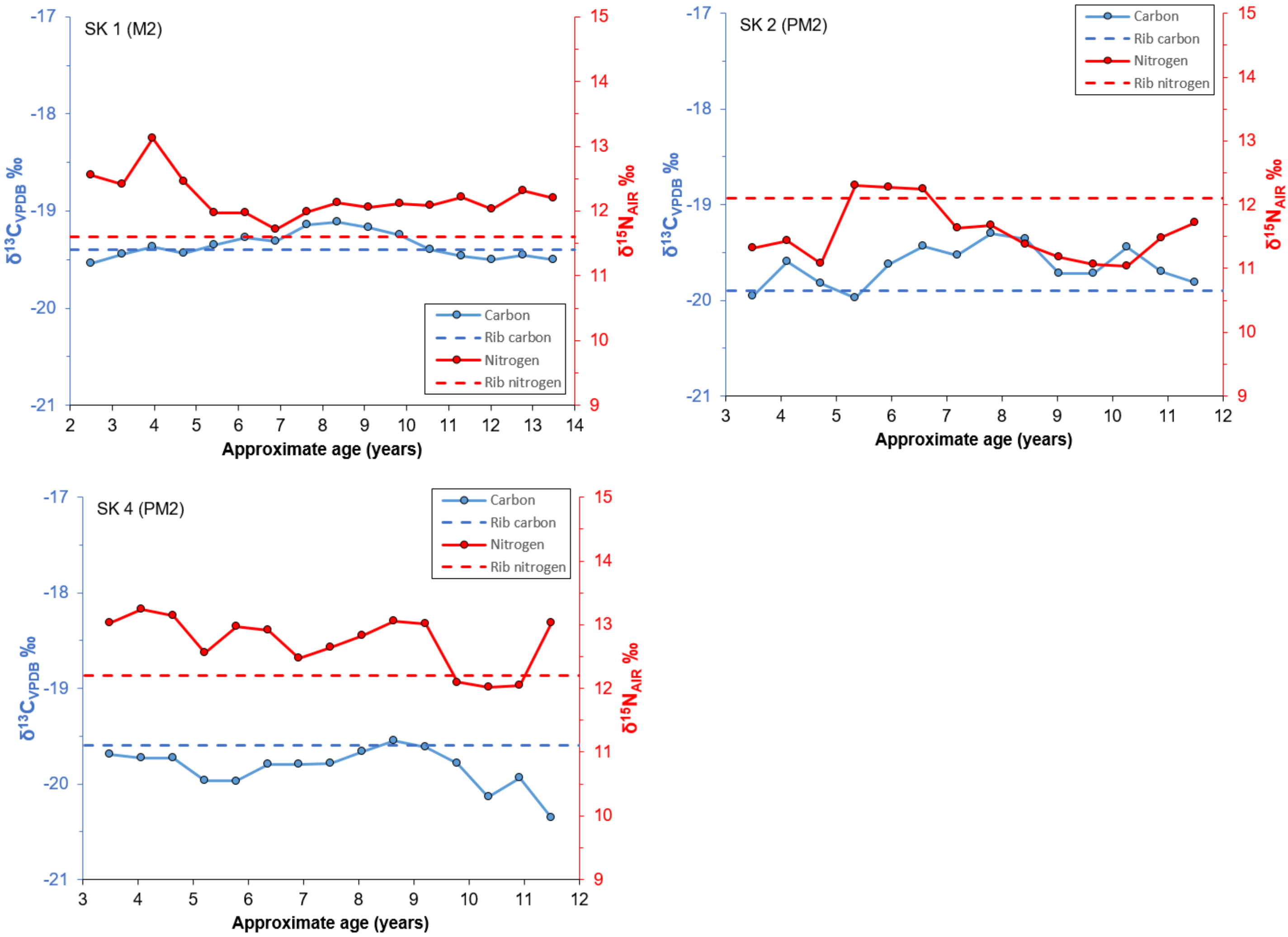


Figure 2 – Incremental dentine $\delta^{13}C$ and $\delta^{15}N$ data plotted against age in years. The dashed blue and red straight lines across the plots indicate the individuals average $\delta^{13}C$ and $\delta^{15}N$ values obtained from their bone collagen.

Table 1 – Mean $\delta^{13}C$ and $\delta^{15}N$ data from incremental analysis of dentine collagen and bulk rib collagen.

Skeleton	Dentine		Bone	
	$\delta^{15}N_{AIR}$ (‰)	$\delta^{13}C_{V\text{-}PDB}$ (‰)	$\delta^{15}N_{AIR}$ (‰)	$\delta^{13}C_{V\text{-}PDB}$ (‰)
SK 1	12.2	-19.4	11.6	-19.4
SK 2	11.6	-19.6	12.1	-19.9
SK 4	12.7	-19.8	12.2	-19.6

3. Assessing Geographical Origins

3.1 Strontium isotope analysis

The isotope analyses of strontium ($^{87}Sr/^{86}Sr$) can provide information on the movements of past populations by identifying individuals who have different isotopic compositions to the geographic area in which they were found (Evans et al., 2012). Strontium isotopes can provide a direct link between an individual and their geographic origin as they are ultimately derived from the local geology. The strontium isotope ($^{87}Sr/^{86}Sr$) characteristics of plants and local animals in different regions vary depending on the relative contributions of strontium from different underlying rocks and the presence or absence of superficial drift deposits (Bentley, 2006). Strontium is released into the environment through weathering and dissolution processes into the overlying soils, plants and animals (Bentley, 2006). Strontium becomes incorporated into the hydroxyapatite lattice of human bone through ingestion of food and water (Montgomery, 2010). Assuming that the majority of a population's food and drink is sourced locally, the strontium isotope composition in human skeletal material should then reflect the bioavailable strontium isotope ratios in their region of origin (Montgomery 2010; Montgomery et al., 2007).

