Colossus Dive Trail Maintenance
&
Wheel Wreck Dating

Project Report

Kevin Camidge

with contributions by

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A number of organisations have given valuable assistance to the project. Ambient Pressure Diving donated consumables for use in the AP rebreathers used by some members of the team. Weezle provided discounted undersuits to the dive team and Otter Watersports provided discounted drysuits for several team members; a dry diver is a happy diver.

Weezle Undersuits

Otter Watersports

Ambient Pressure Diving

The Team

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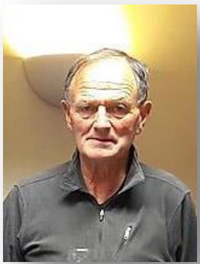


Terry Perkins
Boat Skipper

Project Name

Colossus Dive Trail Maintenance & Wheel Wreck Dating 2019 (7875)

Summary Description

This project undertook maintenance of the *Colossus* dive trail and the collection of further dating evidence from the Wheel Wreck to aid the identification of this wreck. Both sites are protected historic wrecks and are only about six kilometres apart. The rationale behind combining these two projects was that considerable financial savings can be made by combining the fieldwork into a single event.

Background

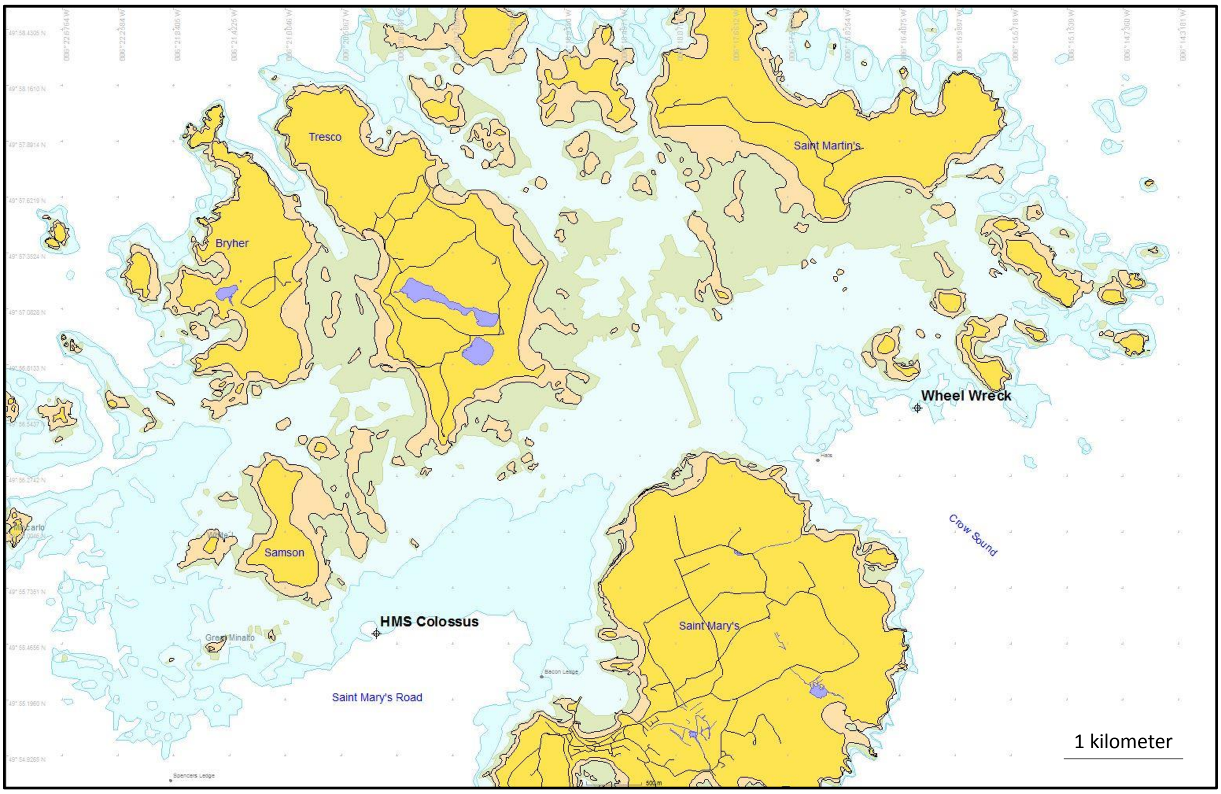


Fig 1: Plan of the Isles of Scilly showing the location of the Colossus *and Wheel Wreck sites*

Colossus Dive Trail

The current designation came into force 18th August 2017 and is defined by the following co-ordinates; N: 49.92688286, -6.34111824 E: 49.92371411, -6.33617442 S: 49.91861193, -6.34401542 W: 49.92178068, -6.34895924.

The dive trail was installed on the site in 2009 and extended in 2012. This work was commissioned by English Heritage and undertaken by the Cornwall and Isles of Scilly Maritime Archaeology Society

(CISMAS). The *Colossus* dive trail is extensively documented in ***Colossus* Dive Trail Report 2009** and ***Colossus* Dive Trail Update 2012** – both available at www.cismas.org.uk/downloads .

When CISMAS visited the *Colossus* dive trail in May and July 2018, it was evident that the trail was in poor condition. A string of lobster pots lay across the site, with the pot line entangled in parts of the trail and upstanding elements of the wreck. At least two of the station markers were not evident (probably disturbed by attempts to recover the pots) and several others had been displaced. The dive trail station markers were covered in marine growth, making the station numbers illegible.

The Wheel Wreck

The site lies to the south of the island of St Martins in the Isles of Scilly, and was discovered by local divers in 2005. It consists of a rectangular pile of iron pipes and wheels 12 metres long by 7 wide, lying on the seabed in an orderly pile which appears to be a cargo mound. Almost nothing of the vessel carrying this cargo survives. The cargo mound sits on a boulder-strewn rocky seabed in about 16m of seawater.

An undesignated site assessment was undertaken in 2006 by Wessex Archaeology. It was concluded that the cargo represents a consignment of mining equipment from a Cornish foundry, thought to date from 1850 onwards. The assessment report includes a basic site plan and photo-mosaic of the cargo mound, as well as drawings of some of the individual components of the machinery (Wessex Archaeology, 2006).

The Wheel Wreck was designated under the Protection of Wrecks Act 1973 on the 5th April 2007. The protected area extends for 75m around position 49° 56.455' N, 006° 16.381'W.

An investigation and survey of the site was carried out by CISMAS in 2018 for Historic England (Camidge, et al., 2018) – the report detailing this work is available at www.cismas.org.uk/downloads .

In April 2018, CISMAS undertook a limited survey of the site on behalf of Historic England. The survey included the recording of the visible cargo mound items, a site plan, a 3D 'structure from motion' record of the cylinder fragments, sampling of the socketed pipes for metallurgic identification and the collection of dating material from around the cargo mound. A small quantity of pottery and glass was recovered from the vicinity of the cargo mound. Appraisal resulted in a date range of 1770 to 1820 for this material. Chemical analysis of the glass suggests that this falls into the earlier part of the date range. In consequence, it seems likely that the site dates from the end of the 18th century. This accords with the date assigned to the previously recovered ceramics in the Undesignated Site Assessment (late 18th century). The 2018 project is documented in the project report (Camidge *et al.* 2018)

Project Objectives

The primary aim of this project was to undertake maintenance of the *Colossus* dive trail to make the site more usable and comprehensible for visitors. We also took steps to improve the interpretation for divers – this was achieved through the production of a new, single 'sheet' waterproof dive slate similar to that recently produced for the Thorness Bay dive trail.

A secondary aim of this project was to refine the dating of the Wheel Wreck through the collection of further dating material from the site. The goal here was to enable identification of the vessel and thus to determine the cargo's origin and destination. This would enable better understanding and hence management of the site.

Methods

The fieldwork was undertaken by a team of six divers between 14th and 21st September 2019. The diving was accomplished from the dive charter boat *Morvoren*, operating from the island of St Martins in the Isles of Scilly. Six days of diving were planned, but only five days were achieved due to adverse weather conditions on the last day. September is late in the diving season and carries an increased risk of adverse weather – sadly this charter 'slot' was all that was available by the time funding for this project was approved.

Each diver undertook two dives per day, with a surface-interval of two hours between dives. The dives were of approximately one hour's duration. An overall total of 53 hours of diving took place.

Priority was given to refurbishing the *HMS Colossus* dive trail. This took three days to complete; the remaining time available was spent on the Wheel Wreck.

Results

Colossus

Condition of the dive trail
The dive trail was heavily covered in marine growth. The south side of the exposed wreckage was largely obscured by a bank of detached kelp over a metre deep. All the dive trail markers were heavily weeded, making the station marker numbers illegible (fig 3). The dive trail sign was obscured by fine seaweed (fig 2).

Fig 2
The seabed sign before cleaning, showing how weed growth was obscuring the sign

Fig 3
One of the station markers, showing how the numbers of the markers had become obscured by weed.

Fig 4
Station marker number six, next to one of the upstanding18lb iron guns (gun 6). Note the build-up of kelp around the gun.

Refurbishment

The first task was to remove the build-up of detached kelp stalks. These are often referred to locally as 'skaffs' or 'kelp bombs' (fig 5). They consist of a loose kelp frond, usually attached to a small to medium sized rock. These appear to drift onto the site from the west, carried by the flood tide.

Fig 5
A kelp 'skaff' being held aloft by a diver on the Colossus *dive trail*

The station marker buoys were then removed and replaced with new marker buoys and ropes. These are fastened to the concrete sinkers on site by looping them through the stainless steel loops which have been cast into the concrete sinkers – for details of their construction see (Camidge, 2009). Small numbered plastic tags have been included beneath the station markers – these have the number etched into the surface and it is hoped they may resist weed growth (fig 6).

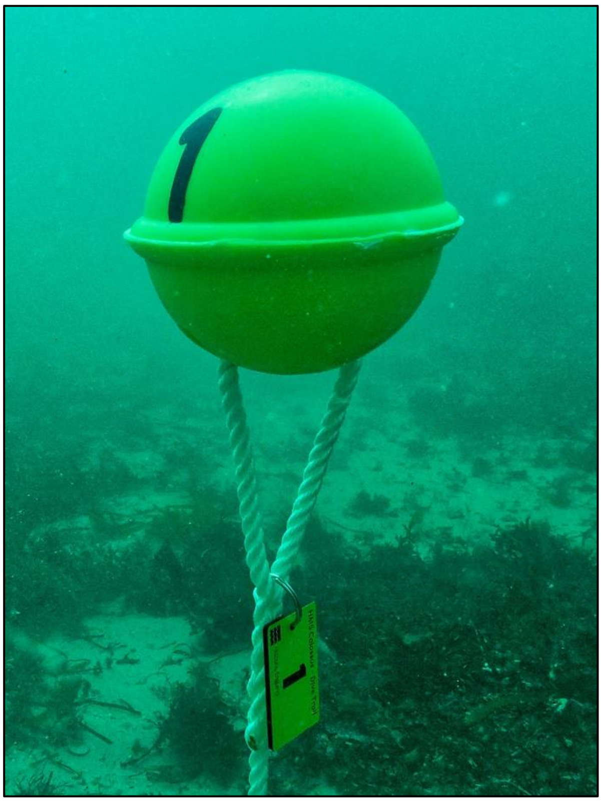


Fig 6 - Two of the new dive trail station markers in place on the refurbished dive trail (stations 1 and 11).

The seabed sign was cleared of the marine growth which was obscuring the text; this was accomplished using a nylon scouring pad. The sign is attached to a concrete plinth by four stainless steel screws. A template of the sign (including the screw holes) has been retained to allow easy manufacture of a replacement sign with the screw holes in the correct positions.

Fig 7
The seabed sign after cleaning – some of the marine growth has become embedded into the fabric of the sign. The sign will probably need replacing at the next refurbishment of the dive trail.

The lead-weighted bottom lines which guide divers around parts of the dive trail were checked, de-weeded and renewed where necessary and additional seabed fastenings installed.

Dive Slate

A new underwater information slate was designed. The previous underwater guide was a laminated multi-page guide; these have been in use for over five years and are starting to delaminate. The underwater dive guides are kept on board the dive charter boats in Scilly and loaned to the divers for the duration of their dive on *Colossus*. After discussion with a number of these divers and the diveboat skippers, it was decided to replace the multi-page guides with a single A4 dive slate printed on both sides. The new slate is printed onto polycarbonate plastic and should be more durable than the previous, laminated guide booklet. Although the new slate has much less information it is easily portable for the site visit and contains a link to enable visitors to get further information from the online virtual dive trails for Scilly – this is designed to work on a smartphone and also contains information, videos and 3D models for the other protected wreck sites in Scilly. The new dive slate is available on the dive charter boats *Morvoren* and *Tiberon* in Scilly. Spare copies will also be held by CISMAS and Historic England Maritime.

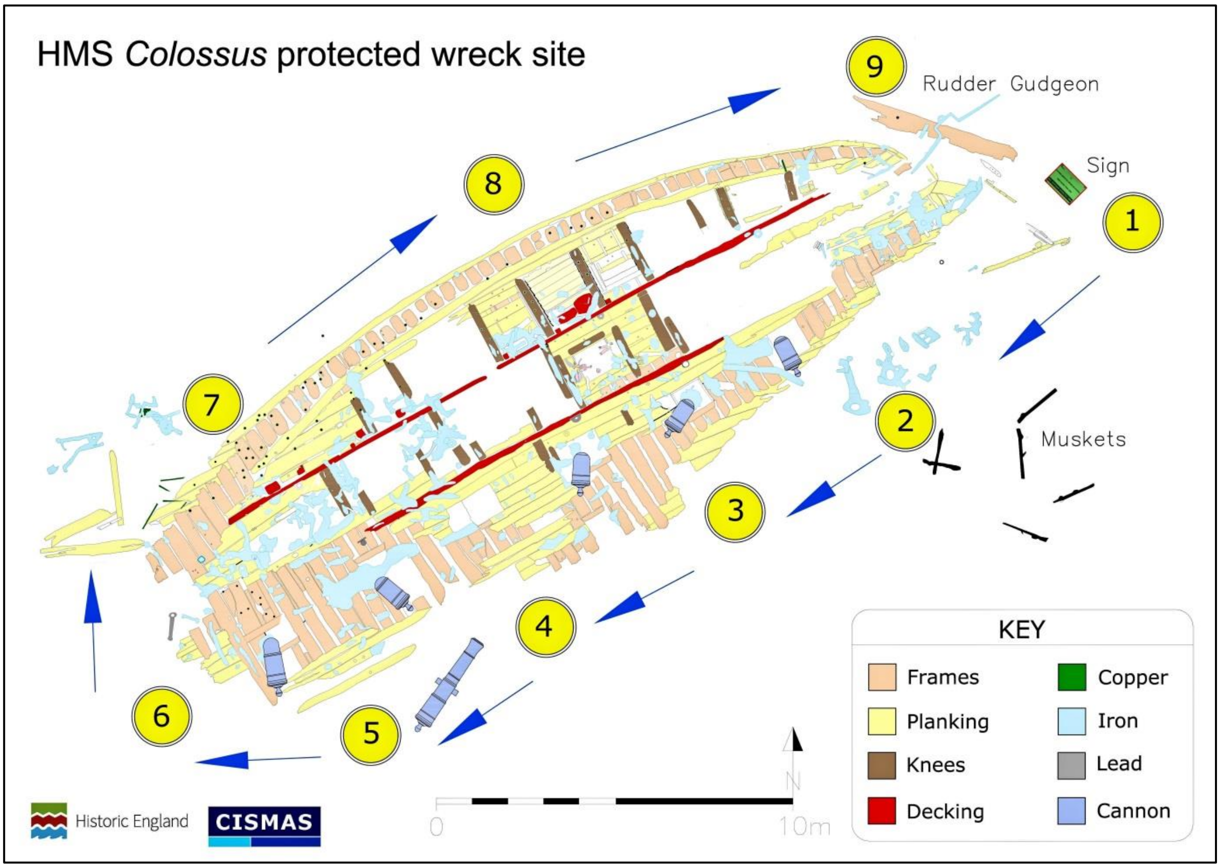


Fig 8 - The new HMS Colossus *dive slate – front surface*

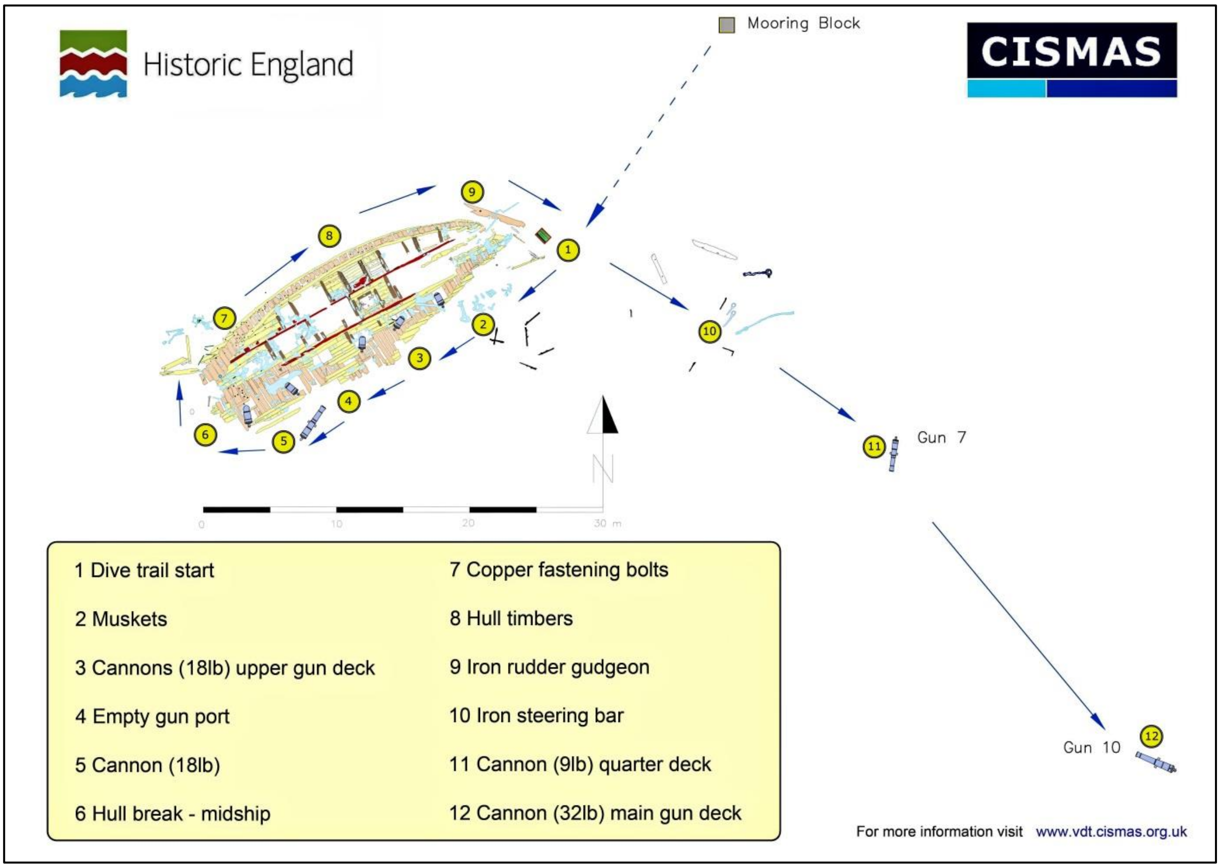


Fig 9 - The new HMS Colossus *dive slate –back surface*

Note that the site plan has been simplified and much small detail removed to make the representation of the site clearer and easier to understand underwater. The dive slate is also available to download as a PDF, so that independent visiting divers can download and laminate their own information slate. http://hmscolossus.cismas.org.uk/wp-content/uploads/2020/03/Colossus-dive-slate-raster-600dpi.pdf