3.1.1 Materials and methods

Core enamel samples (c. 10 mg) were prepared for strontium isotope analysis using column chemistry methods outlined in Font et al. (2008) at the Arthur Holmes Isotope Geology

Laboratory (AHIGL), Durham University. In brief, samples were digested overnight in 3M HNO_3 on a hotplate at 100°C before being loaded onto cleaned and preconditioned columns containing Eichrom strontium-specific resin. A purified Sr fraction was eluted from the column in 400μL H_2O and acidified with 15.5M HNO_3 to yield a 3% HNO_3 solution.

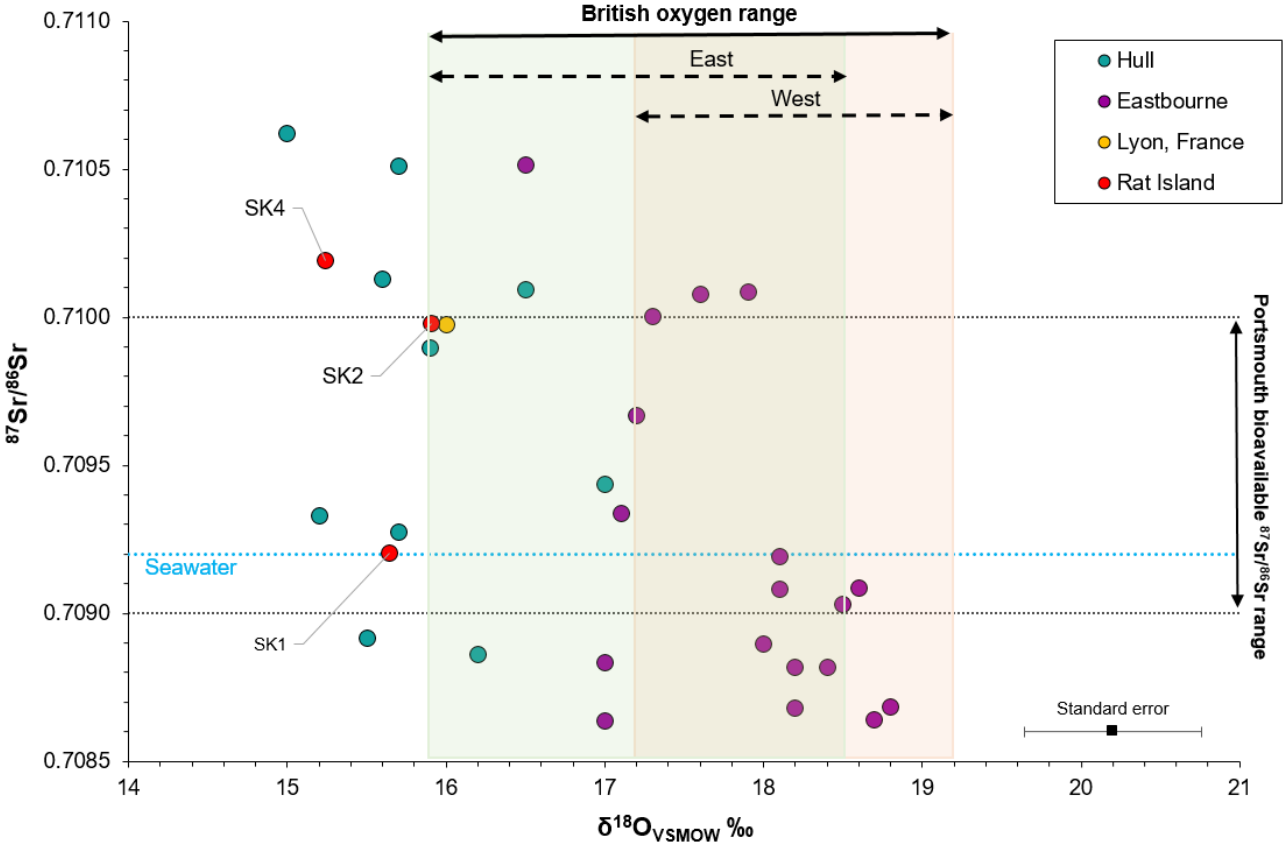
Following Sr purification, the size of the ^{86}Sr beam was tested for each sample to derive a dilution factor so that each sample yielded a beam size of approximately 30V ^{88}Sr to match the intensity of the isotopic reference material, NBS987. Samples were aspirated using an ESI PFA-50 nebuliser coupled to a Glass Expansion Cinnabar micro-cyclonic spraychamber. Sr isotopes were measured using a static multi-collection routine with each measurement comprising a single block of 50 cycles with and integration time of 4s per cycle (total analysis time ~3.5mins). Instrumental mass bias was corrected for using an $^{88}Sr/^{86}Sr$ ratio of 8.375209 (the reciprocal of the more commonly used $^{86}Sr/^{88}Sr$ ratio of 0.1194) and an exponential law. Corrections for isobaric interferences from Rb and Kr on ^{87}Sr and ^{86}Sr were performed using ^{85}Rb and ^{83}Kr as the monitor masses but were insignificant. In all samples the ^{85}Rb intensity was < 1mV with an $^{85}Rb/^{88}Sr$ ratio of < 0.0003 (average 0.0001). ^{83}Kr was between 0.32 and 0.39mV in all samples. . Samples were analysed during a single analytical session during which the average $^{87}Sr/^{86}Sr$ ratio and reproducibility for the international isotope reference material NBS987 was 0.710269 ± 0.000013 (2σ; n=12). Maximum error based on internal precision of individual analysis and analytical reproducibility of the reference material is considered to be 0.000013 (2σ). Sr isotope data for samples is normalised to an 'accepted' value for NBS987 of 0.71024.

3.1.2 Results and interpretation

The Burrow Island individuals' strontium isotope data is presented in Table 2 and Figure 3, alongside comparative data from Sussex and a northern port city (Hughes et al., 2018; Roberts et al., 2012). The strontium isotope ratios from the Burrow Island individuals tooth enamel range from 0.7092 to 0.7102, which is similar to other populations from Sussex and within the range expected for Britain (Evans et al., 2018; Hughes et al., 2018). The strontium concentrations from the same teeth ranged from 53 to 80 ppm, which is typical of archaeological humans from southern Britain (Evans et al., 2012).

Burrow Island is a tidal island in Gosport, West Sussex, the geology of which primarily comprises of Palaeogene sedimentary rocks from the Bracklesham, Thames and Lambeth groups (e.g., clay, gravel, limestone, mudstone, silts, and sandstone) (Hopson, 2010). Regions such as this are estimated to produce bioavailable $^{87}Sr/^{86}Sr$ values between 0.7090 and 0.7100 (Evans et al., 2018). It is expected that people who source the majority of their food and drink from within this region would have $^{87}Sr/^{86}Sr$ values close to this range. As can be seen in Figure 3, two of the Burrow Island individuals (SK1 and SK2) have $^{87}Sr/^{86}Sr$ values consistent with a childhood spent in the local area, however it is important to note that these values are common in humans across Britain and wider Europe. Individual SK4 has a $^{87}Sr/^{86}Sr$ value higher than expected for a childhood spent in southern England, with a value over 0.7100, $^{87}Sr/^{86}Sr$ values like this are more commonly found in regions with older geology, such as western and northern England, Wales and Scotland. Individuals originating from regions of Chalk, such as Eastbourne, would be expected to have $^{87}Sr/^{86}Sr$ values below 0.7092 so these parts of southern England can be excluded as places of origin for the three individuals.

Figure 3 – Burrow (Rat) Island strontium and oxygen isotope data alongside



comparative data from Eastbourne in Sussex (Hughes et al., 2018), Hull (Roberts et al., 2012) and Lyon, France (Moore and Montgomery 2021). The horizontal dotted lines represent the bioavailable strontium isotope range for Portsmouth (Evans et al., 2018). The shaded green and orange boxes represent the 2 sd oxygen isotope range expected for Britain (Evans et al., 2012).

Table 2 – Strontium values from tooth enamel samples from the Burrow (Rat) Island individuals.

Skeleton	Sr ppm	$^{87}Sr/^{86}Sr$	2SE

SK 1	53	0.709205	0.00002
SK 2	73	0.709979	0.000018
SK 4	80	0.710191	0.000015

3.2 Oxygen isotope analysis

Oxygen incorporated into hydroxyapatite is predominantly derived from ingested fluids, the isotopic composition of which fluctuates due to climatic and environmental variables such as temperature, rainfall, altitude and latitude (Darling and Talbot, 2003). Therefore, oxygen isotopes ($\delta^{18}O$) measured in human tissues are an indirect reflection of the local meteoric water composition (Kohn, 1996). Oxygen undergoes metabolic fractionation once ingested. Therefore, regression formulae must be applied to allow comparison with modern drinking water values in order to discern childhood geographical origins and palaeo-climate (Chenery et al., 2012; Fricke et al., 1995). In addition to this, $\delta^{18}O$ values can also be influenced by culturally mediated behaviour. The processing (boiling, brewing etc.) of a significant portion of an individual's drinking water before ingestion can result in higher than expected values, and as such, interpretation must be performed with caution (Brettell et al., 2012; Camin et al., 2008; Daux et al., 2008).

3.2.1 Materials and methods

Samples were transferred to Iso Analytical for stable isotope analysis. Samples were weighed into Exetainer™ tubes and flushed with 99.995% helium. Carbonate in the samples was converted to CO_2 by adding phosphoric acid and letting the samples sit overnight for the reaction to occur. Reference materials (IA-R022, NBS-18, and IA-R066) were prepared along the same methods. CO_2 from the samples was then analysed by Continuous Flow-Isotope Ratio Mass Spectrometry (CF-IRMS). The CO_2 was sampled from the Exetainer™ tubes into a continuously flowing He stream using a double holed needle. The CO_2 was resolved on a packed column gas chromatograph and the resultant chromatographic peak carried forward into the ion source of a Europa Scientific 20-20 IRMS where it was ionized and accelerated. Gas species of different mass were separated in a magnetic field then simultaneously measured using a Faraday cup collector array to measure the isotopomers of CO_2 at m/z 44, 45, and 46. The phosphoric acid used for digestion was prepared in accordance with Coplen et al. (1983) and injected through the septum into the vials. All samples were run in duplicate.

3.2.2 Results and interpretation

The Burrow Island individual's oxygen isotope data is presented in Table 3 and Figure 3 alongside comparative data from Sussex and Hull. The $\delta^{18}O_{VSMOW}$ data for the Burrow Island individuals range from 15.2‰ to 15.9‰, which is on the edge of the range expected for archaeological humans from Britain (Evans et al., 2012). Figure 3 shows the expected oxygen isotope range for Britain in archaeological populations, with the eastern 'low rainfall' range delineated by the green box to the left and the western 'high rainfall' range outlined by the orange box to the right (Evans et al., 2012).

SK1 and SK4 plot outside the expected range for Britain, with oxygen values lower than expected for Britain, although unusual, similarly low oxygen isotope values have been observed in 19th century populations from London and Ireland. However, when the analytical error and large uncertainties associated with oxygen conversion equations are considered only SK4 falls outside the 2 sd range for Britain. Oxygen values can be influenced by a multitude of factors, most environmental and cultural processes which alter the oxygen isotope ratio of water result in higher values than those expected for the local area (Brettell et al., 2012). To obtain such a low value, cold/winter ground or rainwater or rainfall from high altitudes would need to be drunk as their predominant water source. It is more probable that the low oxygen value seen in SK4 is indicative of a childhood spent in a cooler region of Europe or a region with a higher altitude than Britain. Similarly low oxygen values have been observed in archaeological populations from Alpine regions of Europe such as northern Italy and southeast France and regions of Eastern Europe such as Romania (Crowder et al. 2020; Moore and Montgomery, 2021a; Milella et al., 2019; Forlin et al., forthcoming).

Table 3 – Measured carbonate ($\delta^{13}C_{V\text{-}PDB}$ and $\delta^{18}O_{V\text{-}PDB}$) and calculated $\delta^{18}O_{V\text{-}SMOW}$ and drinking water values for the Burrow (Rat) Island enamel samples.