Deadeye and Chains

One of the largest iron items found in 2017 was a timber lower deadeye complete with iron chains C10.1 (Camidge, 2017, p. 34) see fig 11. The chains are the iron straps used to fasten the lower deadeye to the outside of the hull of the ship. This deadeye is very similar to another (F1355) found in 2015 some 7m to the east (Camidge, 2015). The diameter of the deadeye (440mm) is such that this would have been one of the main or foremast deadeyes – the mizzen deadeyes were smaller. It was partly buried within the seabed and lies on its edge rather than flat on the seabed. This deadeye lies right next to the dive trail around the site, but remained unrecognised until the survey in 2017. A series of photographs was taken this year (2019) to allow a 3D model of the deadeye to be made ('structure from motion'). This model has been placed on the CISMAS sketchfab site and subsequently embedded in the Isles of Scilly virtual dive trail.
https://hmscolossus.cismas.org.uk/deadeye-and-chains/

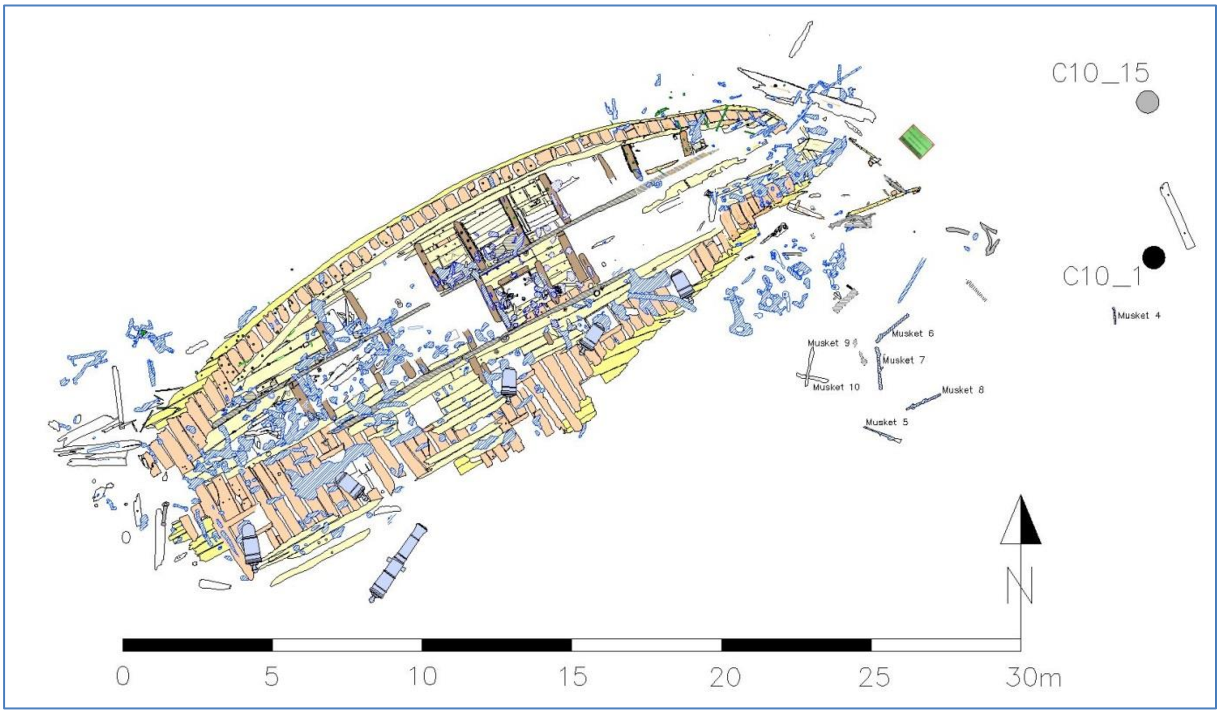


Fig 10 - The location of Deadeye, C10.1 and the lead weights, C10.15

Fig 11
The deadeye and chains C10.1. The gap between the top of the deadeye and the iron chains is where the wood of the deadeye has decayed. Two of the three 'eyes' still contain rope.

Scale = 0.5m (taken with a very wide-angle lens which is why the scale in the foreground looks disproportionally large – one of the problems of underwater scales) – the central part of the deadeye is 0.44m in diameter

Sediment Level Monitoring
The sediment levels in the vicinity of the exposed stern remains have been measured regularly since 2003. At least one set of measurements has been collected annually with the exception of 2016; in total 32 sets of readings have been collected for the 14 separate sediment level monitoring points. This is probably the most extensive set of sediment level data from any of the English protected wreck sites.

The sediment levels were last recorded in July 2018 and again in September 2019. The mean change over all points was a fall in the seabed sediment levels of 7.46mm since July 2018.

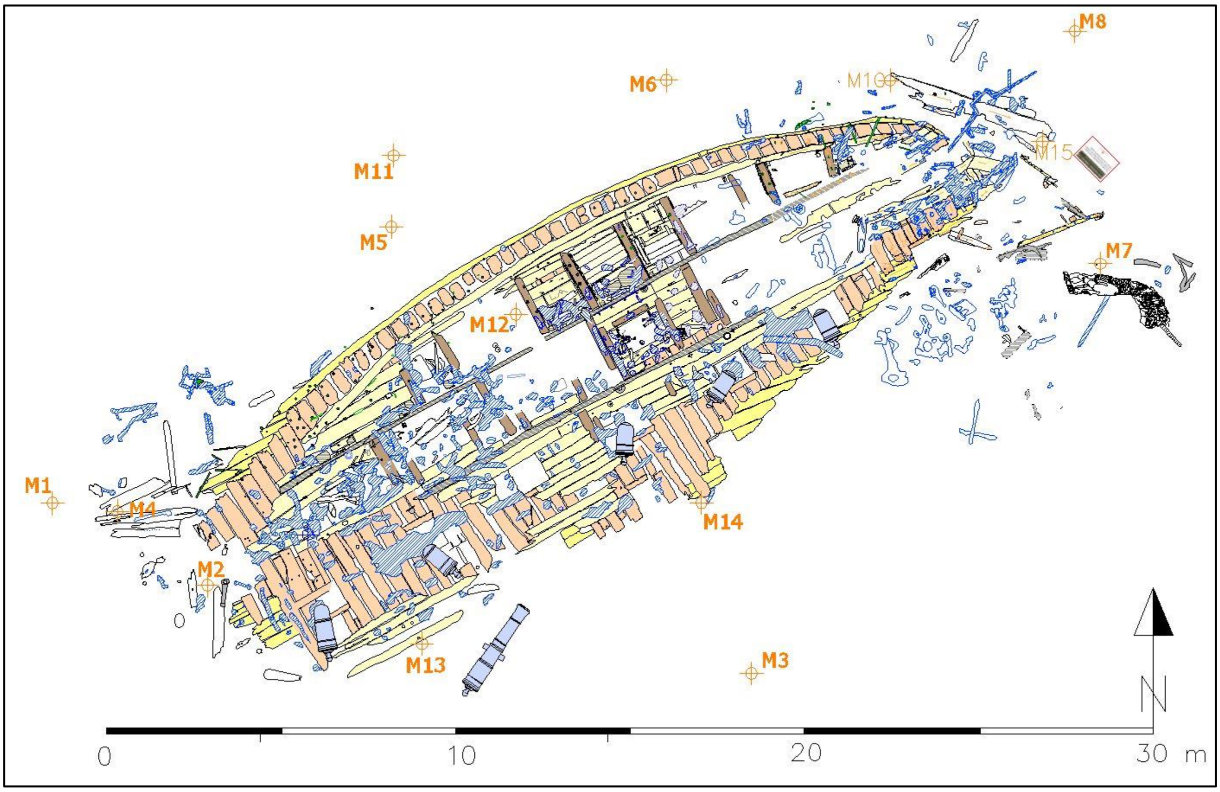


Fig 12 - The location of the 14 sediment level monitoring points around the wreck (M1 to M8 and M10 to M15)

As noted previously the overall fall in sediment levels is derived from the mean change of all points; as can be seen from fig 13 the levels fell in some places while they actually rose in others. This year has seen large drops in level on the eastern side of the wreck while there were rises in level at the south-western edge of the site. In the past when several sets of readings were taken over the course of a single year it was observed that the sand levels rose and fell apparently in very low amplitude waves and dips across the site.

It would be interesting to compare the sediment monitoring results from this site with data collected from other historic wreck sites.

Sediment level change at different points around the site (mm)				
Monitor Point	**July 2018**	**Sept 2019**	**Change**	**Position**
M1	-	135	-	W
M2	150	100	+50	W
M3	175	165	+10	S
M4	140	190	-50	W
M5	145	165	-20	N
M6	170	140	+30	N
M7	185	210	-75	E
M8	105	137	-32	E
M10	120	130	-20	N
M11	130	110	+20	N
M12	135	155	-20	Central
M13	195	170	+25	S
M14	170	160	+10	S
M15	65	90	-25	E
Mean change since 2018			**-7.46**	

Fig 13
Table showing the sediment measurements taken in 2018 and 2019. All measurements are in millimetres. Where no measurement is shown, the monitoring point could not be located on the seabed – usually because of obscuring weed cover.

Note there is no M9 monitoring point

Two Very Peculiar Lead Objects (C10.15)

A pair of identical, enigmatic lead objects were found partly buried in the seabed some 10m to the east of the stern of *Colossus* (for location see C10.15 in fig 10 above). It was difficult to ascribe a function to these objects on an 18th century warship. After consultation with Historic England it was decided to recover them to allow further investigation. Analysis of one of the weights determined that they were made from lead of >99% purity – see Appendix III.

Fig 14
The pair of lead objects C10.15 on the seabed some 10m to the east of the stern of Colossus*.*
Scale = 0.5m

The lead objects appeared to be weights, each slightly cylindrically-curved (representing a diameter of approximately 0.95m (3 feet). Each has two holes of 15mm (1/2 inch) diameter running through the thickness of the weights, presumably for attachment (fig 19 below). Each weighs about 24.5kg (54lb). The superficial similarity to modern scuba diving weights prompted the speculation that these might have been connected with early salvage diving on the site of *Colossus*. We know of at least two successful early salvage divers who worked on the wreck of *Colossus*: the first of these was Ralph Tonkin of Penzance. The following account is from the Sherbourne Mercury of 25th March 1805 (listed as port news for Torbay on the 20th March 1805).

> *This day arrived the sloop DANIEL, Captain Richard Duff, from the Island of Scilly, by an order from His Majesty's Board of Ordnance, to take up the guns and the remaining part of the wreck of his Majesty's ship VENERABLE, under the direction of Mr. Ralph Tonkin, of Penzance, and are the same crew who took up the guns and the stores of his Majesty's ship COLOSSUS, wrecked on Scilly Rocks a few years since.*

Board of Ordnance records dated August 1799 attest to his success, stating that 'Messrs Tomkins & Co' were paid £479/9s/11d for the recovery of 37 iron guns (36 of which were deemed serviceable). (Camidge, 2017, pp. 14-15). Details of Mr Tonkin's diving apparatus survive in a print he had made, illustrating his salvage operations on the wreck of the *Abergavenny* in September 1805. This shows his apparatus to consist of a small copper 'bell' worn over the upper torso with arm holes sealed with leather tubes. The bell is shown weighted with a band of lead around the lower edge. The print does not show enough detail to see clearly what form the lead takes, but this does not appear to be an obvious match for the lead objects found on *Colossus*.

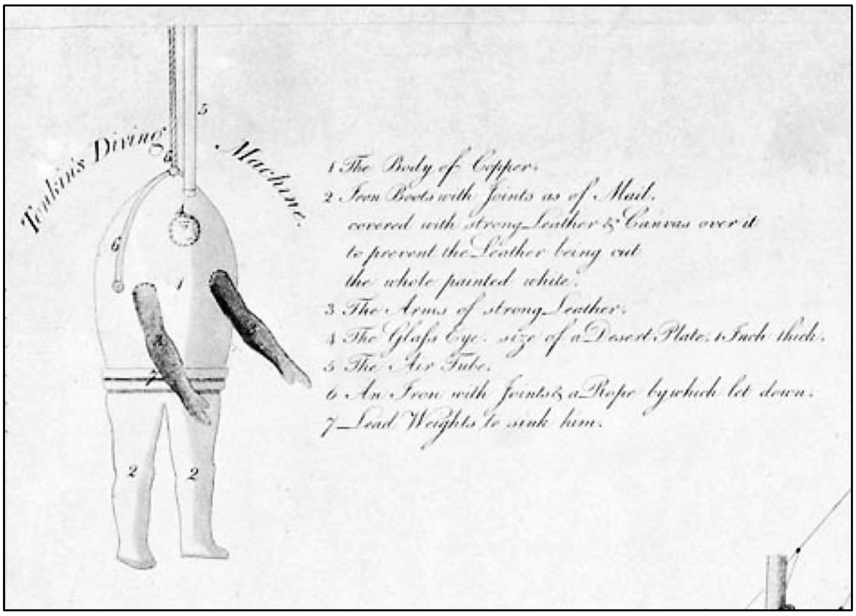


Fig 16
Detail from Tonkin's print of his salvage operations on the wreck of the Abergavenny *in 1805 – note item '7 Lead weights to sink him' – which do not bear much resemblance to the objects recovered from* Colossus

In 1833 the renowned salvage diver John Deane visited Scilly and dived on the wrecks of *Colossus* and the brig *Hope* (carrying ivory and gold dust). Deane was accompanied by another diver, William

Edwards. We are told that '*After an uneventful passage to the Scilly Isles, John searched for and quickly found the wreck of Colossus'* (Bevan, 2010, p. 90). He recovered a number of iron guns from *Colossus* as well as 17 cwt of copper sheathing (Wessex Archaeology, 2003, p. 15).
Intriguingly, they also suffered an unusual and somewhat incredible accident – reported in the *Hampshire Telegraph* 1833 Nov 4th p2:

> *It is now thirty-five years since his Majesty's ship Colossus was wrecked in St Mary's Roads, Scilly. A few weeks since, two young men (brothers) were there with a diving apparatus of a new construction, and succeeded in bringing-up several pieces of cannon, &c. from the wreck. The following extraordinary fact merits investigation: one of the guns exploded on being struck with a hammer, while lying near St. Mary's quay, and the wadding &c. fell on Rat Island. Master-Gunner Ross was severely injured in the leg by the accident.*

It is hard to believe that a charge of black powder would remain dry and viable after immersion in 15m of seawater for 35 years. One possible explanation is that they thought the gun was in such good condition that they would try it with a charge of powder – which would also explain the presence of '*Master-gunner Ross'*. Whatever the truth of this strange event, it is clear that they did raise a number of guns from *Colossus*, and even made illustrations of some of them.

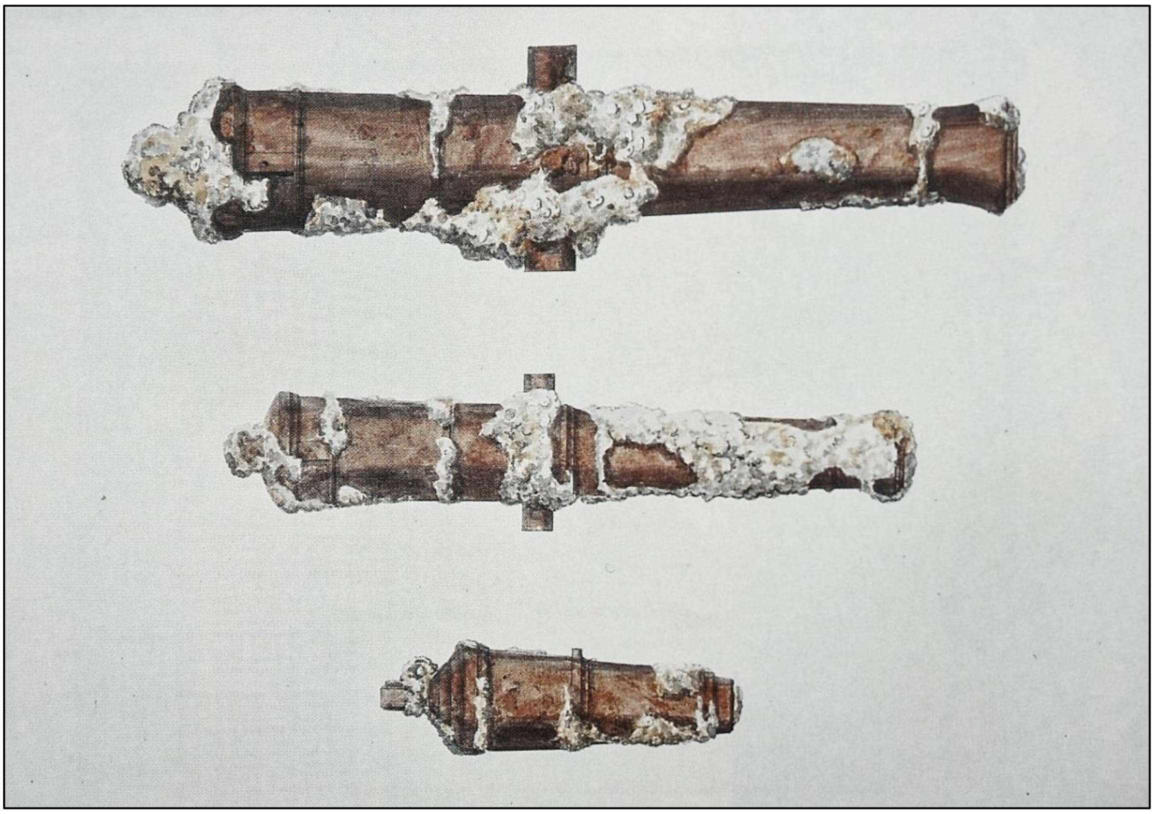


Fig 17 – Deane's drawing of guns recovered from Colossus. *They are probably an 18lb Armstrong (upper gun deck), 9lb Armstrong (quarter deck/forecastle) and a Carronade* (Bevan, 1996).*It is interesting to note how much iron corrosion concretion had accumulated on the guns in just 35 years.*

Illustrations of the Deanes' diving equipment clearly show the diver with two lead weights of exactly the same shape as those recovered from the wreck (figs 18 and 19). Furthermore, a description of their diving equipment in the *Berwick Advertiser*, May 1840 (Bevan, 1996, pp. 165-6) states that the diver was weighted with *'Two pieces of lead, of one half cwt each'* – this being 56lb, it is remarkably close to the 54lb weight of our recovered lead objects.

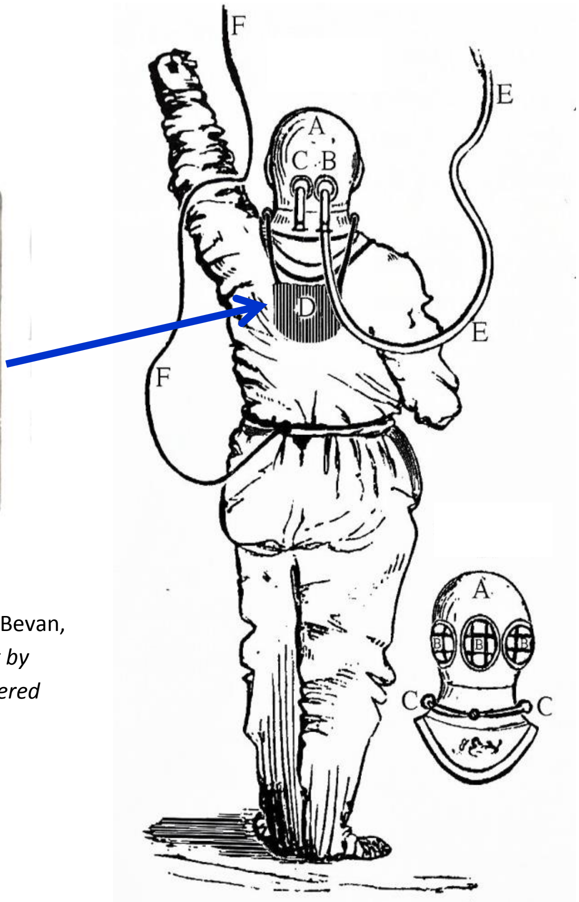


Fig 18

Right – the Deane helmet and dress as illustrated in 1842 (Bevan, 1996, p. 196)*. Note the weight suspended from the helmet by two ropes. Above – one of the lead weights (C10.15) recovered from near the stern of* Colossus

Below – A detail from an illustration made by Charles Deane of their diving operations in London Docks (Deane, 1835, p. Plate 10) *Note the weight on the diver's back – the same shape as those found on* Colossus.