Skeleton	$\delta^{13}C_{V\text{-}PDB}$ carbonate measured (‰)	$\delta^{18}O_{V\text{-}PDB}$ carbonate measured (‰)	$\delta^{18}O_{V\text{-}SMOW}$ carbonate calculated (‰)	$\delta^{18}O_{V\text{-}SMOW}$ phosphate calculated (‰)	$\delta^{18}O_{V\text{-}SMOW}$ precipitation calculated* (‰)
SK 1	-12.7	-6.2	24.5	15.6	-9.6
SK 2	-12.7	-5.9	24.8	15.9	-9.2
SK 4	-12.8	-6.6	24.1	15.2	-10.3

3.3 Lead isotope analysis

In principle the isotope ratios of lead in pre-industrial societies reflect those of the local underlying geology (Erel et al., 1994; Komárek et al., 2008; Montgomery et al., 2000). Societies with metallurgical technologies however tend to exhibit elevated skeletal lead concentrations, which are accompanied by a clustering of lead isotope ratios. These homogenised lead isotope ratios tend to reflect the predominant lead sources available to that particular population (Millard et al., 2014; Montgomery et al., 2010). This 'cultural focusing' shifts skeletal lead isotope ratios away from geogenic lead congruent with geographical provenance, towards isotope ratios converging around the dominant anthropogenic ore sources utilised in a particular cultural sphere (Gulson et al., 1997; Kamenov and Gulson, 2014). These anthropogenic skeletal lead isotope ratios are therefore indicative of socio-cultural provenance (Carlson, 1996; Montgomery et al., 2005) and can be effective in differentiating between cultural groups within skeletal populations, as individuals exposed to foreign lead sources should stand out from those exposed to local lead, making migrants from other countries relatively easy to identify (Montgomery, 2002). Furthermore, lead concentrations in tooth enamel provide a measure of childhood exposure to environmental lead pollution and can offer information beyond simply the extent of an individual's lead burden. Being able to distinguish between geogenic and anthropogenic lead exposure in this way offers insights into the technological capabilities and/or technologies actively utilised by a particular population. It is likely that populations exhibiting geogenic lead isotope ratios did not use lead or lead products to the extent necessary for the acquisition of high, anthropogenic lead concentrations. To date studies utilising lead isotope ratios have shown that human lead burdens below 0.8 ppm in conjunction with non-ore lead isotope ratios appear to represent geogenic lead exposure and values over this are considered anthropogenic (Moore et al., 2020; Shaw et al., 2016; Millard et al., 2014; Montgomery et al., 2010).

3.3.1 Materials and methods

For Pb isotope analysis a purified Pb fraction was eluted from the same Eichrom Sr-specific resin column used to collect the Sr fraction, using 400 µL 8M HCl. The 8M HCl Pb fraction solution was then dried down and taken up in 500 µL 3% HNO_3 for isotope analysis. Thallium was added to each sample in order to correct Pb isotope ratios for the effects of instrumental mass bias. Each Pb sample was tested for Pb concentration and subsequently spiked with a Tl standard to achieve a Pb/Tl ratio of ~12, which simultaneously minimizes the tails from ^{205}Tl onto ^{204}Pb and from ^{206}Pb onto ^{205}Tl. Since the mass bias behaviour of Pb and Tl during MC-ICPMS are very slightly different it is necessary to optimise the ^{205}Tl/^{203}Tl ratio for Thallium in each analytical session to correct for this difference and essentially force the mass bias factor (β) for Tl to equal that for Pb (Tlβ/Pbβ = 1). This was accomplished by adjusting the ^{205}Tl/^{203}Tl to minimise the offset between the measured and accepted Pb isotope ratios for the international isotope reference material NBS981. In our case we use the Pb isotope ratios of

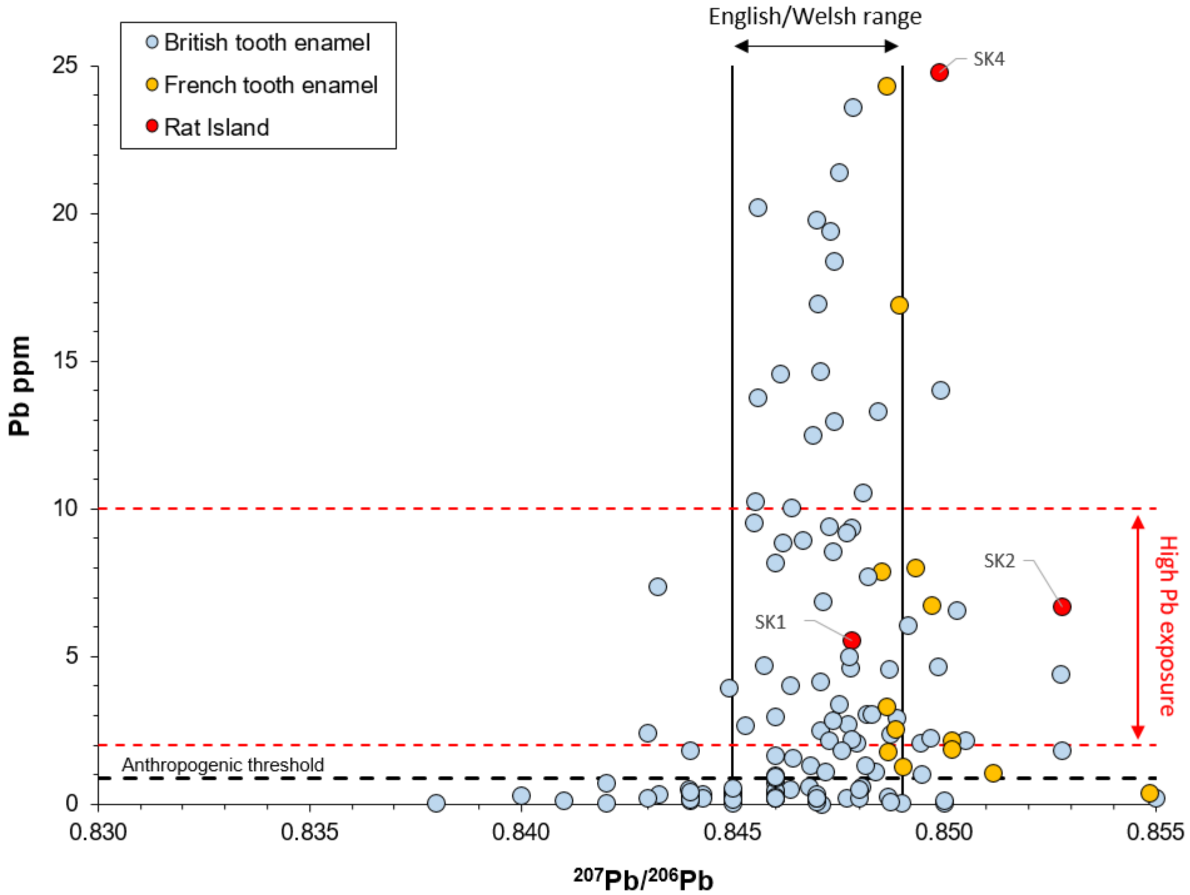
Baker *et al.* (2004) as the accepted values for NBS 981. The optimised $^{205}Tl/^{203}Tl$ ratios are then used to correct the mass bias on each sample Pb ratio. In this session, the optimised $^{205}Tl/^{203}Tl$ ratios used varied between 2.3892 and 2.3896, which, on average, is only slightly higher than the typical ratio used (2.3881-2.3885) but reflects the use of the Cetac Aridus II desolvating nebuliser and X skimmer cone (see below).

Due to the very low Pb concentration of the majority of the samples, we had to employ a high sensitivity sample introduction system comprising an Aridus II desolvating nebuliser and the high sensitivity 'X' skimmer cone. This combination provides an order of magnitude increase in signal size to ~1000V total Pb signal per ppm of Pb in the sample aliquot. As for Sr a typical Pb isotope measurement comprised a static multi-collection routine, with ^{205}Tl in the axial detector, of 1 block of 50 cycles with an integration time of 4 sec per cycle. Nine repeat analyses of the international Pb isotope reference material NBS981 analysed over the course of the analytical session gave the following isotope ratios: $^{206}Pb/^{204}Pb = 16.94162 \pm 0.000475$ (28.0 ppm, 2 sd), $^{207}Pb/^{204}Pb = 15.49992 \pm 0.000505$ (32.6 ppm, 2σ), $^{208}Pb/^{204}Pb = 36.72606 \pm 0.001698$ (46.2 ppm, 2σ), $^{207}Pb/^{206}Pb = 0.91490 \pm 0.000009$ (10.1 ppm, 2σ), $^{208}Pb/^{206}Pb = 2.16781 \pm 0.000076$ (34.9 ppm, 2σ). These are in excellent agreement with accepted values of 16.9416, 15.4999, 36.7258, 0.9149 and 2.16779 from Baker *et al.* (2004).

3.3.2 Results and interpretation

The Burrow Island individuals tooth enamel lead concentrations range from 5.5 to 24.8 ppm, this range is consistent with lead concentrations seen in other 19th century populations from Britain (see Fig. 4). All the Burrow Island individuals have tooth enamel lead concentrations consistent with anthropogenic lead exposure (≥ 0.8 ppm), indicating an early childhood spent in a polluted environment (Millard et al., 2014; Montgomery et al., 2010). Individual SK4 has a significantly higher lead concentration than the other two Burrow Island individuals, with a tooth enamel lead concentration equivalent to a childhood blood lead level of 24.8 µg dL^{-1} *(Grobler et al., 2000).* A study of lead concentrations in modern tooth enamel concluded that lead levels ranging between 2 to 10 ppm signifies high levels of exposure (Gulson and Wilson, 1994). Due to the high lead concentration measured in SK4's tooth enamel, it is possible this individual suffered the ill effects of lead poisoning during childhood (Moore et al., 2021).

Lead isotope ratios tend to form clusters or linear arrays that spread over a wide range of values, meaning that there is often overlap between lead ore fields from different countries. Due to this overlap, which is evident in both tooth enamel and lead ore data (see Fig 5), it is clear that lead isotope ratios are not country specific. Nevertheless, lead isotope ratios can be useful in distinguishing between broad regions of Europe, such as Eastern vs. Western Europe or Atlantic vs. circum-Mediterranean Europe. General trends in European tooth enamel lead isotope ratios have shown to relate to major orogenic events, during which, lead ores are often formed (Moore, 2019; Evans et al., 2018; Blichert-Toft et al., 2016). Individuals from regions with older, Hercynian, Cambrian or Precambrian orogeny (e.g., Britain, France, and Germany) tend to have lower $^{208}Pb/^{206}Pb$ ratios than individuals from regions with younger, Alpine orogeny (e.g., Spain and Italy) (Moore, 2019). Figure 5 clearly demonstrates this trend with the tooth enamel samples from Spain and Italy plotting in a linear array above contemporaneous samples from England and France. Here the lead isotope data for Burrow Island clearly demonstrates these individuals did not spend their early childhood in a region with younger lead ores but are consistent with a childhood spent in France or Britain. SK1 has lead isotope ratios consistent with the English/Welsh anthropogenic range identified by Montgomery et al., (2010), suggesting that SK1 spent their childhood in England or Wales. SK2 and SK4 plot outside this anthropogenic range, with higher $^{207}Pb/^{206}Pb$ values than expected for individuals living in England. High $^{207}Pb/^{206}Pb$ values such as these are more



commonly seen in individuals from Scotland or France.

Figure 4 – Tooth enamel lead concentrations (ppm) against $^{207}Pb/^{206}Pb$ isotope ratios. The black dashed line indicates the threshold for anthropogenic exposure (Millard et

al., 2014) and the range delineated by the red dotted lines indicates the range for high exposure (Gulson and Wilson, 1994). Comparative tooth enamel data from (Moore et al., 2020; Shaw et al., 2016; Millard et al., 2014; and Montgomery et al., 2010; Trickett, 2006, Moore, 2019; Moore and Montgomery 2021).