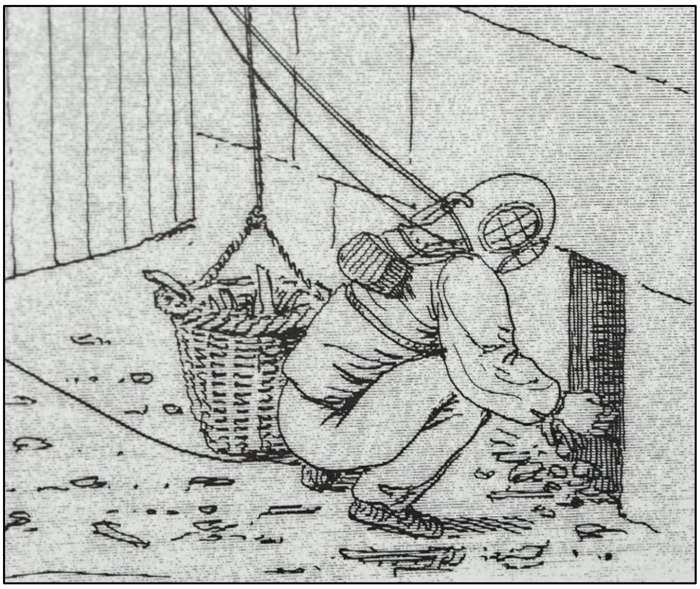


Fig 19 - One of the pair of lead weights C10.15B found on the seabed to the east of the stern of Colossus. *Note there are no mould-lines or casting shrinkage hollows evident on either of the weights.*

The case for the identification of C10.15 as the Deanes' dive weights can be made as follows. Firstly they are shaped just like the Deane weights shown in contemporary illustrations – down to details such as curve, convex bottom and rope-hole positions. The mass is almost the same as that stated for the Deane weights; there are exactly the right number, two; and lastly we know the Deanes were there in 1833 and recovered guns and copper from *Colossus*.

Given the similarity of form, mass, material and quantity it seems reasonable to postulate that these weights were lost or jettisoned by the Deanes while salvage diving on the wreck of *Colossus* in 1833.

3D models of the two dive weights can be viewed on the CISMAS sketchfab page:

https://sketchfab.com/3d-models/dean-brothers-diving-weight-from-hms-colossusfcc6d7a7b7594cb19d5f20c5d867f61c

https://sketchfab.com/3d-models/dean-brothers-diving-weight-from-hms-colossus-69867c64b9734e44801f53aa34d1a3ce

Wheel Wreck

An investigation of the Wheel Wreck was undertaken by CISMAS in 2018 – the report of this work is available at www.cismas.org.uk. The Wheel Wreck was originally dated to the latter half of the 19th century, mainly on the identification of a quantity of 'boiler tubes' on the site. These socketed pipes have now been subjected to analysis and found to be made of cast iron, and are therefore unlikely to be boiler tubes. They appear, in fact, to be interlocking cast iron pipes – probably used for transport of water at low pressure. Therefore the post-1850 date previously assigned to the site is no longer valid.

Collecting Dating Evidence

The investigations carried out by CISMAS in 2018 established that the Wheel Wreck probably dates to somewhere between 1770 and 1820 (Camidge, et al., 2018). Of the vessel itself very little remains but the size and shape of the cargo mound suggest a vessel of at least 18ft (5.5m) beam of between 70 to 100 tons capacity. In order to identify the vessel, cargo origin and destination we need to refine the date range. To this end we collected further dating evidence this year.

The seabed around the cargo mound is covered with large granite boulders, which makes searching difficult and time consuming. The search was conducted using the same technique as that employed in 2018 (Camidge, et al., 2018, p. 12); datum lines 30m long were extended beyond the cargo mound in various directions. The end of each datum line was fixed to the cargo mound and its alignment established by use of an underwater magnetic compass – the bearing was taken at the end of the datum farthest from the cargo mound to minimise the magnetic influence of the cargo itself. The seabed either side of each datum was searched visually by a pair of divers for a distance of 2m either side of the datum line. The position of any objects located was fixed by offsets from the datum line. The areas searched this year are shown in fig 20 below

The objects recovered will all be deposited at the Isles of Scilly Museum.

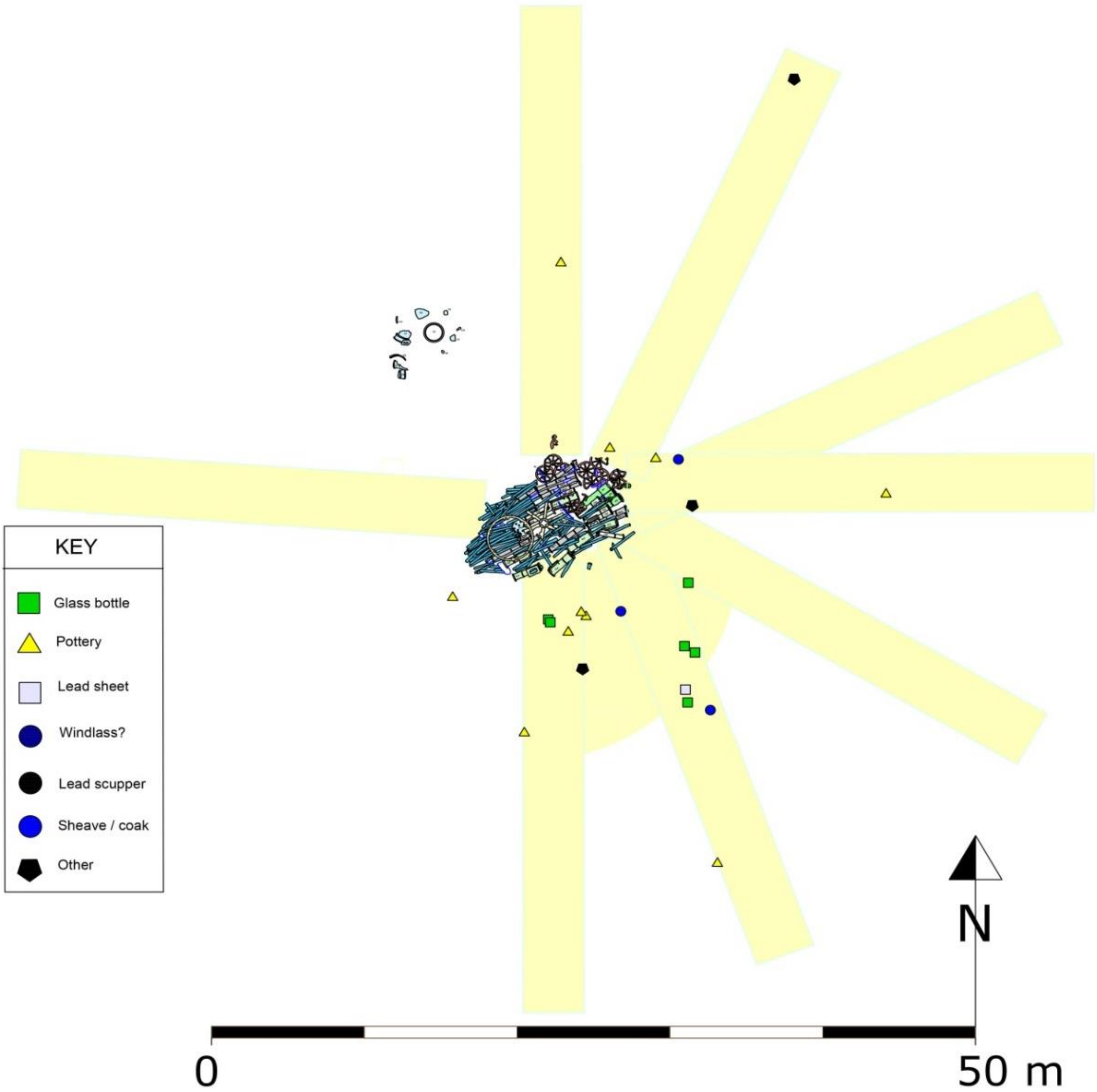


Fig 20 - The areas searched for dating material in 2019 (shaded light yellow) and the distribution of the objects recovered (geometric shapes - see key for object types)

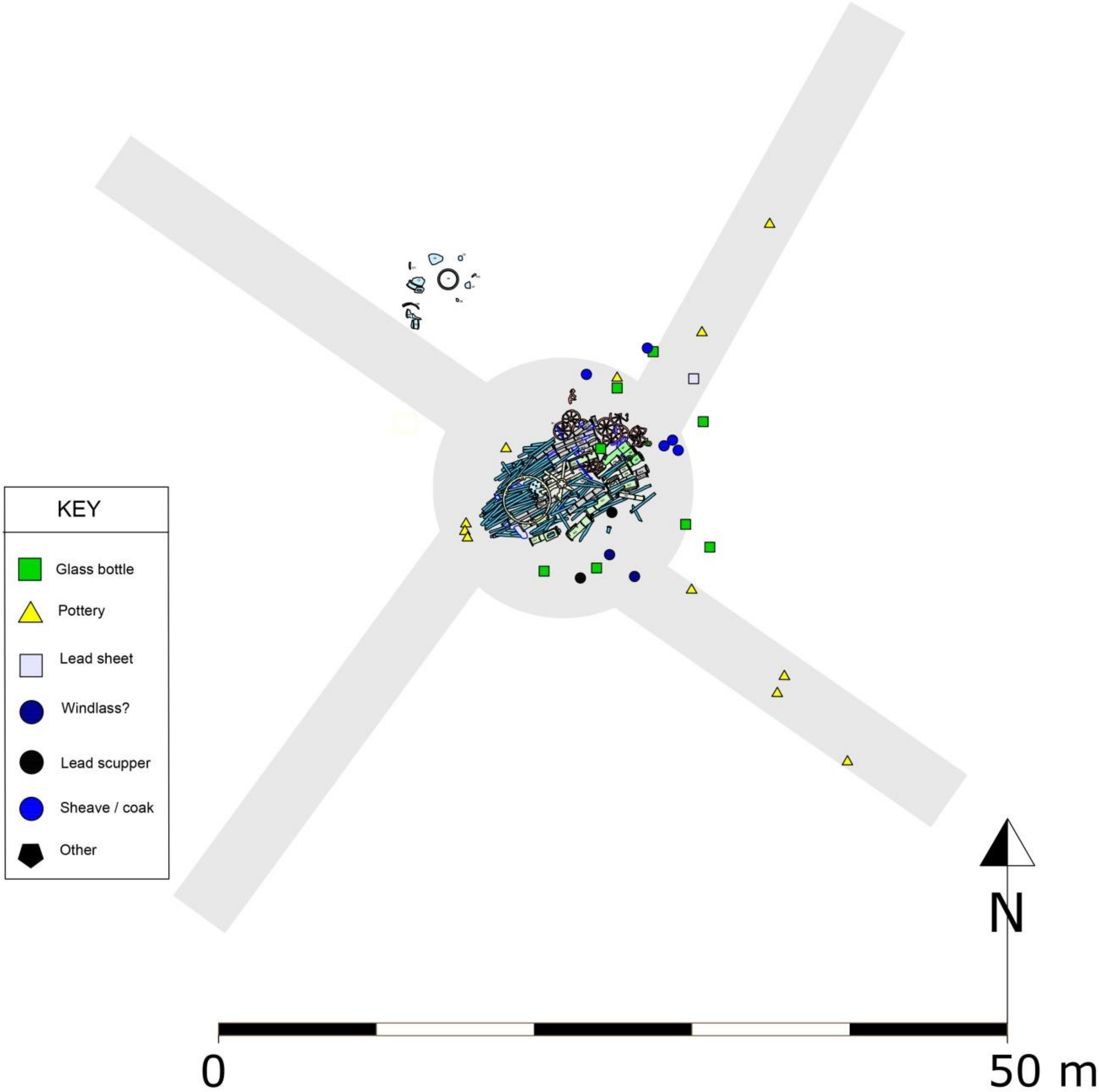


Fig 21 - The areas searched for dating material in 2018 (shaded grey) and the distribution of the objects recovered (geometric shapes - see key for object types)

For comparison, the distribution of the material recovered in 2018 is shown in fig 21 above. In 2018 750 square metres of seabed were searched, yielding 32 objects, while in 2019, 1150 square metres were searched resulting in 27 objects recovered. The pottery and glass recovered in 2019 was all of fairly modest size when compared to the pieces recovered in 2018, possibly suggesting that most of the larger pieces have now been recovered.

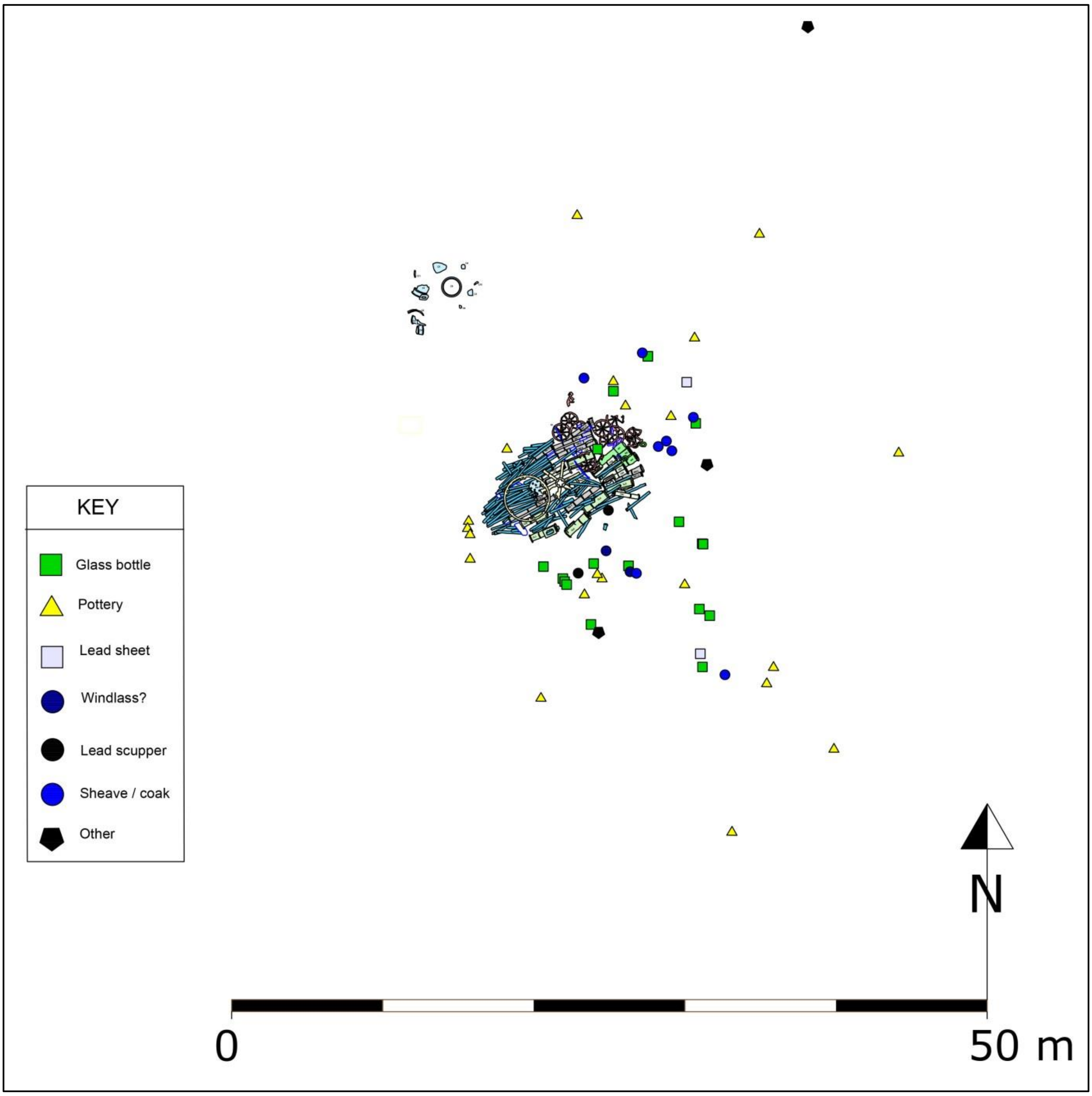


Fig 22 - The distribution of all the recovered objects (2018 and 2019) classified by object type

Number 2019	Number 2018	Description	Material
3	5	Block sheave and coaks	Wood and copper alloy
10	11	Pottery fragments	Ceramic
11	10	Vessel glass	Glass
1		Metal Sheet fragment	Stainless steel?
1	1	Lead sheet	Lead
1		Copper sheet	Copper alloy

Fig 23
Summary of object types recovered in 2018 and 2019

Dating of the Pottery and Glass

The finds record for the objects recovered in 2018 and 2019 appears in appendix I, along with photographs of the recovered artefacts.

John Allan undertook the appraisal of the ten fragments of pottery recovered in 2019 and his identification and date estimates are reproduced in the table in appendix I. Ian Scott carried out the appraisal of the eleven glass fragments and his identifications and date estimates are also incorporated in the table. On the whole, the finds from 2019 have only confirmed the date range established in 2018 – approximately 1770-1820. There are, however, additional issues which need to be noted concerning this collection of material.

Firstly there are two 20th century objects in the 2019 collection: (F103) a glass object which is probably a diesel fuel-filter cover from a small boat, and (F106) a fragment of extremely thin stainless steel sheet. The latter is very light and probably highly mobile, so could easily have been moved onto the site by the tide. The glass filter bowl (F103) is the most northerly object shown on the distribution plan (Fig 22) and can probably be viewed as an outlier, almost certainly thrown overboard from a small craft as part of general marine rubbish. Secondly, three of the pottery fragments recovered in 2019 have been assigned a date estimate which considerably predates the rest of the material recovered. These are (F105) 15th/16th C, (F137) 15/16th C and (F140) 16th/17th C. If these date estimates are correct then these three fragments of pottery are clearly not associated with the cargo of cast iron or with the other dated items recovered in 2018.

Distribution

The distribution of objects around the cargo mound is distinctly asymmetric – see figs 20-22, with almost no objects found to the north and west of the cargo mound and a distinct cluster to the south and east. There is very little tidal flow in the area of the site so the almost complete lack of objects found to the north-west of the cargo mound is difficult to explain.

Cargo Typology

Although we are not aware of any published typology of pitwork, there are a considerable number of published works on early mining and pumping machinery. Reference to these suggests that the material contained within the cargo mound of the Wheel Wreck exhibits features more typical of the 18th century than of the 19th century. A summary of the main examples of these is presented below.

The Clack Pieces

Clack pieces are one way valves used in pump columns to prevent water from falling back down the pump column while the pumps are not acting on the rising main. They were called clack valves during the 19th century. Clack pieces can also be used as 'bucket doors' (in which case the actual clack valve is omitted) – these are inspection covers to allow maintenance of a bucket pump (also known as a lift pump) (Farey, 1827, p. 215).