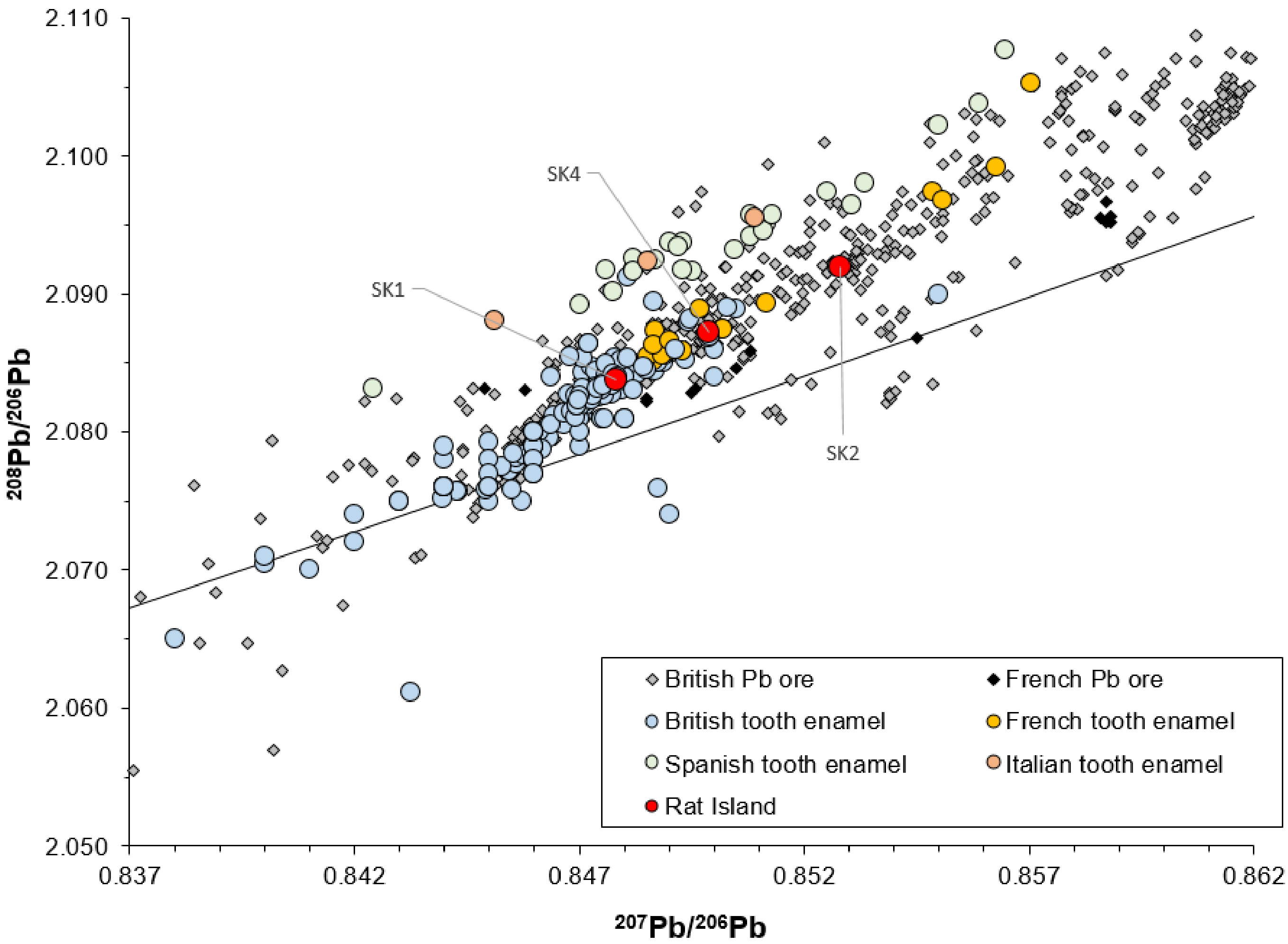


Figure 5 – $^{207}Pb/^{206}Pb$ against $^{208}Pb/^{206}Pb$ showing how tooth enamel samples from England and France group with regional Pb ore. Comparative tooth enamel data from Moore et al., 2020; Shaw et al., 2016; Millard et al, 2014; Montgomery et al., 2010; Trickett, 2006. Lead ore data from Rohl, 1996; Baron et al., 2006; Durali-Mueller et al., 2007 and Butcher and Ponting, 2014. Analytical error is within the symbols

Table 4 – Lead isotope values from tooth enamel samples from the Burrow (Rat) Island individuals.

Skeleton	Pb ppm	$^{206}Pb/^{204}Pb$	2SE	$^{207}Pb/^{204}Pb$	2SE	$^{208}Pb/^{204}Pb$	2SE	$^{207}Pb/^{206}Pb$	2SE	$^{208}Pb/^{206}Pb$	2SE
SK 1	5.5	18.44051	0.00047	15.63409	0.00047	38.42704	0.00140	0.84780	0.00001	2.083806	0.00004
SK 2	6.7	18.33902	0.00036	15.63925	0.00034	38.36463	0.00103	0.85279	0.00001	2.091971	0.00003
SK 4	24.8	18.38229	0.00046	15.62259	0.00046	38.36872	0.00127	0.84987	0.00001	2.087275	0.00002

4 Conclusions

Diet and mobility of three individuals from Burrow Island were investigated using a range of isotopes. All three individuals had isotope characteristics that suggest possible childhood origins in Britain. The carbon and nitrogen isotope values from the ribs of the three individuals indicate an adult diet based predominantly on terrestrial C_3 resources with a minor inclusion of marine protein, which is consistent with other 19th century populations from the south coast of England. Incremental dentine analysis revealed that all three individuals experienced a period of physiological stress around the age of 11 years, which may be associated with increased growth during puberty. The Burrow Island individuals display a relatively wide range of strontium isotope ratios, the values seen in SK1 and SK2 are consistent with a childhood spent in the local area, however it is important to note that these values are common in humans across Britain and wider Europe. Individual SK4 has an $^{87}Sr/^{86}Sr$ value higher than expected for a childhood spent in southern England, with a value more commonly found in regions with older geology, such as western and northern England, Wales, and Scotland. All three individuals exhibit low oxygen isotope values, however when analytical and uncertainty errors associated with oxygen data are considered, SK1 and SK2 have oxygen isotope values that fall within the estimated UK range. SK4 falls outside the 2 sd range for Britain with an oxygen value indicative of a childhood spent in a cooler region of Europe or a region with a higher altitude than Britain, such as Europe such as northern Italy and southeast France. The lead isotope characteristics seen in the three individuals from Burrow Island are consistent with a childhood spent in Britain, however, these values are not unique and can be found in other regions of Europe such as France. The isotope characteristics of SK2 are a good example of this, as can be seen in Fig. 2 SK2 plots closely with an individual from Lyon, France and has lead isotope values that plot within the overlap between British and French lead ores. As such, childhood origins from northeast regions of continental Europe cannot be ruled out, especially when the connections with the prison hulks docked in the nearby harbour, known to house French prisoners of war are considered (Laws, 1950; Vaughan, 1897).