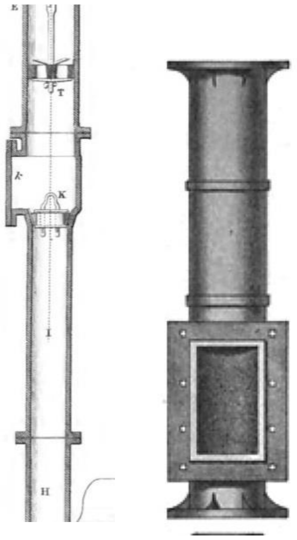


Fig 24
Illustrations of early clack pieces or bucket pump inspection pieces. This type of clack-piece is usually 6 feet long with square bolt holes.
(Farey, 1827)
(Greenwell, 1889)

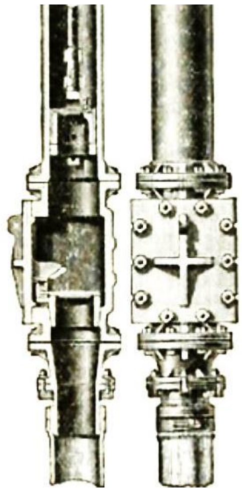


Fig 25
Illustration of the later type of clack piece. Note how they do not incorporate any pipe in the casting and the round bolt holes.
(Behr, 1896)

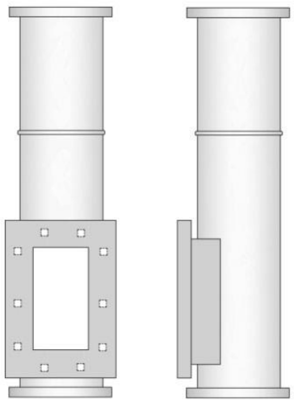


Fig 26
Drawing showing the form of the clack pieces found on the Wheel Wreck. Note the clack door opening is incorporated into a length of pipe, which is 6 feet long. No actual clack doors have been found on the Wheel Wreck. Also note the square bolt holes and lack of flange fillets.
(Camidge, et al., 2018)

The earlier clack pieces (18th-early 19th century) incorporate a length of pump pipe and are usually 6 feet in length – fig 24. The later (19th century) type does not incorporate the pump pipe – fig 25. A total of 14 clack pieces have been found on the Wheel Wreck, all are 6 feet long and they are clearly of the earlier type – fig 26. It is also significant that the clacks from the Wheel Wreck have square bolt holes and lack reinforcing fillets between the flanges and pipe bodies.

The Socketed Pipes

These pipes are 1.95m long, with an external diameter of 0.12m and an internal diameter of 0.10m. They have a socket at one end (0.11m long, external diameter 0.16m, internal 0.13m) which is large enough to accept the un-socketed end of the next pipe with a small gap (see fig 28 below). Several of these pipes are broken and a small fragment of the cast iron was taken for analysis in 2018.

Fig 27
The stack of cast iron socketed pipes on the western side of the cargo mound. Just over 100 of these have been recorded and more probably lie concealed within the cargo mound. Each pipe is 1.95m long.

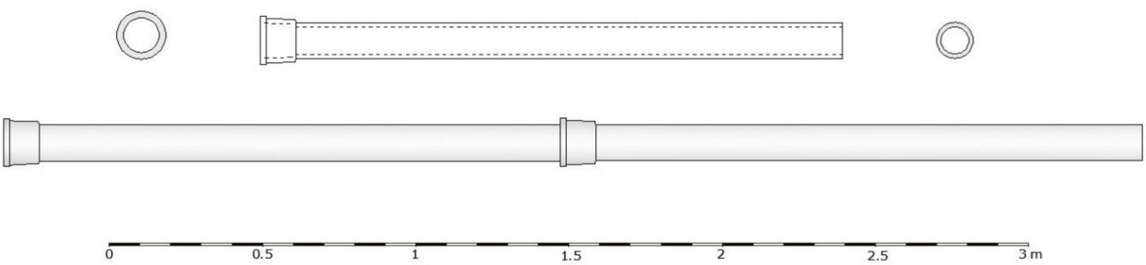


Fig 28 - A reconstruction drawing of the socketed pipes showing how the pipes would have been fitted together

The metallurgical analysis of the socketed pipes showed that they were made of a hypo-eutectic white cast iron. The analysis went on to say:

> *From a dating point of this is suggestive that the tubes were probably made somewhere between the early to mid-18th century – when foundry technology would have advanced enough to make the production of relatively thin-walled cast-iron tubes viable – and the earlier 19th century after which iron tubes like this are more likely to be cast as the more durable grey cast iron, cast iron making technology having advanced again by then.* (Camidge, et al., 2018, pp. 71-74)

This, while not being conclusive, does suggest a date of manufacture somewhere in the 18th century rather than the 19th century.

Flange Fillets

The rising mains, clack pieces and windbores in the cargo mound all have circular flanges which facilitate bolting them together in the pump column - see fig 29. The junction of the flange and pipe was a weak point where cracks in the cast iron could develop. To counter this tendency, a number of iron fillets were cast into the angle between flange and pipe. The lack of fillets could indicate an early date of manufacture or possibly is a feature of a particular foundry. All the 19th century pitwork observed on land exhibits these flange fillets.

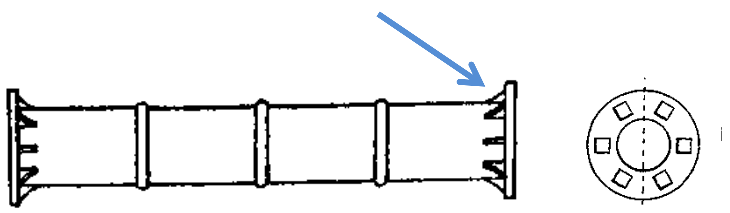
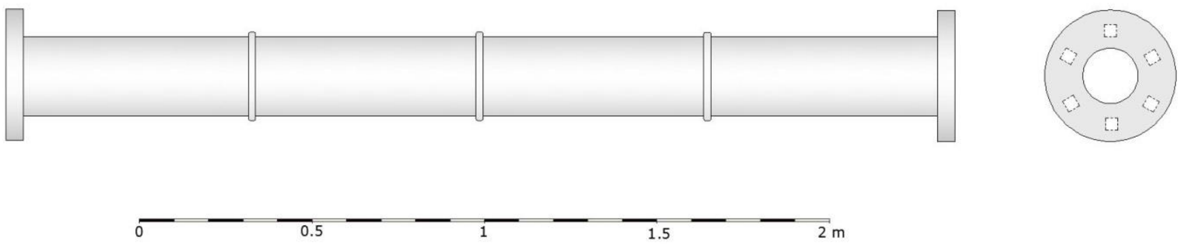


Fig 29
Left: Illustration of a typical rising main showing the position of the flange reinforcing fillet (arrowed) (Taylor, 1829)

Below: A reconstruction drawing of a rising main from the Wheel Wreck showing the lack of reinforcing fillets



The Cylinder Fragments

A small group of six iron fragments has been noted some 11m to the north-west of the cargo mound. These fragments all appear to be the remains of a cast iron cylinder which has been broken into six major pieces and a greater number of smaller fragments. The seabed in this area is composed of large stone boulders, so locating all the smaller fragments was problematic. The area around these six fragments was searched and a further five fragments were identified and surveyed. This brings the total number of fragments located to eleven (C1 – C11).

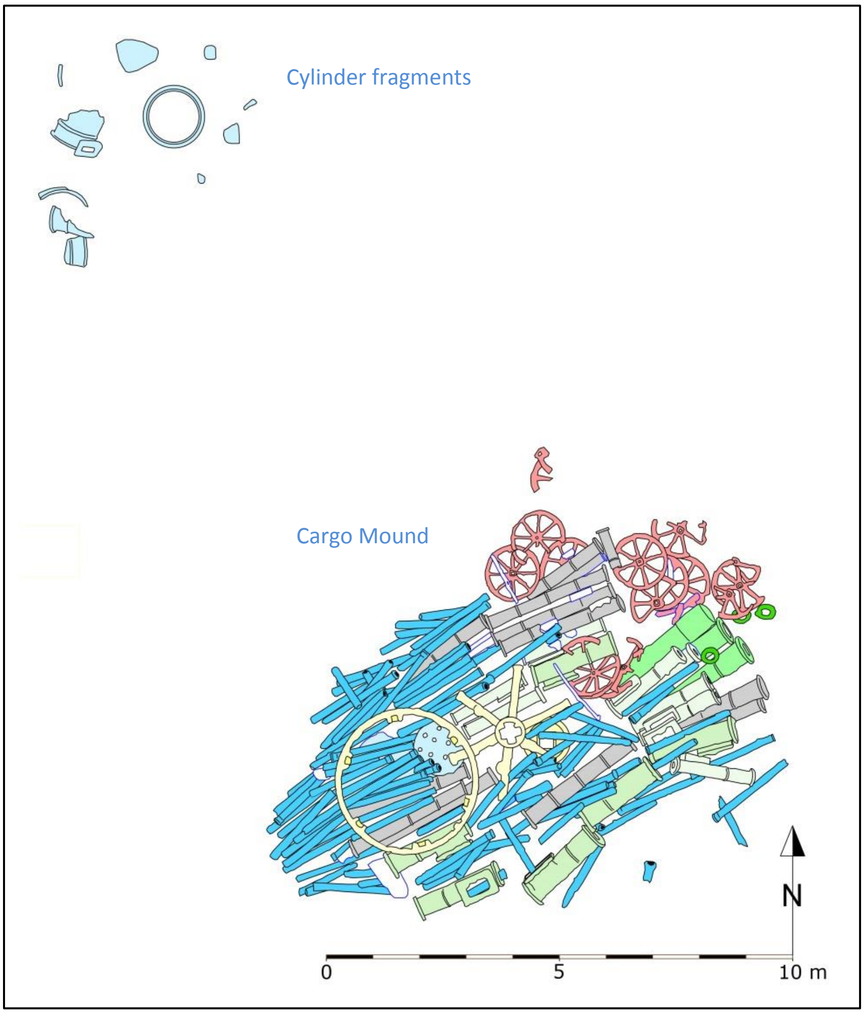


Fig 30
Plan showing the location of the cast iron cylinder fragments relative to the cargo mound.

The cylinder has an internal diameter of 1.08m (42.5 inches), and external diameter of 1.16m; the flange with bolt holes has a maximum diameter of 1.32m. This is probably a steam engine cylinder – engine cylinders of this period are usually categorised by their internal diameter in inches (Barton, 1966). If this is a cylinder from a steam engine, it is probably not from a rotative engine, as rotative engine cylinders of this period are usually of smaller diameter than this example (Stewart, 2017). The most likely use for this engine is as a pumping engine for raising water in a mine, waterworks or in a canal system. One further possibility is that it was a 'blowing engine' used to blow air into a blast furnace. An example of such an engine is the 42 inch Grazebrook blowing engine which was built by M & W Grazebrook to a Watt design in 1817, and survives at Dartmouth Circus in Birmingham.

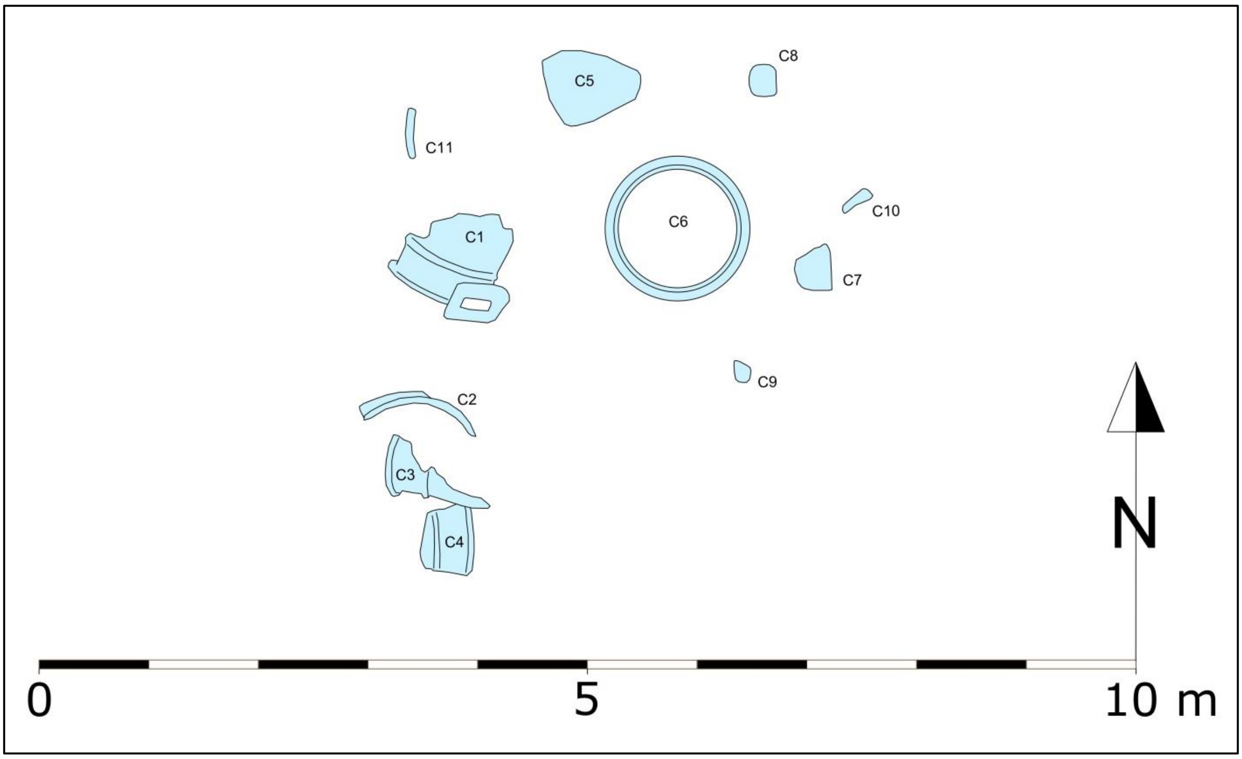


Fig 31 - Plan of the eleven cast iron cylinder fragments C1-C11. Only one fragment (C6) shows the whole diameter of the cylinder – and this has a large fracture running vertically down the southern side.

Fig 32
The Grazebrook blowing engine preserved on a traffic island in Birmingham. The engine was built in 1817 and has a 42 inch cylinder (the same diameter as the Wheel Wreck cylinder). The drive cylinder is on the left, cased in wood – the cylindrical object on the right is the 84 inch air pump.

A small fragment of cast iron cylinder (F111) was recovered for further investigation. When the sample was mounted, sectioned and polished it was possible to establish the true thickness of the cylinder wall, measured at 21mm (7/8 of an inch) in the piece collected – see appendix II.

Fig 33
The broken cast iron cylinder (C6) lying upright on the seabed. Note the flange at the bottom and the reinforcing ring on the outside – 0.33m above the flange. The cylinder survives to a height of 0.84m with an internal diameter of 1.08m (42.5 inches)

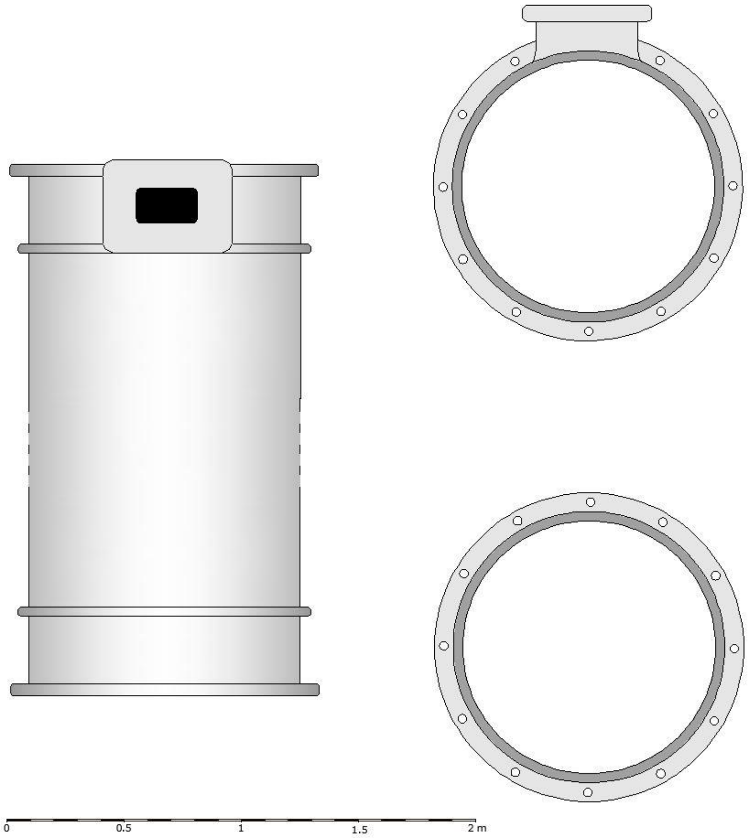


Fig 34
A reconstruction drawing of the Wheel Wreck cast iron cylinder. We do not know exactly how tall the cylinder would have been as it is so badly broken – the reconstruction shows a cylinder height of 8 feet (based on similar 42 inch engines). Note the unusual spacing of the external reinforcing bands (these are usually spaced equidistantly).

Fig 35
A 33 inch engine cylinder on display in the Science Museum, London. This engine was known as 'Old Bess' and was built by Boulton and Watt in 1777. It was used to pump water to drive a water wheel in their Soho works in Birmingham. Note the rectangular steam port similar to that found on the Wheel Wreck cylinder fragment (C1).

The early Bolton and Watt engine known as 'Old Bess' and preserved in the Science Museum London was built in Birmingham in 1777. The engine cylinder has a number of similarities with items discovered on the Wheel Wreck - fig 35. The steam port appears to be very similar to that surviving in fragment C1 - see reconstruction drawing fig 34. The circular object SW2 discovered in 2018 and tentatively identified as a cylinder cover/head bears an uncanny resemblance to that on 'Old Bess' – compare figs 35 and 36.

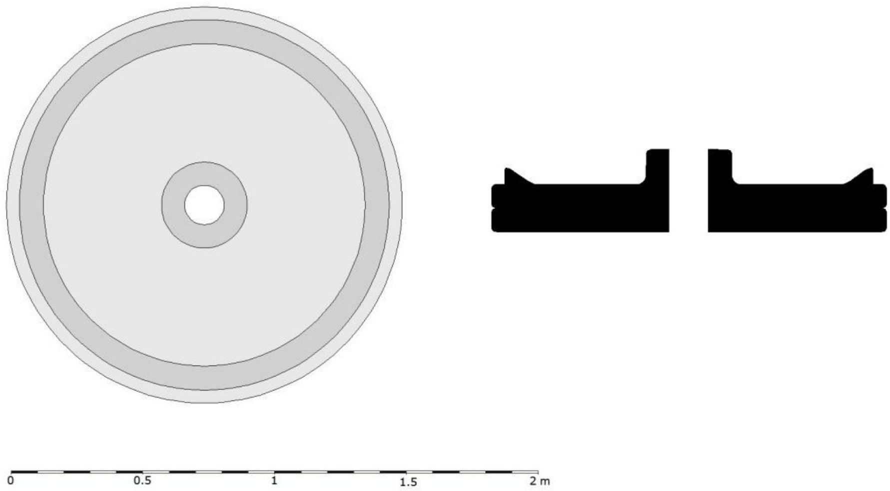


Fig 36

Reconstruction drawing and section of (SW2) – a small circular iron object partly buried under the large toothed wheel (LW1). Reconstructed from remote video footage. The drawing shows the orientation as found in the cargo mound – but the cover as illustrated may be upside-down.

Metallurgy

A small fragment of iron was found adjacent to the cylinder fragment C7 and recovered for further study (sample F111). The complete analysis of the sample is contained in appendix II below. The relic cast iron structure of the sample was identified and the approximate date of the cast iron was estimated. '*In this case an estimate of later 18th or earlier 19th century would be appropriate for the largely 'grey' iron relic structure'*. This accords well with the date estimate for the pottery and glass recovered from the site.

Wiggle Match Dating

The project design states that one of the wooden pulley-block sheaves previously observed on the site would be sought and recovered with a view to attempting C14 wiggle match dating. Peter Marshall of Historic England agreed to assess these for suitability if any were found. Three separate fragments of wooden sheaves were found and recovered (F100, F107 and F114). These samples were sent to Peter Marshall but were not judged suitable for any refinement of the existing date estimate for the site (1770-1820). The explanation provided was as follows:

> *Wiggle-matching would only be practical if large structural timbers had been recovered from the vessel, as this is not the case then the use of this technique cannot be considered. As such the dating of single samples, that would probably provide a calibrated date range of c cal AD 1670-1945, is not going to help refine the dating evidence that already exists, . We will therefore not be undertaking any radiocarbon dating.*

The Oxford Radiocarbon Unit has suggested that wiggle match dating (WMD) would be viable if there were at least 30 rings in one of the samples allowing 6+ AMS dates to be taken at 5 year intervals. However, this would be costly and thus may not be considered worthwhile. What should perhaps now be undertaken is an expert examination of the samples to determine how many growth rings are present and whether there is any sapwood. If no sapwood exists in the samples, then any date obtained would represent a *terminus post quem* rather than a felling date. The samples have been retained and are currently in refrigerated storage.

Recording the Flange Bolt Holes

The pitwork contained within the cargo mound was designed to be bolted together by means of bolt holes cast into the flanges of the clack pieces and rising mains. In earlier pitwork these holes were always square or rectangular in shape; later in the 19th century the holes were usually round in shape (Mitchell, 1899). It is not clear why the holes were square, round sectioned bolts were used, but the heads and nuts were also square in the earlier examples. It would seem, however, that circular washers were used to bridge the square flange holes.

Fig 37
Detail of the square flange holes, round bolts with square heads and round washers common on Cornish pitwork in the 18th and early 19th century. This example is at East Pool Mine, Taylor's Shaft near Redruth.

Fig 38 - Examples of rectangular and square flange bolt holes – these are 13 inch rising mains reused as mooring posts at Penzance quay (internally filled with concrete). The scale is 10cm long.

A detailed examination of the flanges from three items in the cargo mound was made in order to establish the shape and size of the flange holes. This involved removal of weed growth and small amounts of iron concretion.

Fig 39
Exposed square shaped bolt hole in the flange of rising main (RM8). Scale = 0.5m long

The results are summarised in the table below; The larger rising main and the large clack piece (RM8 & CL2) had square shaped bolt holes 30x30mm, while the smaller rising main (RM13) had square shaped bolt holes 25x25mm.

Flange Bolt Hole Dimensions				
Context	**Type**	**Internal diameter**	**Length**	**Flange bolt hole**
RM8	Rising main	9 inch (0.22m)	9 ft (2.77m)	1 1/8 inch □ (30x30mm)
RM13	Rising Main	6-7 inch (0.16m)	9 ft (2.74m)	1 inch □ (25x25mm)
CL2	Clack piece	9-10 inch (0.24m)	6 ft (1.87m)	1 1/8 inch □ (30x30mm)

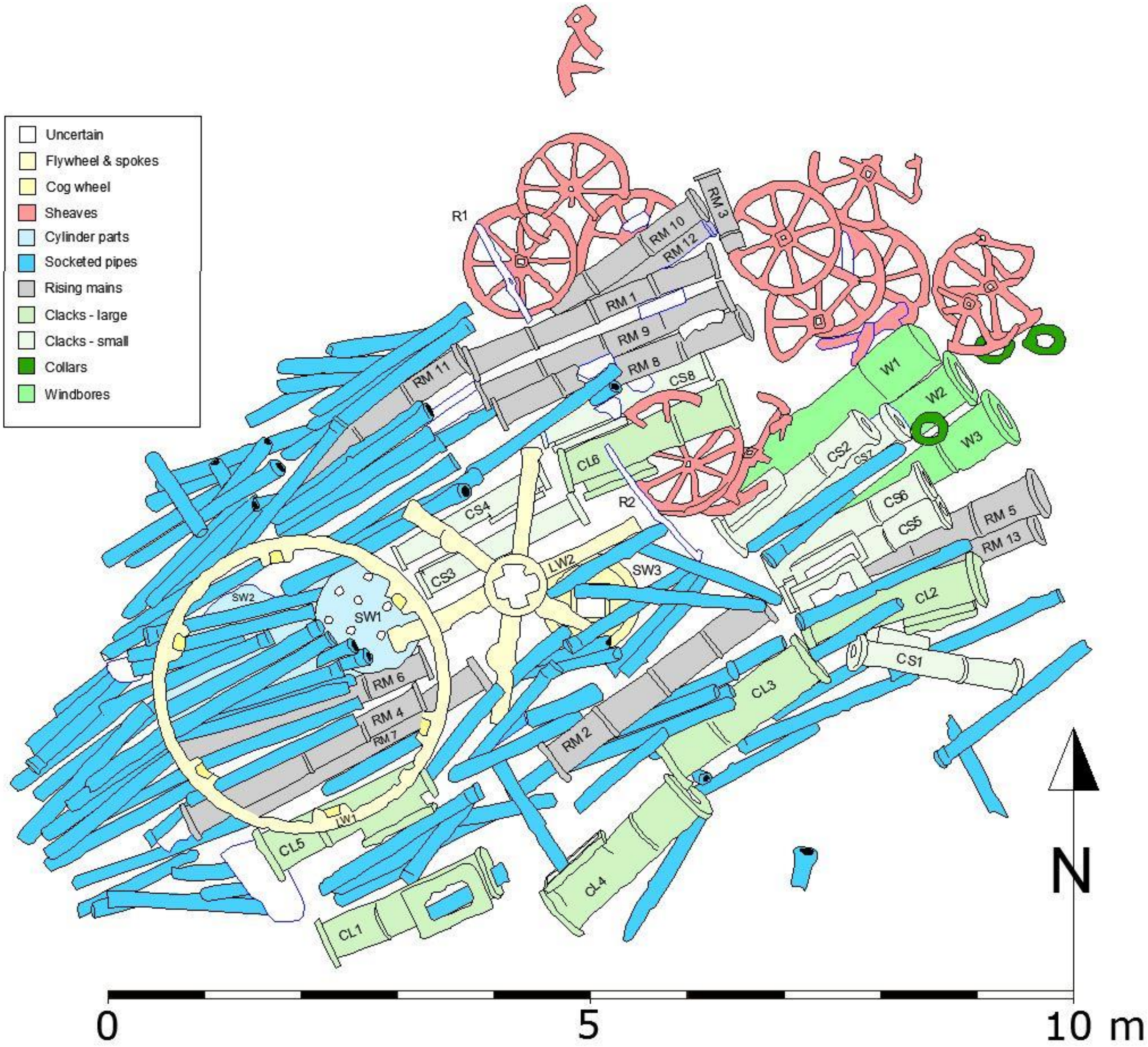


Fig 40 - Plan of the cargo mound showing the positions of the three cargo items where the flange holes were examined: clack piece (CL2), rising mains (RM8) and (RM13).

The Epoxy Putty

In 2018 a small area of iron concretion was removed from the large wheel rim (LW1) to allow inspection of the gear teeth on the outer rim. After recording, the de-concreted area was protected using epoxy putty (Camidge, et al., 2018, p. 13). In 2019 an inspection of the epoxy putty was made to determine how it had fared after 12 months on the seabed. The epoxy putty had become coated in the same fine flora which covers the rest of the iron objects on the site, which made locating it challenging. The growth was removed by lightly wiping the area with a gloved hand, and this showed that the epoxy putty is still in place and in good condition.

Fig 45- Two views of the large toothed wheel, (LW1) showing the epoxy putty (arrowed) put in place in 2018 to cover the small area deconcreted to enable recording of the gear teeth

The Remains of the Vessel

We do not know the name or the precise date of the vessel carrying the 'Wheel Wreck' cargo. The finds recovered from around the cargo suggest a date of 1770-1820. Very few objects originating from the vessel (rather than personal items or the cargo) have been located: three lead scupper pipes, eight wooden block-sheaves with copper-alloy coaks, and two complex iron objects which were possibly windlasses. In addition some lead sheathing probably also originated from the vessel. The distribution of these objects is similar to that of the pottery and glass which has been recovered. This is discussed in the 2018 project report (Camidge, et al., 2018, pp. 49-54)

The paucity of remains from the vessel itself is puzzling; at the very least the anchors should be evident. Even a simple wooden vessel requires iron or copper fastenings to hold the hull together – no hull fastenings have been located on this site. The lack of ironwork associated with the masts and rigging is perhaps more easily explained as these could easily have drifted away or been salvaged shortly after the loss of the vessel. However, the nature of the seabed around the cargo mound (large, tightly packed granite boulders) makes locating small objects difficult.

Further work has been undertaken recording the iron windlasses (O3 & O5) and discovering concordances for the unusual triangular copper alloy sheave coaks.

Recording the Windlasses

One of the few survivals from the vessel itself is two, very similar, complex iron objects (O3 & O5) which appear to be constructed of wrought iron. They were both found on the seabed to the south of the cargo mound - fig 46. Although the function of these two objects is not certain, their appearance is suggestive of a deck-mounted windlass. Proper investigation of the form and precise dimensions is not possible without removing the iron concretion from around them. We did, however, take a series of photographs of each to enable 'structure from motion' 3D models to be produced. Each consists of a central, cylindrical 'ropeway' with complex fittings on each side.

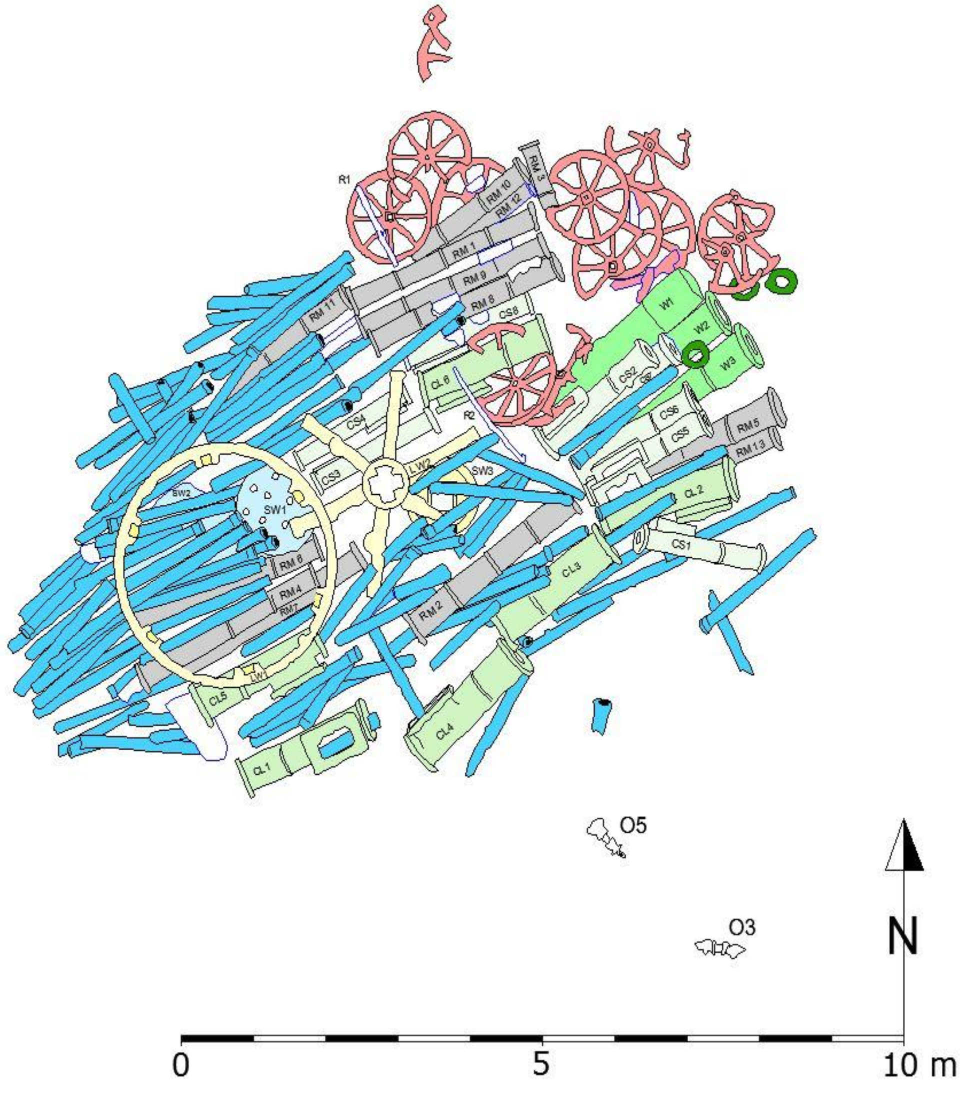


Fig 46 - The location of the two complex iron objects (O3) and (O5) to the south of the cargo mound

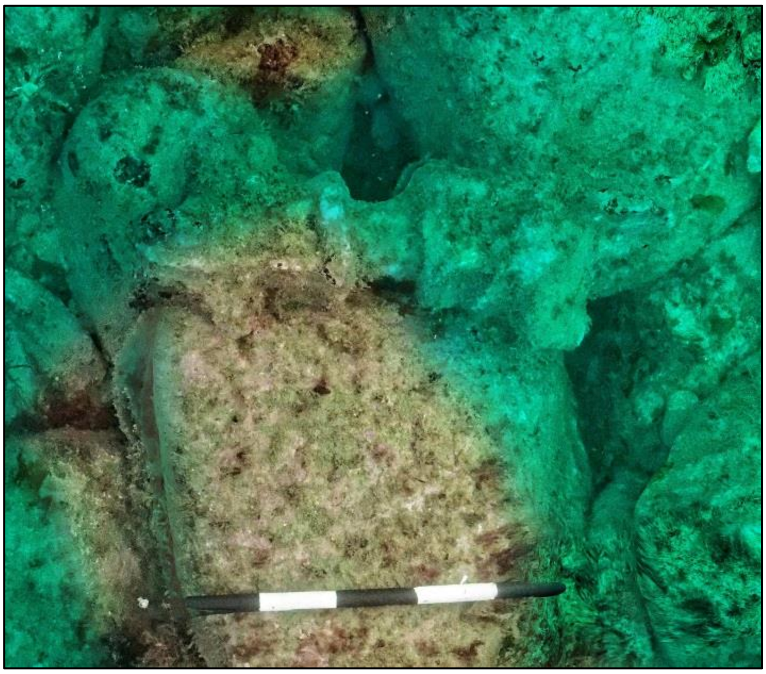


Fig 47

One of the complex iron objects found to the south of the cargo mound (O3). This is an ortho output from the 3D 'structure from motion' model

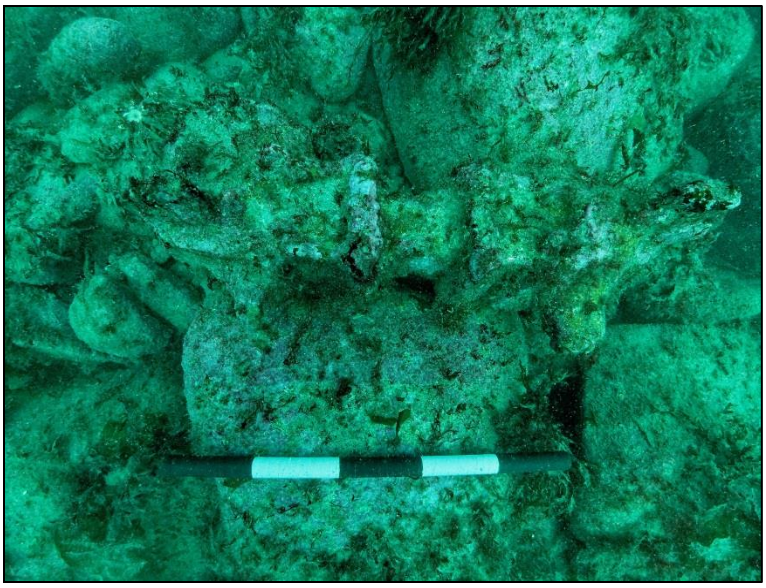


Fig 48

The same object (O3) shown in an underwater photograph

Scale = 0.5m

The 3D 'structure from motion' model can be viewed on the CISMAS Sketchfab page:

https://sketchfab.com/3d-models/wheel-wreck-possible-windlass-ww-o3-4686ed0a258f4dcda2c75fb880632596

The Triangular Sheave Coaks

Although very little from the vessel itself has been found on the site, one exception is a number of pulley-block sheaves and coaks (all probably derived from the rigging of the ship). Five were found in 2018 and a further three in 2019. The sheaves themselves are made of wood, and while no formal identification has yet been made they appear to be of oak. Of particular interest are five copper-alloy coaks which are of an unusual design (F21, F22, F23, F29 and F100). They are triangular in shape with the ends of the 'lobes' cut off square – see figs 49-51 below. One coak of the conventional round-lobed design was also found (F33). A detailed description of these appears in the 2018 project report (Camidge, et al., 2018, pp. 50-51). The coaks appear to be asymmetrical and their dimensions are not uniform, suggesting that they were hand made. A concordance for similarly shaped sheave coaks has been found on the wreck of the *General Carleton*, wrecked off the Polish coast in 1785, built at Whitby in 1777 - fig 52 below. It should be noted however that the excavator reports that the coaks were made from steel (Polish Maritime Museum, 2008, p. 310). Although this does not constitute conclusive dating, the use of coaks of the same form in 1777 does offer support to the current date range 1770-1820 assigned to the Wheel Wreck.

Fig 49 - Wooden sheave with triangular copper alloy coak (F100) found on the Wheel Wreck in

Fig 50 - Triangular copper alloy coak (F22) found on the Wheel Wreck in 2018

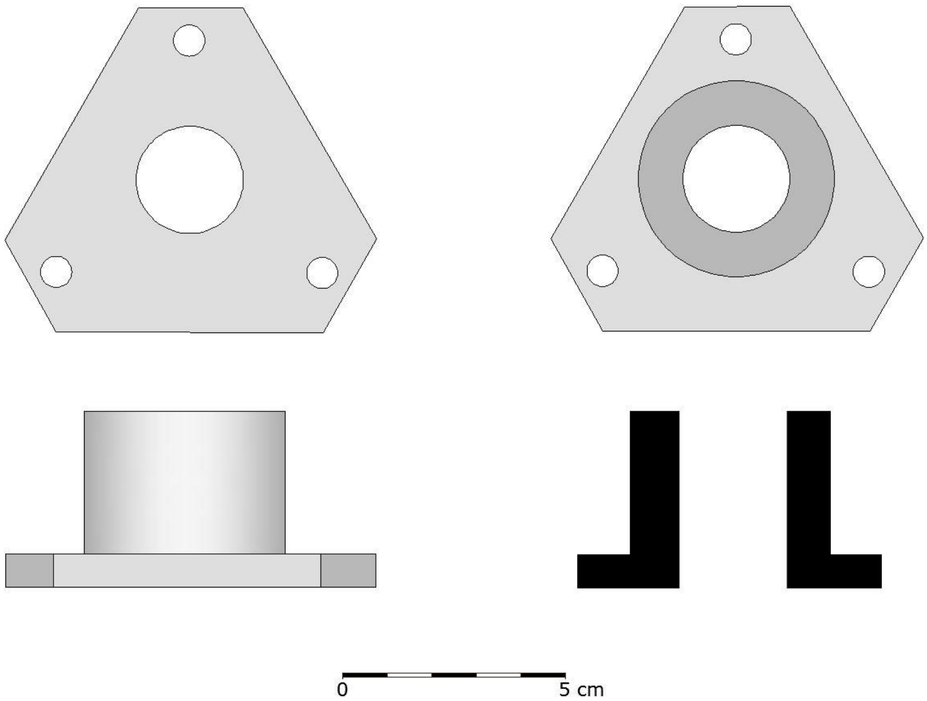


Fig 51 - Reconstruction drawing of one of the copper alloy coaks (F22) found on the Wheel Wreck in 2018. The dimensions of each individual coak varies slightly.