References

Ambrose, S.H., Butler, B.M., Hanson, D.B., Hunter-Anderson, R.L., Krueger, H.W., (1997). Stable isotopic analysis of human diet in the Marianas Archipelago, western Pacific. Am. J. Phys. Anth. 104, 343-361

Ambrose, S., Katzenberg, M.A., (2000). Biogeochemical Approaches to Paleodietary Analysis, Kluwer Academic/Plenum. New York.

Baron, S., Carignan, J., Laurent, S. and Ploquin, A., (2006). Medieval lead making on Mont-Lozère Massif (Cévennes-France): tracing ore sources using Pb isotopes. Applied geochemistry, 21(2), pp.241-252.

Beaumont, J., Geber, J., Powers, N., Wilson, A., Lee-Thorp, J., Montgomery, J., (2013). Victims and survivors: Stable isotopes used to identify migrants from the Great Irish Famine to 19th century London. Am. J. Phys. Anth. 150, 87-98.

Bentley, R.A., (2006). Strontium isotopes from the Earth to the archaeological skeleton: a review. J. Archaeol. Meth. Theory 13, 135–187.

Brettell, R., Montgomery, J., Evans, J., (2012). Brewing and stewing: the effect of culturally mediated behaviour on the oxygen isotope composition of ingested fluids and the implications for human provenance studies. J. Anal. Atom Spectrom. 27, 778-785

Camin, F., Perini, M., Colombari, G., Bontempo, L., Versini, G., (2008). Influence of dietary composition on the carbon, nitrogen, oxygen and hydrogen stable isotope ratios of milk. Rapid Commun. Mass Sp. 22, 1690-1696.

Carlson, A.K., (1996). Lead isotope analysis of human bone for addressing cultural affinity: a case study from Rocky Mountain House, Alberta. J. Archaeol. Sci. 23, 557–567

Chenery, C.A., Pashley, V., Lamb, A.L., Sloane, H.J., Evans, J.A., (2012). The oxygen isotope relationship between the phosphate and structural carbonate fractions of human bioapatite. Rapid Commun. Mass Sp. 26, 309-319.

Coplen, T.B., Kendall, C. and Hopple, J., (1983). Comparison of stable isotope reference samples. *Nature*, *302*(5905), pp.236-238.

Darling, W.G., Talbot, J.C., (2003). The O and H stable isotopic composition of fresh waters in the British Isles: 1. Rainfall. Hydrol. Earth Sci. 7, 163-181.

Daux, V., Lècuyer, C., Hèran, M., Amoit, R., Simon, L., Fourel, F., Martinaeu, F., Lynnerup, N., Richer, H., Escargeul, G., (2008). Oxygen isotope fractionation between human phosphate and water revisited. J. Hum. Evol. 55, 1138-1147

DeNiro, M.J., Epstein, S., (1978). Influence of diet on the distribution of carbon isotopes in animals. Geochem. Cosmochem. Acta. 42, 495-506

Erel, Y., Harlavan, Y., Blum, J.D., (1994). Lead isotope systematics of granitoid weathering. Geochim. Cosmochim. Acta 58, 5299–5306.

Evans, J.A., Chenery, C.A. and Montgomery, J., (2012). A summary of strontium and oxygen isotope variation in archaeological human tooth enamel excavated from Britain. *Journal of Analytical Atomic Spectrometry*, *27*(5), pp.754-764

Evans, J.A., Chenery, C.A., Mee, K., Cartwright, C.E., Lee, K.A., Marchant, A.P., and Hannaford, L. (2018). Biosphere Isotope Domains GB (V1): Interactive Website. British Geological Survey. (Interactive Resource). https://doi.org/10.5285/3b141dce-76fc-4c54-96fa-c232e98010ea

Font, L., Davidson, J.P., Pearson, D.G., Nowell, G.M., Jerram, D.A., Ottley, C.J., et al., (2008). Sr and Pb isotope micro-analysis of plagioclase crystals from Skye Lavas: an insight into open-system processes in a flood basalt province. Journal of Petrology 49 (8), 1449–1471.

Fricke, H.C., O'Neill, J.R., Lynnerup, N., 1995. Oxygen isotope composition of human tooth enamel from Medieval Greenland: linking climate and society. Geol. 23, 869-872

Grobler, S.R., Theunissen, F.S. and Kotze, T., (2000). The relation between lead concentrations in human dental tissues and in blood. *Archives of oral biology*, *45*(7), pp.607-609

Gulson, B.L. and D. Wilson. (1994). History of lead exposure in children revealed from isotopic analyses of teeth. *Archives of Environmental Health* 49:279-283

Gulson, B.L., Jameson, C.W., Gillings, B.R., (1997). Stable lead isotopes in teeth as indicators of past domicile - a potential tool in forensic science? J. Forensic Sci. 42,787–791

Hopson, P.M., (2010). The geology of the Portsmouth region: a perspective of the Wessex and Hampshire Basins. Proceedings of the 16th Extractive Industry Geology Conference, EIG Conferences Ltd, 194pp

Hughes, S.S., Millard, A.R., Chenery, C.A., Nowell, G. and Pearson, D.G., (2018). Isotopic analysis of burials from the early Anglo-Saxon cemetery at Eastbourne, Sussex, UK. *Journal of Archaeological Science: Reports*, *19*, pp.513-525.