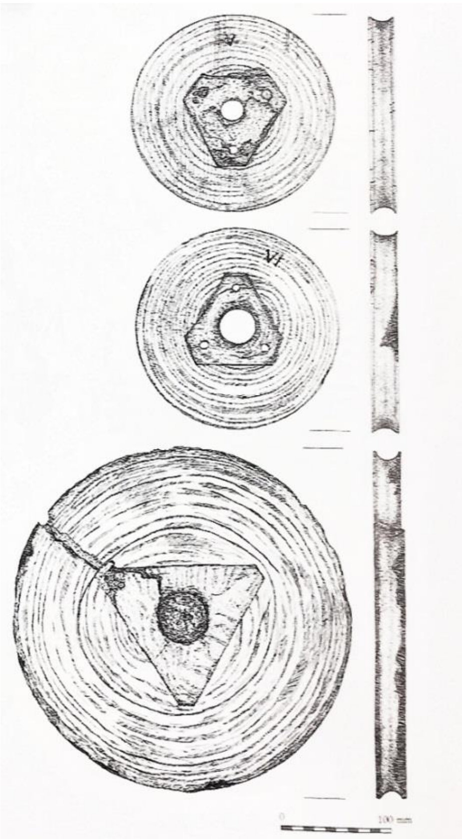


Fig 52
Block sheaves found on the wreck of the General Carleton*, built at Whitby in 1777. Note the shape of the coak cutouts in the sheaves – which matches the shape of those found on the Wheel Wreck.* (Polish Maritime Museum, 2008, p. 310)

The Identity of the Vessel

We have not been able to identify the vessel which was carrying the 'Wheel Wreck' cargo. Not only are the remains of the vessel sparse but its identity has proved elusive. The vessel identity was discussed at some length in (Camidge, et al., 2018, pp. 47-61) A study of the vessels known to have foundered in Scilly between 1770 and 1840 was undertaken in an attempt to throw some light on the matter. In total 45 candidates were identified spanning the years 1775 to 1840, and these are presented in Appendix IV below. The criteria for selecting these candidates were date, cargo, location and the voyage origin/destination.

Date: Although the date range established by the associated pottery and glass is 1770-1820 this was extended to 1840 to include the *Plenty* (wrecked 1840) which has been suggested as a candidate for the Wheel Wreck (Edward Cumming personal correspondence).

Cargo: The listed cargo eliminated many of the known wrecks in Scilly within the target period. Five of the candidate wrecks have a cargo listed as iron, the rest of the candidates (40) had no cargo specified. This was later reduced to 37 as three cargoes were identified from other sources (pilchards, coal and copper ore). The term iron can cover a great many types of cargo, and need not refer to the pitwork and engine parts comprising the Wheel Wreck cargo.

Location: The wreck had to be located in or near the Isles of Scilly to be included. Many wrecks are reported as 'lost in Scilly' but where a more precise location is given this often eliminated the wreck. Only those locations close to the Wheel Wreck were selected. The most relevant location is probably Crow Sound and Crow Bar. Five of the candidate wrecks mention Crow Bar or Sound as the location of loss: *Linnet*, Unknown, *Shannon, Prosper* and *Victoria* (for details see Appendix IV).

Voyage: The origin and destination of the voyage was listed for 30 of the 45 candidates listed. The most common starting port was Newport which applies to five of the candidate vessels; no less than nine of them began their voyage in Wales.

Once the candidate vessel list had been constructed, a search was made in the British Newspaper Archive for each of the vessels. This resulted in extra information coming to light for about half the wrecks and enabled nine of the vessels to be eliminated, leaving 36 candidates. The eliminated wrecks have been left in the list – but shaded to show that they are no longer candidates (the reasons for elimination have been highlighted in grey). This leaves 19 vessels (three unnamed) of the late 18th century – the most likely group in the author's opinion - and 17 in the early 19th century (four of which are unnamed). At present we are simply not able to say which of these is most likely to be the vessel which resulted in the Wheel Wreck; indeed, it is possible that the Wheel Wreck vessel is not in the candidate list at all.

Discussion

The Wheel Wreck

Although the primary aim of this project was the refurbishment of the *Colossus* dive trail an ancillary aim was to refine the dating for the Wheel Wreck with the aspiration that this would aid the identification of the vessel – and thus the cargo origin and destination. Sadly, this aspiration remains largely unfulfilled. Further pottery and glass objects were found and recovered, but analysis of these did not narrow the existing date span, which remains at 1770-1820. Three small timber samples were collected, but the hoped for wiggle match carbon 14 dating did not as it turned out prove possible. However, these samples have been retained in case it should prove possible to take this forward at a future date.

It is worth reiterating what has been found - and what is missing. We have a cargo of cast iron parts, to the most part in an orderly, rectangular pile apparently still delineating the shape and size of the hold in which they were originally stowed. From this an estimate of the vessel size was made (Camidge, et al., 2018, pp. 47-49). Of the vessel itself, remarkably little is evident: three lead scuppers, eight block sheaves and coaks (running rigging parts), two possible deck windlasses and some strips of sheet lead. The absence of the vessel's fabric is plausible as it would have been made of wood which is unlikely to survive on the rocky seabed of this site. But where are the iron fastenings which held the hull and masts together? Where are the anchors, hawse pieces and other iron parts of the vessel?

The original site appraisal undertaken in 2005 dealt with this conundrum by suggesting that the vessel capsized and deposited the cargo on the seabed and then floated away (Wessex Archaeology, 2006). Attractive as this scenario is in terms of explaining the lack of vessel remains, it does not explain the orderly stack of the cargo mound – which would surely present as a much more haphazard and scattered pile of pipes and wheels if they had fallen from the hold to the seabed. This is especially so when you consider the nature of the seabed beneath the cargo mound – large, unevenly spaced boulders. The cargo mound as a whole has very large voids beneath it – these suggest that the pipes and wheels were bound together by the iron corrosion products before the wooden hold containing them had decayed. The masts could have been salvaged after the wreck given the relatively shallow water of the wreck site. The anchors may have been salvaged or possibly deployed prior to the wrecking - in which case they may be lying on the seabed some 40-100m distance from the cargo mound. There is also the question of the loading order. If the cargo has fallen from a capsized vessel then it is now upside-down – see fig 40. The question of cargo stacking is explored in more detail in the 2018 report (Camidge, et al., 2018, pp. 14-42).

It is not uncommon for historic wreck sites to remain unidentified – for example of the 54 protected wreck sites in England only 30 have been positively identified, three have plausible but not proven identities and 21 remain unidentified (almost 40% of the total). A list of candidate wrecks for the Wheel Wreck has been constructed – see Appendix IV. This lists 36 vessels lost in Scilly, any one of which could be the vessel we seek. There is also the possibility that the vessel concerned is not on the candidate list at all. We may never know the identity of the Wheel Wreck. A good exemplar of this possibility is the entry for 1784 in the candidate list presented in Appendix IV:

> *Several vessels wrecked during the month of January … in gales and fog. 'A letter from St Mary's in Scilly has the following article: We have had such blowing and foggy weather, that more Vessels have run on the rocks than have been remembered for a long Time before, and indeed it is no wonder, for the thickness of the fog hid the Light from the Eyes of the Mariners, and almost every night there were Signals of Distress made, but it was impossible for us to give them any Assistance, without Danger of being lost ourselves. A great many Pieces of Wreck float on the Water, but we have not yet been able to get any Account of what Ships are lost'*

To make a credible identification of the Wheel Wreck vessel we need to narrow down the possible date range or discover a cargo description which matches the cargo mound on the seabed. The attempt to narrow the date range has so far failed, and despite considerable research no detailed cargo descriptions for any of the candidate wrecks have been found.

As previously noted, others have suggested identifications for the wheel wreck. Richard Larn has proposed the *Padstow* (1804) while Edward Cumming has suggested the *Plenty* (1840). Both are included in the candidate list in Appendix IV but neither can claim anything decisive by way of association with the Wheel Wreck. The *Plenty* probably lies in deeper water about a mile to the east of St Mary's, and seems too late to fit with the dating evidence we have. Even the *Padstow* is probably slightly too late to fit comfortably.

What we have achieved is a fairly good understanding of what the individual components of the cargo mound are. These identifications have been covered in the results section above and in the 2018 report. What is clear is that this is not a coherent collection of Cornish mine pumping components, as previously thought. The steam engine is missing major components and the pitwork has an imbalance in the numbers of clack pieces, rising mains and windbores. If this cargo was destined for a single project then further shipments would have contained the missing items. It should also be noted that in the 18th century it was common for engines to be sourced from several different manufacturers at geographically disparate locations. The major engine items missing are the boiler, beam parts, condenser and air pump as well as the many sundry valves and control rods. While the engine cylinder diameter would seem to exclude winding engines, we should also take care to consider the other uses to which pitwork and engine parts may be put: canal systems, water works and blowing engines, to name but a few. Many features of the cargo suggest a late 18th century rather than a 19th century date, which agrees with the metallurgy, chemical analysis of the glass and the concordance for the triangular copper alloy coaks.

The cargo is composed entirely of iron castings. Two separate castings have been subjected to metallurgical analysis: a fragment of the iron cylinder (see appendix II) and one of the socketed water pipes (Camidge, et al., 2018, pp. 71-74). The socketed pipe analysed in 2018 was found to be predominantly composed of white cast iron, while the fragment of cylinder analysed in 2019 was mottled cast iron (a mixture of white and grey cast iron). The terms 'grey' and 'white' cast iron derive from their physical appearance when freshly broken. The white appearance is caused by the presence of a small amount of cementite (iron carbide), while grey cast iron results when the cementite breaks down into graphite (free carbon) while liquid (Bailey, 1975). White cast iron is very hard and brittle and would have been impossible to machine in the 18^{th} century. White iron also shrinks considerable on solidifying, while grey shrinks very little. Grey cast iron is less brittle and is more easily machined – important for items like the engine cylinder which would have been machined. Grey and white forms of iron can be formed from the same pour and even in the same casting:

> *Yet grey and white iron were nominally the same metal. In fact the two appearances could come from the same melt, and could even be found simultaneously in the same iron casting. They could even be found intimately mixed together, when the colour was described as mottled.* (Williams, 2013, p. 127)

A number of factors influence the form of the finished casting, but the main one is the rate of cooling. The longer the casting took to cool the more likely it was to form grey cast iron. Thicker castings (or thicker parts of the same casting) would take longer to cool and be more likely to form grey iron. The founder could also influence the outcome by changing the proportions of carbon, silicone and phosphorous in the mix.

The presence of white and mottled cast iron in the cargo samples analysed runs counter to what we would expect. The mottled cast iron found in the cylinder sample would have made the cylinder very difficult to machine. The white cast iron of the socketed pipes would have made these pipes extremely brittle. However, the sample was taken from a broken fragment of pipe – it may have broken because this particular pipe was unusually brittle – the unbroken pipes may have been the more usual grey iron. We have the possibility that these castings were substandard – but we do not know how common this was at that date. This is clearly an interesting avenue of research and the collection of further samples from the cargo mound should be considered.

The most numerous items in the Wheel Wreck cargo mound are the socketed water pipes with over a hundred having been recorded – thus representing at least 600 feet of pipework when assembled. These low pressure cast iron water pipes were not a recognised feature of 18^{th} century Cornish mining equipment. They can, however, still be seen in use to this day as underground drainage pipes in Penzance and other towns (Camidge, et al., 2018, p. 17).

How do we improve our understanding of this unique wreck? The most obvious requirement is to improve the dating of the site. We have probably exhausted what can be done by recovering pottery and glass from the seabed, and it is clear from the work undertaken in 2019 that only smaller, less diagnostic items remain on the surface. A small scale excavation next to the cargo mound (especially on the southern side) may expose timbers from the vessel which could facilitate C14 wiggle match dating - indeed the small timber samples already collected may prove suitable if sufficient growth rings survive, and this should certainly be investigated. Although this would only provide a *terminus post quem* for the manufacture of the pulley sheave, even this would be helpful in our quest to date this wreck.

As previously suggested, a detailed magnetometer survey of the area around the cargo mound may bring to light further items associated with this wreck – especially the vessel's anchors which are currently entirely missing.

As the metallurgical samples taken to date have yielded useful information, further sampling of the different elements of the cargo mound could be a very useful source of further information.

Lastly, the condition of the cargo mound needs to be periodically monitored. The majority of the cast iron appears to be robust and strong, but where broken pieces have been sampled they have been found to be extremely frangible with little more than finger pressure required to break pieces off. Shot weights or small boat anchors dropped onto the cargo mound are likely to cause considerable damage.

Colossus

The *Colossus* dive trail was successfully refurbished. Physical dive trails offer a unique opportunity for the diving public to experience historic wreck sites with interpretive assistance. However, one of the drawbacks of physical dive trails is that the trail needs to be monitored and refurbished at regular intervals (much like terrestrial sites which are open to the public, but do not have custodial staff). If the dive trail is not monitored and refurbished as necessary it will become ineffectual as a dive trail – as indeed the *Colossus* dive trail was by late 2018. A new, simpler underwater information slate has been produced. This is available on the Isles of Scilly dive charter boats and as a downloadable PDF on the online virtual dive trail. The older, more comprehensive, dive booklet is still available as a downloadable PDF on the CISMAS website.

The sediment levels around the *Colossus* have been measured regularly since 2003. This is the most extensive set of sediment level data from any of the protected wreck sites – the levels have been measured on 32 separate occasions over the last 17 years. Maintaining sediment level monitoring points on the seabed is neither easy nor glamorous. I have long believed that this data set is undervalued and is deserving of specialist analysis. In 2019 there was a modest diminution of sediment level (a mean fall of 7.46mm relative to the levels pertaining in 2018). A fall in measured sediment height has been recorded every year except in 2003 and 2007, when the mean levels actually rose. The greatest mean fall in levels was recorded in 2011, when it fell by 69mm. The sediment level monitoring points have been renewed twice since they were installed in 2002. I understand that formal sediment monitoring is no longer undertaken on other protected wreck sites. It may be time to consider the value of continuing to collect this data on the *Colossus* site. A summary of the sediment level data (2003-2018) is presented in appendix V.

One of the items recently exposed by the falling sediment levels on the site was a deadeye and chains C10.1 exposed on the diver trail (between station markers 1 and 10) in 2017. A series of photographs were taken to allow a 3D 'structure from motion' model to be produced; this has been placed on the Scilly virtual dive trails web site. The upper, wooden part of the deadeye is already being attacked by marine wood-boring organisms. This is evident on the photographs and on the 3D model – see fig 11.

The two lead weights recovered from the site in 2019 would appear to have been lost or jettisoned by the early diving pioneers the Deane brothers while salvage diving on the wreck of *Colossus* in 1833. This is important and portentous. We know that salvage divers worked on the wreck of *Colossus* – but we have never known upon which of the two wreck sites (Roland Morris' bow site or the 2001 stern site) these operations occurred. The Deans arrived in 1833 and quickly found the site, which suggests that they were informed where to look by those who had witnessed the wreck. This strongly suggests that the wreck site of *Colossus* was perceived to be where the stern lies now (and where the Deanes' weights were found), and not where Roland Morris found pottery and scattered iron guns. This not only corroborates the wrecking theory proposed in 2017 (Camidge, 2017). It also explains the mystery of the missing guns on the stern site – they were salvaged by Tonkin (1799) and the Deanes (1833). The only guns left on the stern site were those partly buried in the seabed (Guns 1 to 6) and thus not easily recovered. At last the oft-repeated assertion that *Colossus* was wrecked on Southard Well Reef, near to the site salvaged by Roland Morris, can now be put to rest.

The two diving weights have been loaned to the Historic Diving Museum in Portsmouth where they will be displayed with the Dean diving helmet. Ultimately, they will be returned to the Isles of Scilly, once the St Mary's museum reopens.

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Appendix I – Objects Recovered

Wheel Wreck 2019 Objects Recovered						
No	**Search**	**Material**	**Position**	**Dims (mm)**	**Description**	**Date**
F100	E(90)	Copper alloy & wood	265180.06 5537182.32	95x90x28	Fragment of a wood pulley-block sheave with attached triangular copper alloy coak bearing <Sent to Peter Marshall 15.10.2019>	
F102	N(05)	Ceramic	265172.35 5537195.72	70x40x3.5	Plain. Staffordshire-type white ware.	After 1750
F103	P22	Glass	265187.62 5537208.29	92x56	Shallow vessel, straight sides slightly angled. Hole in centre of circular base. Colourless glass. Has a raised moulding around the vessel just below the rim, possibly to help secure a lid The crispness of the moulding especially around the rim and at the heel suggests that the vessel *could* be machine moulded and therefore modern. Probably a diesel filter cover from a small boat	20th C
F104	P22	Ceramic	265175.56 5537208.29	30x25x8 30x18x8	2 very small frags of mineralised friable material. Possibly not pottery at all or prehistoric?	?
F105	P22	Ceramic	265170.53 5537182.38	62x45x5	North Devon gravel-tempered ware. Unglazed, thin. Part of a jug?	15th C-16th C
F106	P67	Iron	265180.97 5537179.26	115x9x0.2	Thin strip of magnetic metal	20th C
F107	P157	Wood	265176.06 5537172.26	65x55x25	Fragment of eroded pulley-block sheave with triangular recess – probably for a coak (see F100) <Sent to Peter Marshall 15.10.2019>	
F108	P157	Glass	265180.46 5537169.65	85x75x7	Wine bottle, sherd from heel of bottle. Green glass	late 18th - early 19th C
F110	P157	Glass	265180.69 5537165.83	76x62x8	Wine bottle, body sherd. Green glass. No diagnostic features	late 18th - early 19th C
F113	P157	Ceramic	265182.60 5537154.82	50x42x5	North Devon gravel tempered – part of a globular jug similar to 137	1550-1800
F114	P157	Wood	265182.15 5537165.34	90x65x25	Eroded wood with the remains of a hole 25∅ - part of a pulley-block sheave? <Sent to Peter Marshall 15.10.2019>	
F115	G(W)	Ceramic	265165.39 5537172.95	110x60x10	Sherd of a Portuguese red coarseware olive jar or costrel. (formerly known as Merida ware)	1500-1720
F116	QSE	Lead	265180.50 5537166.68	75x51x1.4	Lead sheet, one square nail hole	?
F117	QSE	Glass	265180.67 5537173.95	45x44x4	Wine bottle heel sherd. Green glass. Bulged heel, probably dip-moulded	late 18th - early 19th C
F130	P157	Glass (x2)	265175.90 5537172.35	83x81x7	a) Wine bottle small sherd from heel of wine bottle, probably dip moulded. b) Square base probably from a case bottle. Green glass. Could be as early as 17th-century or as late as early 20th-century	a) probably late 18th – early 19th C b) probably 18th or 19th C
F131	QSE	Glass	265171.38 5537171.65	42x40x6	Wine bottle, body sherd. Green glass. No diagnostic features	could be late 18th - early 19th C
F132	QSE	Glass	265171.43 5537171.50	72x60x6	Wine bottle pushup, low domed. Not closely datable	probably mid to late 18th C
F133	QSE	Glass	265171.51 5537171.33	46x35x4	Wine bottle, body sherd. Green glass. No diagnostic features	probably 18th or 19th C
F134	QSE	Ceramic	265172.81 5537170.55	56x20x3.5	White ware. Staffordshire type earthenware.	1750 - 1920
F135	QSE	Glass	265173.19 5537168.51	37∅x16	Wine bottle finish, down tooled rim over applied string rim. Green glass	late 18th - early 19th C

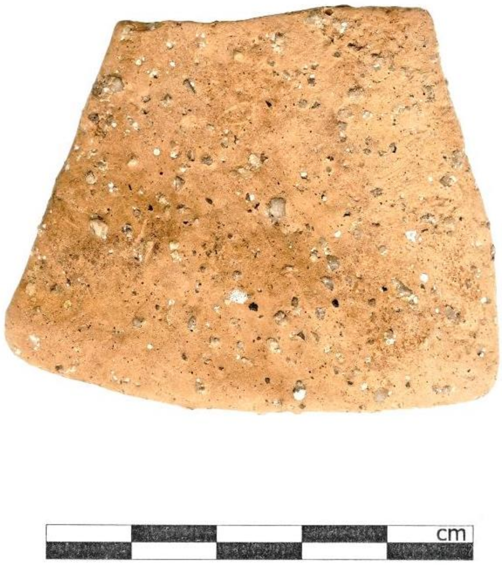
Wheel Wreck 2019 Objects Recovered						
No	**Search**	**Material**	**Position**	**Dims (mm)**	**Description**	**Date**
F136	QSE	Copper Alloy	265173.28 5537168.36	47x35x0.4	Thin copper-alloy sheet	?
F137	QSE	Ceramic	265169.91 5537163.80	30x25x3	North Devon, thin wheel-thrown	Late 15th/16th C
F138	QSE	Glass	265181.07 5537169.22	90x88x6	Wine bottle, body sherd. Green glass. No diagnostic features	probably 18th or 19th C
F139	QSE	Ceramic	265173.79 5537171.88	90x74x6	Black-glazed red ware ribbed body fragment. 'Jackfield –type', possibly part of a jug	18th – early 19th C
F140	QSE	Ceramic	265173.94 5537171.73	67x42x6	Red earthenware. Possibly North Devon	16th - 17th C

F100, the remains of a timber block-sheave with a triangular copper-alloy coak

F103, glass object – probably a filter bowl

F102, white ware pottery sherd

F104, pottery fragments?



F105, fragment of North Devon shell tempered ware

F107, eroded fragment of wooden pulley block sheave

F106, a sliver of extremely thin ferrous metal sheet

F108, fragment of glass wine bottle

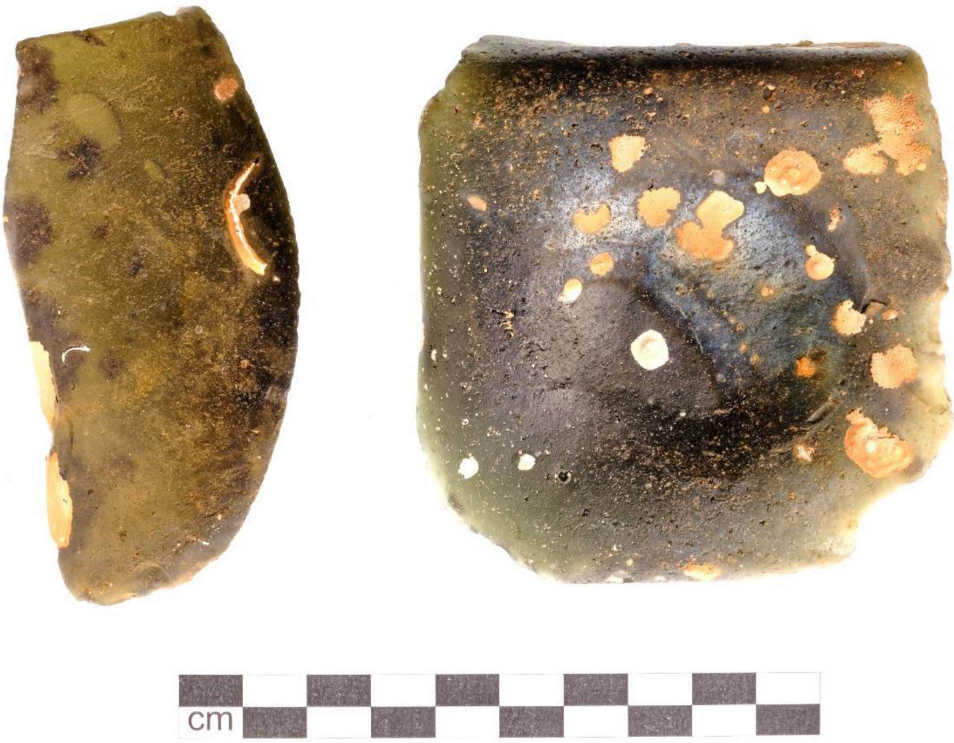
F110, fragment of glass wine bottle

F113, North Devon shell tempered ware

F114 eroded fragment of wood

F115 coarse ware pottery fragment

F117 coarse fragment of glass wine bottle



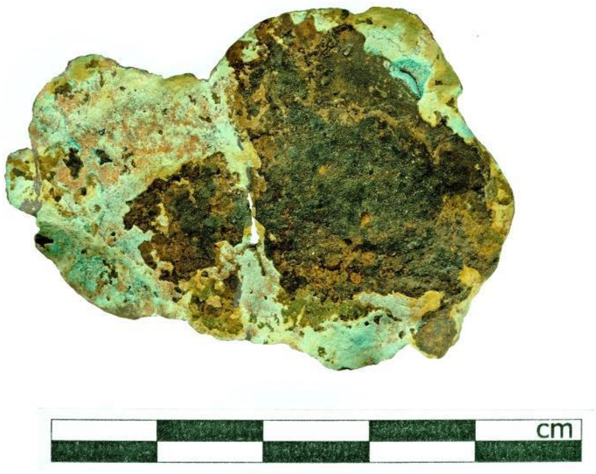
F130 two glass bottle fragments – the piece on the right is a square base from a case bottle

F131 fragment of bottle glass

F132 fragment of bottle glass

F134 white ware pottery

F135 part of a glass wine bottle rim



F136 fragment of copper sheet

F133 fragment of bottle glass

F137 fragment of pottery

F138 fragment of glass bottle

F140 red earthenware pottery fragment

Pottery and Glass recovered for dating in 2018				
Context	**Type**	**Description**	**Preliminary date**	**Author**
F1	Glass	Green bottle base with deep kick and pontil mark. Formed in a dip mould with kick made after removal from the mould. Plus a fragment of shoulder	1760s -> 1820s	IS
F2	Pot	Rim of a buff earthenware vessel, soft-fired. Plant pot?	?	JA
F3	Pot	White ware chamber pot with part of the handle	Post 1770	JA
F4	Pot	North Devon gravel-tempered coarse ware	17-18th C	JA
F5	Pot	Grey brown salt glazed stoneware seltzer bottle. Possibly German	18th C ->	JA
F6	Glass	Fragment of green vessel glass	?	
F7	Pot	Rim of white ware bowl – Staffordshire type	Post 1770	JA
F9	Pot	Base of Jackfield or Buckley type coarse ware with internal black glaze	Late 17th - early 19th c	JA
F10	Glass	Bottle base neck and body frag. Free-blown (three frags)	1770-1830 Later 18th C -> early 19th C	JA & JP SP
F24	Glass	Green bottle base with kick and pontil mark		
F25 F26 F27	Pot	English brown salt glazed stoneware bottle. Possibly Bristol	18th - 19th C	JA
F30	Glass	Small green bottle fragment from shoulder		
F31	Glass	Green bottle neck. Neck rim craked off and fire polished. String rim uptooled	1770s -> 1780s	IS
F32	Pot	White ware Staffordshire earthenware	Post 1770	JA
F34	Pot	Rim – North Devon gravel tempered ware	17th - 18thC	JA
F46	Glass	Two frags of green bottle glass (base and body)	?	
JA = John Allan : SP = Sarah Paynter : IS = Ian Scott : JP = Jacqui Pearce				

Table of Objects Recorded in 2018						
Search	**Easting**	**Northing**	**Dims (mm)**	**Description**	**No**	**Recovered**
W	265165.93	5537174.85	300x340x40	Flat iron object, concreted	O1	x
E	265184.41	5537194.51	95x55x3	Pot frag	F7	✓
E	265184.32	5537194.32	26x20x20	Fe frag	F8	✓
E	265180.12	5537187.64	140x50x14	Pot frag (base)	F9	✓
E	265179.57	5537184.71	148x85x2	Lead sheet with nail holes	F28	✓
E	265180.26	5537181.96	60x50x5	Glass bottle neck	F30	✓
E	265176.96	5537186.52	90x20x5	3 glass bottle frags	F10	✓
E	265176.66	5537186.64	80x105x25	Copper alloy sheave coak (2 lobed with flat ends)	F29	✓
P	265172.74	5537184.97	150x100x35	Sheave frag and copper alloy coak (3 lobed with rounded ends)	F33	✓
P	265174.71	5537184.76	140x70x8	Pot frag (rim)	F34	✓
P	265170.14	5537172.43	105x80x5	Glass bottle base	F24	✓
P	265173.88	5537180.20	90x70x4	Glass bottle base	F1	✓
P	265177.69	5537180.42	110x100x45	Remnants of wood sheave with copper alloy coak (coak same as F23)	F21	✓
P	265178.61	5537180.14	85x80x40	Copper alloy sheave coak, 3 lobed with flat lobe ends	F22	✓
P	265178.27	5537180.70	70x25	Copper alloy sheave coak, 3 lobed	F23	✓
P	265165.23	5537174.57	190x140x11	Pot frag	F25	✓
P	265165.09	5537175.05	210x160x8	Pot frag	F26	✓
P	265165.14	5537175.48	110x85x9	Pot frag	F27	✓
P	265174.73	5537184.05	80x50x7	2 frags of bottle glass	F46	✓
S	265184.90	5537164.61	58x55x3	Pot frag, glazed	F3	✓
S	265185.44	5537165.68	60x60x5	Pot frag	F4	✓
S	265179.46	5537171.28	70x65x9	Pot frag (rim)	F5	✓
S	265177.08	5537172.94	111x60x30	Iron, concreted	O2	X
S	265175.62	5537172.07	700x250x300	Complex iron object – see sketch	O3	x
S	265172.38	5537172.02	340x60∅	Lead scupper pipe	O4	X
S	265176.96	5537186.52	85x22x5	Glass frag (green)	F6	✓
S	265174.31	5537173.53	70x30x30	Complex iron object – see sketch	O5	X
S	265189.36	5537160.36	30x20x3	Pot frag	F32	✓
N	265167.69	5537180.25	105x90x10	Pot frag	F2	✓
N	265164	5537191	1.16∅	Iron cylinder	O6	X
NE	265179.08	5537175.46	50x25	Glass bottle frag	F31	✓
P	265174.3	5537176.3	335x61∅	Lead scupper	O7	X
NW	265166	5537177		Fragment of iron – sample for analysis	I 1	✓
NW	265166	5537177		Fragment of iron – sample for analysis	I 1	✓
NW	265166	5537177		Fragment of iron – sample for analysis	I 1	✓
NW	265166	5537177		Fragment of iron – sample for analysis	I 1	✓

2018 object photographs can be viewed in (Camidge, et al., 2018) available to download at www.cismas.org.uk

Appendix II – Iron Analysis by Dr Brian Gilmour

Introduction

Iron is one of the most prevalent materials associated with shipwreck sites, but is often considered the least useful as a diagnostic or dating tool because of its relatively poor survival. Iron can be either associated with the structure of the ship or of the cargo it was carrying when it sank. Unfortunately although almost ubiquitous on shipwreck sites – and sometimes it is almost the only thing to survive – it is generally overlooked as a potential diagnostic tool. But it is possible that iron (the material) or ironwork (the artefacts) can be utilised as a source of useful information that can help identify and date both ships and their cargoes.

Terrestrial survival of ironwork

Modern ironwork quickly corrodes in damp air especially in many coastal environments leading to exfoliation and loss of the shape and metallic structure of the iron. This is partly dependent on the form of iron that is exposed to weathering. Iron also corrodes rapidly in the ground even though the shape of an object often survives relatively well even if the metallic iron usually survives to a very variable extent and sometimes not at all.

Any iron that does survive can often enable the structure of the iron – and hence its type and aspects of its technology to be identified. This in turn can be used as an approximate dating tool as iron technology has gone through a number of changes over time and most of these changes are well known. Unfortunately the well aerated ground conditions usually encountered on land mean that an iron object expands slightly as it corrodes and this leads to the consequent destruction of any of the crystalline structure of the metal. But it is much less well known that where corrosion is slower it can result in a fossilization process where a relic of the original metal crystalline structure is preserved allowing the type of iron alloy to be identified, often surprisingly well even if no metal survives at all. Iron can corrode very slowly in such a way as to become totally mineralized but preserving the shape of at least some of the original iron structure – as a ‘negative relic’ – is well illustrated by the very slow but steady corrosion penetration seen (recently by the author) in one low carbon iron part of a late Anglo-Saxon *seax* (a specialised form of large knife). This has been included here to illustrate how the iron structure ends up as a totally mineralized ‘negative’ of the original iron structure. In this case the original uncorroded iron is visible next to the mineralized part where the low carbon iron crystal microstructure is exceptionally well preserved (fig. 1).

An example like this shows how very slow but steady corrosion in the ground – where access to oxygen is restricted – can leave a relic’ ‘iron micro-structure still in place. This relic structure can allow the original iron metal structure (in this case low carbon iron) to be identified and described even where no actual metal survives.

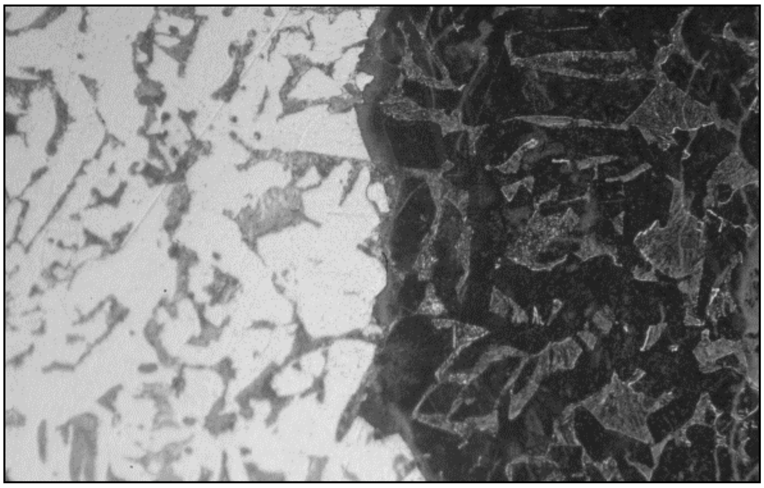


Fig. 1:
View showing the black and white 'colour' inversion typical of the effect of the very slow corrosion of an iron microstructure in this case the low carbon iron microstructure seen in part of a 10/11th century seax where the corrosion has advanced very slowly from (here) right to left preserving the microstructure as a relic – in this case almost perfectly preserved – which allows the original metal to be identified (field of view 0.5mm, magnification as seen here approximately x200).

Ironwork from the sea

Pre-modern iron corrodes especially fast on constant exposure to wet salty (ie sea) air, usually with severely destructive effects. However it is less well known that iron corrodes more slowly, but still steadily, under the sea where there is less dissolved oxygen present. As in the example of slow corrosion in the ground given above this can lead to the preservation of at least some relic structural information allowing the type of iron used to be identified.

The aim of this analysis is to examine the potential of some mineralised ironwork from a very poorly preserved wreck site to yield relic structural information that can aid the identification, dating and understanding of either a ship or its cargo. With this in mind several samples from a poorly preserved shipwreck site – lying just south of the island of St Martins, in the Isles of Scilly – were submitted for analytical appraisal. This shipwreck site – named the 'Wheel Wreck' site after many wheels found amongst the remains of cargo which included the remnants of large early (?) pumping engines possibly intended for use in the Cornish mines. However there was little remaining of the ship itself apart from some fragments of possible rigging apparatus. Some of these remnants were examined as part of the present pilot study to examine what useful information might be recoverable from the ironwork and how this approach might be applied to other wreck sites.

These remnants consisted corrosion encrusted fragments from two main contexts. The first consisted of a fist sized piece from the main cylinder of an early (Newcomen or early Boulton and Watt) engine, part of the cargo of mine pumping equipment being carried by the ship and intended for delivery to an unkown destination. Other samples included a fragment a probable pulley/winch (or similar ship's equipment) consisting of a lump of degraded wood with the much degraded remains of a circular section (probable wrought) iron pin embedded within it.

Sample 1: Engine cylinder fragment [F111]

Fig. 2: Polished section through a fragment of the steam engine cylinder (the cylinder itself is 1.08m in diameter). The cast iron of the cylinder wall is 88mm long, and is the roughly rectangular piece in the centre of the section - view almost totally mineralised, much of the dissolved iron having re-precipitated to form the rusty brown corrosion crust on the outside (approximately life size).

A slice was cut from the centre of the fist-sized engine cylinder fragment (this main cylinder being approximately 1.08m/43 inches in diameter) and this was dried and mounted in epoxy resin and prepared for metallographic analysis (optical microscopy). Mineralisation of the cast iron was found to be more or less complete (with only a few very tiny possible flecks of metal surviving) but the corrosion process had been slow so that the cylinder fragment retained its original dimensions showing the cast iron cylinder wall to have been approximately 21mm (7/8 inch) thick (fig 2). Another consequence of the slow but persistent corrosion is that a relic form/shape of the original cast iron structure is well preserved right across the section (fig. 3). Typical of very slow corrosion which can preserve the 'fossilized' or 'relic' shape of an iron micro-structure the iron itself has been converted into a now black iron mineral which forms a matrix around the former graphite 'florets' of the cast which now show up as white flakes although they would once have shown up as black in section. Thus the view in section now shows up as a black and white (colour) inversion, which is much like a photographic negative.

Fig. 3: Photomacrograph showing the totally corroded nature – resembling a photographic negative – of the original cast iron from which the engine cylinder wall was cast (magnification approx x5).

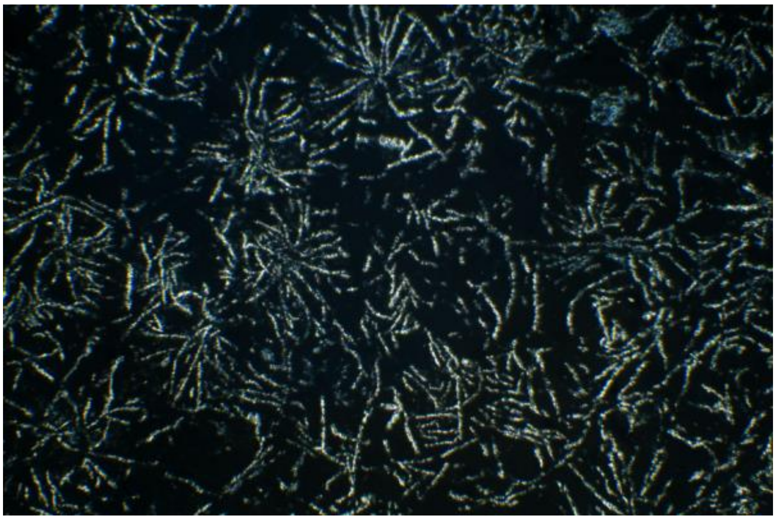


Fig. 4: Detail of part the relatively well preserved relic shape and original internal cast structure of the now totally mineralized iron cylinder wall of this engine, The original shape of the graphite (grey iron) 'florets' is clearly visible now visible as white flakes against a black, formerly iron matrix, a colour inversion of the original appearance (field of view 4mm, magnification as seen here approximately x25).