Kamenov, G.D., Gulson, B.L., (2014). The Pb isotopic record of historical to modern human lead exposure. Sci. Total. Environ. 490, 861–870

Kendall, E., Millard, A. and Beaumont, J., (2021). The “weanling's dilemma” revisited: Evolving bodies of evidence and the problem of infant paleodietary interpretation. *American Journal of Physical Anthropology*.

Kohn, M.J., 1996. Predicting animal $\delta^{18}O$. Accounting for diet and physiological adaptation', Geochim. Cosmochim. Acta. 60, 4811-4829.

Kohn, M.J., (1999). You are what you eat. Sci. 283, 335-336.

Komárek, M., Ettler, V., Chrastny, V., Mihaljevič, M., (2008). Lead isotopes in environmental science: a review. Environ. Int. 34, 562–577

Laws, M.E.S., (1950). Prisoners of War. *Royal United Services Institution. Journal*, *95*(577), pp.91-94.

Lee-Thorp, J.A., (2008). On isotopes and old bones. Archaeometry, 50, 925-950

Mays, S. and Beavan, N., (2012). An investigation of diet in early Anglo-Saxon England using carbon and nitrogen stable isotope analysis of human bone collagen. *Journal of Archaeological Science*, *39*(4), pp.867-874.

Millard, A.R., Montgomery, J., Tricket, M., Beaumont, J., Evans, J., Chenery, S., (2014). Childhood lead exposure in the British Isles during the industrial revolution. In: Zuckerman, M.K. (Ed.), Modern Environment and Human Health: Revisiting the Second Epidemiological Transition. John Wiley & Sons Inc., Oxford, pp. 279–300

Montgomery, J., Budd, P., Evans, J., (2000). Reconstructing the lifetime movements of ancient people: a Neolithic case study from southern England. Eur. J. Archaeol. 3, 370–385

Montgomery, J., (2002). Lead and Strontium Isotope Compositions of Human Dental Tissues as an Indicator of Ancient Exposure and Population Dynamics. University of Bradford, PhD thesis.

Montgomery, J., Evans, J.A., Powlesland, D., Roberts, C.A., (2005). Continuity or colonisation in Anglo-Saxon England? Isotope evidence for mobility, subsistence practice and status at West Heslerton. Am J. Phys. Anth. 126, 123–138

Montgomery, J., Evans, J.A. and Cooper, R.E., (2007). Resolving archaeological populations with Sr-isotope mixing models. *Applied Geochemistry*, *22*(7), pp.1502-1514.

Montgomery, J. (2010). Passports from the past: Investigating human dispersals using strontium isotope analysis of tooth enamel. Annals of Human Biology, 37(3), 325-346.

Montgomery, J., Evans, J.A., Chenery, S.R., Pashley, V., Killgrove, K., (2010). ’Gleaming, white and deadly’: using lead to track human exposure and geographic origins in the Roman period in Britain. J. Roman Archaeol. Suppl. Ser. Suppl. 78, 199–226.

Moore, J., (2019). Death Metal: Characterising the effects of environmental lead pollution on mobility and childhood health within the Roman Empire. *Unpublished PhD Thesis*. Durham University

Moore, J., Rose, A., Anderson, S., Evans, J., Nowell, G., Gröcke, D.R., Pashley, V., Kirby, M. and Montgomery, J., (2020). A multi-isotope (C, N, O, Sr, Pb) study of Iron Age and Roman period skeletons from east Edinburgh, Scotland exploring the relationship between decapitation burials and geographical origins. *Journal of Archaeological Science: Reports*, *29*, p.102075

Moore, J., Williams-Ward, M., Filipek, K.L., Gowland, R.L. and Montgomery, J., (2021). Poisoned pregnancies: consequences of prenatal lead exposure in relation to infant mortality in the Roman Empire. In *The Family in Past Perspective* (pp. 137-158). Routledge

Richards, M.P., Fuller, B.T., Molleson, T.I., (2006). Stable isotope palaeodietary study of humans and fauna from the multi-period (Iron Age, Viking, Late Medieval) site of Newark Bay, Orkney. J. Archaeol. Sci. 33, 122-131.

Robinson, D., (2001). '$\delta^{15}N$ as an indicator of the nitrogen cycle. Trends Ecol. Evol. 16, pp. 153-162.

O'Connell, T.C. and Hedges, R.E., (1999). Investigations into the effect of diet on modern human hair isotopic values. *American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists*, *108*(4), pp.409-425

Roberts, P., Weston, S., Wild, B., Boston, C., Ditchfield, P., Shortland, A.J. and Pollard, A.M., (2012). The men of Nelson's navy: A comparative stable isotope dietary study of late 18th century and early 19th century servicemen from Royal Naval Hospital burial grounds at Plymouth and Gosport, England. *American Journal of Physical Anthropology*, *148*(1), pp.1-10.

Rohl, B.M., (1996). Lead isotope data from the Isotrace Laboratory, Oxford: archaeometry data base 2, galena from Britain and Ireland. Archaeometry 38, 165–180.

Schoeninger, M.J., DeNiro, M.J., Tauber, H., (1983). Stable nitrogen isotope ratios of bone-collagen reflect marine and terrestrial components of prehistoric human diet. Science. 220, 1381-1383

Schoeninger, M.J., DeNiro, M.J., (1984). Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. Geochim. Cosmochim. Acta. 48, 625-639

Shaw, H., Montgomery, J., Redfern, R., Gowland, R., Evans, J., (2016). Identifying migrants in Roman London using lead and strontium stable isotopes. J. Archaeol. Sci. 66, 57–68

Trickett, M. (2006). *A Tale of Two Cities: Diet, Health and Migration in Post-Medieval Coventry and Chelsea through Biographical Reconstruction, Osteoarchaeology and Isotope Biogeochemistry*. Unpublished PhD thesis, Durham University, UK.

Tykot, R.H. (2004). Stable Isotopes and Diet: You are what you eat, in Martini, M., Maliazzo, M., Piacentini, M., (Eds.), P. Int. Sch .Physics. IOS PRESS, Amsterdam

Vaughan, J., (1897). French prisoners at portchester. *The Cornhill magazine*, *3*(14), pp.217-226