The mainly grey cast iron nature of the engine cylinder wall fragment is relatively well preserved as the 'relic' cast iron structure visible here (in figs 3 and 4) – white flakes in a dark grey/black matrix. However although the main structure of the former graphite flakes survives quite well the internal structure of the iron matrix does not and is now only visible as very dark grey/black areas in between the 'fossilized' white remnants of the former graphite flakes. It is also noticeable that the former graphite flakes also have some wider spaces in between them possibly suggesting that the cast iron although predominantly one of 'grey iron' may also have shown some tendency to a white iron structure.

The lack of surviving metallic iron in this fragment of engine cylinder wall makes it impossible to say what the iron matrix of the cast iron of this metal actually consisted of. However the gaps between the former graphite flake clusters suggests that the metal may well have been similar to the structure of a sample from the wall of a Newcomen engine included here for comparison (figs 5-7). In this case the metal is also predominantly one of 'grey' iron with black graphite flakes in a typical steely iron (actually mainly eutectoid steel) matrix. However there is also some tendency towards a white cast iron structure showing up as paler areas within the steel matrix as can be seen better at higher magnification (fig 7). The former cast iron structure of the very large engine cylinder is likely to have been similar to that seen in the Newcomen engine sample (figs 5-7).

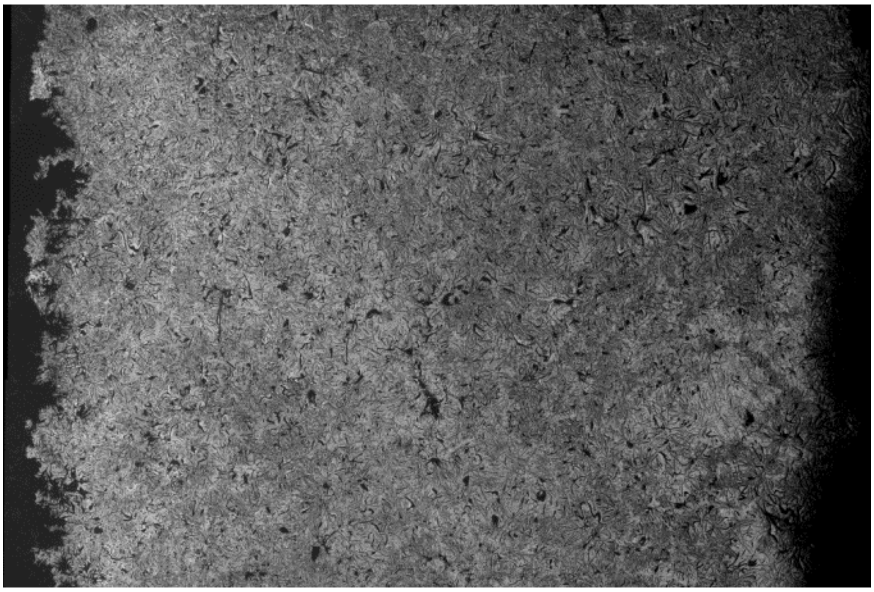


Fig.5: Photo macrograph of part of the cylinder wall of a Newcomen engine (approx mid 18th century) showing the original, largely grey cast iron structure (etched 2% nital, field of view 12mm, magnification as seen here approximately x10).

Fig. 6: Detailed view of part of the same structure of the cast iron Newcomen engine cylinder seen in fig. 4. A generally grey cast iron structure of black graphite flakes is visible against a mainly dark grey steel matrix with some pale (ferritic) iron areas also visible (etched 2% nital, field of view 2.5mm, magnification as seen here approximately x50).

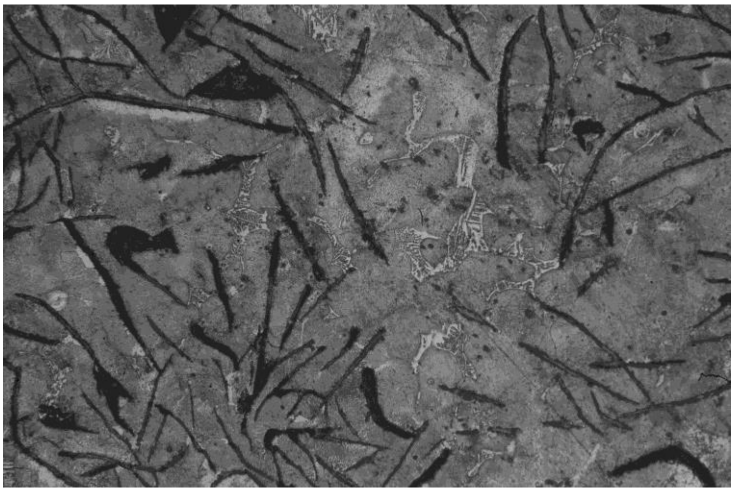


Fig. 7: More detailed view of part of the same microstructure of the Newcomen engine (as seen in figure 5 and 6) showing loose clusters of (black) graphite flakes in a generally steel matrix although the paler parts of the steely matrix here show a tendency towards a white cast iron structure (field of view 1mm, magnification as seen here approximately x100).

In the case of the Wheel Wreck engine cylinder fragment the general flake structure of the graphite survives quite well but it has begun to break down and the structure of the iron matrix does not survive although a steely matrix similar to the comparable (but probably smaller) Newcomen engine could be expected.

Sample 2: Fragment of possible iron windlass [O5]:

Fig. 8: View of the first (longitudinal) section through the fragment of wood with a 17mm diameter (wrought) iron pin embedded within it. This may represent a surviving part of a pulley/winch arrangement, possibly a deck windlass

Fig. 9: Transverse view of (40mm long) part of the same overall wooden fragment (seen in fig. 8) – shown here at approximate 1.5 times life size to emphasis the wood grain structure – probably a hard wood such as oak.

This second smaller lump to be examined from the Wheel Wreck site would appear to form part of a (composite wood-iron) pulley, winch, or similar. A longitudinal section through the wood of the lump also cut through the corroded remnants of a circular section (probable wrought) iron pin embedded in the wood. With further research it may be possible to identify the piece of equipment that this item came from and also it is possible that enough wood survives in another, similar nearby wooden lump to make possible a wiggle-match radiocarbon date from a wood sample like that shown here (in fig 9) with sequence of identifiable annual growth rings.

Conclusions

The first of the two fragments (F111) studied was identified (when collected) as a likely fragment of a steam engine cast iron cylinder of a beam engine similar to those used in the Cornish mines of the time. As usual the original shape of this fragment was difficult to see because it was caked (as usual) with concreted iron corrosion products on the outside. It is also clear the concretion on this lump represents the end production of a gradual leaching process where the metallic iron in the cylinder wall fragment was gradually dissolved and leached out of the metal only to form an insoluble iron compound once it reached the surface of the cylinder wall fragment. Thus the iron in the concreted mass originally came from the cylinder wall itself.

One effect of the formation of the corrosion crust was to slow down the corrosion of the cylinder wall fragment underneath. It is clear from this investigation that the corrosion process was slow and steady enough to allow a fossilization process to take place where the internal shape of internal structure of the iron was preserved. Effectively the iron metal was substituted by a compact iron corrosion compound of the same dimensions as the original iron. The excess iron was leached out of the metal and redeposited as part of the corrosion crust. Although the fossilization process did not preserve more subtle aspect of the cast iron structure the shape of the graphite 'florets' – the classic identifying component of 'grey' cast iron (see glossary below) was quite well preserved so that the general form of the original cast iron could be identified.

In this case the gaps between the florets suggest that the original cast iron was primarily 'grey' cast iron but that the background structure may in part have been one of 'white' cast iron. The two forms of cast iron are identical chemically one or the other, or a combination of both will form depending on the rate at which the metal solidified originally. This process can be altered – and therefore controlled – by the presence (or addition) of small amounts of impurities (for instance silicon and phosphorus). This is why a typical cast iron fireback of the 16/17th century is usually found to consist of a mixed (grey and white) form of cast iron ('mottled' iron) whereas a fire back of the 18/19th century is increasingly likely to consist of 'grey' iron only. Thus if the relic cast iron structure can be identified then the approximate date of the cast iron can be gauged. In this case an estimate of later 18th or earlier 19th century would be appropriate for the largely 'grey' iron relic structure, more or less exactly the same as that suggested by the roughly datable ceramics found at the Wheel Wreck site.

The second sample was found to consist of a fragment of wood belonging to a pulley or winch arrangement which incorporated the totally corroded remnants of a circular section wrought iron pin or bar approximately 20mm in diameter. So far no further work has been done on this pin but it would be well worth finding and investigating any corroded bar iron to look for similar relic cast iron structures to that found in the engine cylinder fragment. These are also likely to survive in part in places. Given the relevant timeframe a relic wrought iron structure may allow a wreck like this to be dated more closely because there was a major change in wrought iron production technology in about 1780 (although any such iron is likely to be nearer 1800 in date) with the introduction of the puddling process together with changes in the way in which bar iron was made. Thus it is quite easy to tell the difference between 'puddled' iron and earlier wrought iron from its structure (mainly the slag content and distribution in the metal). In the case of the Wheel Wreck site further work should enable us to work out if the wreck is more likely to be early 19th rather than mid to late 18th century. Thus the main technological date markers for the (different) changes that occurred in both post-medieval cast and wrought iron (both consequences of developments in iron production after 1500AD) can be used as date indicators because of the phenomenon of the survival of relic structures in iron. The same of course is true to a varying extent to iron produced before 1500. Before this all iron on most ships (in British waters) is likely to be of bloomery origin and a possible approximate date may be possible, especially where actual metallic iron survives for instance in more anaerobic parts of a shipwreck).

Thus given a careful study of the ironwork from many shipwreck sites it should be possible to assign date ranges for many otherwise undatable shipwrecks. This process should get better once more of a database of surviving structures is established which can then be used for identifying new unknown submerged ironwork.

Glossary of technical terms

Cast iron
Iron-carbon alloys containing approximately 2-5% carbon are classed as cast irons. Much of the carbon is present either in its combined form, iron carbide or cementite (q .v.) - white cast iron or white iron -or as free carbon, graphite flakes in a matrix consisting of varying proportions of the eutectoid pearlite or ferrite (q.v.) - grey cast iron or grey iron. When liquid cast iron solidifies, white cast iron will form if the cooling rate is sufficiently rapid, grey cast iron if the cooling rate is slower. The cooling rate is dependent on the presence of quite small quantities of certain impurities in the metal. For instance, silicon promotes the formation of graphite, whereas phosphorus (above 0.1%) promotes the formation of cementite. An intermediate cooling rate can result in mottled iron, which has a white iron matrix with roughly spheroidal patches of grey iron dispersed within it.

Low-carbon iron
In this study, a term used to refer to low-carbon or mild steel, with less than 0.3% carbon, which cannot be quenched. See also hypo-eutectoid steel.

Metallographic analysis
The examination of a flat, polished and etched area of metal with a microscope and related equipment to determine its crystal structure and as much as possible of its past history.

Wrought iron
Plain iron produced indirectly from its ore by the decarburisation of cast iron, either by fining or puddling since approximately 1500 AD (in Britain) before which all iron was produced by the (solid state) bloomery and such iron should only be referred to as bloomery iron.

Appendix III – Lead Analysis by Dr. Francesca Gherardi

XRF analysis of samples collected from lead weights from *HMS Colossus*
Dr. Francesca Gherardi, Investigative Science, Historic England

Introduction

Two lead objects (C10.15), preliminary identified as weights used by the Deane brothers as part of their early diving equipment (pre 1833), were recovered from the seabed about 10 m to the east of the Colossus wreck.

X-ray fluorescence (XRF) analysis was carried out in order to study the elemental composition of the weights, in comparison with a sample (F1351) collected from a stern window sash weigh (pre 1787), recovered from Colossus in 2015.

Materials and Methods

The samples were collected from the lead weights by Kevin Camidge using a 3.5 mm HSS twist drill driven at very low speed. The samples were then analysed by XRF, using a Bruker M4 Tornado µ-XRF spectrometer, with the Al 630 µm filter.

Three points per sample were analysed and the average results are reported as mass percent (%).

Results and discussion

XRF spectra collected from C10.15 and F1351 are reported in Figure 1. The spectra are very similar and they exhibit peaks at energy levels associated with the presence of mainly lead (Pb), while other elements are in traces: tin (Sn), antimony (Sb), copper (Cu) and bismuth (Bi).

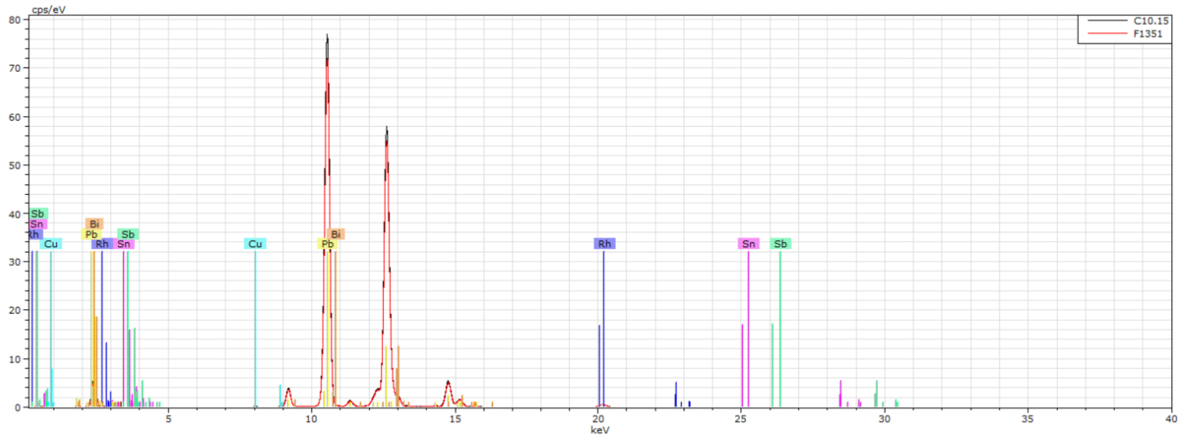


Figure 1: XRF spectra collected from the lead weights: black spectrum refers to C10.15 sample; red spectrum refers to F1351 sample.

In Table 1 and Figure 2, the average normalised results (percentages) of the three analyses per sample are reported together with standard deviations. Both samples show a very high lead content (>99%), which is consistent with the results obtained from the analysis of lead ingots from 18th century shipwrecks (Tripati et al. 2003; van Duivenvoorde et al. 2013). Such a high content of lead in ingots was also obtained from the analyses of samples collected from lead weights used in a shipwreck from the 11th-13th centuries (Galili et al. 2019).

Trace elements slightly differ in C10.15 and F1351, especially in the Sn content, being slightly higher in the sample collected from C10.15 (Table 1 and Figure 2). The percentage of trace elements slightly differ in samples of lead ingots reported in the literature (Galili et al. 2019; Tripati et al. 2003; van Duivenvoorde et al. 2013), but this is probably related to the fact that the analyses were carried out by using analytical techniques, which have different detection limits (e.g. ICP-AES, Atomic Absorption Spectrometer, portable XRF, etc.) and following different calibration procedures for quantitative analysis.

Table 1: XRF data of normalised mass (%) of different elements in the samples collected from the lead weights. The results are an average of three analyses per sample.

Sample	Pb	Sn	Sb	Cu	Bi
C10.15	99.28±0.15	0.50±0.10	0.18±0.08	0.03±0.03	0.01±0.00
F1351	99.59±0.25	0.26±0.14	0.13±0.14	0.01±0.00	0.01±0.00

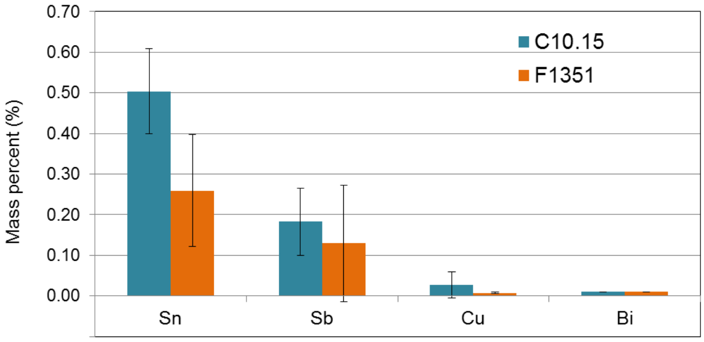


Figure 2: graph reporting XRF data of normalised mass (%) of different trace elements in the samples collected from the lead weights. The results are an average of three analyses per sample.

Conclusions

XRF results obtained from the analysis of samples collected from lead weights C10.15 and F1315 indicate that they have a similar elemental composition, as they are both mainly composed of lead (>99%) and the lead is not alloyed with other metals of alloy concentrations. The obtained results are consistent with data collected from lead ingots from 18^{th} century shipwreck.

Isotopic analysis of lead can be performed to reveal the probable source of the lead and maybe discriminate the production and provenance of the two lead weights, but this assuming that they were made from different lead sources, and is complicated by factors like recycling.

A possible explanation for the different aspect of the C10.15 lead weights, compared to other lead objects recovered from the archaeological site, may be the different environment to which they were exposed.

References

Galili E, Rosen B, Arenson S, Nir-El Y, Jacoby D (2019) A cargo of lead ingots from a shipwreck off Ashkelon, Israel 11th–13th centuries AD. International Journal of Nautical Archaeology 48(2):453-465 doi:10.1111/1095-9270.12365

Tripati S, Parthiban G, Vora KH, Sundaresh, Bandodker SN (2003) Lead ingots from a shipwreck off Poompuhar, Tamil Nadu, East Coast of India: evidence for overseas trade and their significance. International Journal of Nautical Archaeology 32(2):225-237 doi:https://doi.org/10.1016/j.ijna.2003.08.006

van Duivenvoorde W, Stedman J, Billström K, Stos-Gale ZA, McCarthy M (2013) The Lead Ingots from the Wreck of the Zuiddorp (1712), Western Australia: a report on their provenance and manufacture. International Journal of Nautical Archaeology 42(1):150-166 doi:10.1111/j.1095-9270.2012.00362.x

Appendix IV – Vessel Candidates

Vessel	Loss	Detail	Type	NRHE UID	Source
WEDDEL	1775 4th Feb	*Stranded on a rock ledge, thence possibly removed to Hugh Town? Hull for Grimsby with iron and textiles.* But Troutbeck says she was wrecked in Old Grimsby and repaired		880183	SC T
TRIUMPH	1776 7th Feb	Anchor cable parted and stranded on a rock in Scilly It is feared ship and cargo are lost. Liverpool to London 'On Wednesday last, the Triumph, Fletcher, from Liverpool to London, parted her cables in a gale of wind at Scilly, and got on the rock, and it is feared both ship and cargo will be lost'	Sailing Vessel	880187	SIBI CC 19.2.1776 p2
JOSEPH	1777 2nd May	For Exeter from Bilbao with a cargo of nuts and iron – stranded, total loss	Sailing Vessel	1208725	SIBI
AGNETTE	1783 July	Wrecked in Scilly	Sailing Vessel	1208770	WoS
Unknown	1784 Jan	Several vessels wrecked during the month of January … in gales and fog 'A letter from St Mary's in Scilly has the following article: We have had such blowing and foggy weather, that more Vessels have run on the rocks than have been remembered for a long Time before, and indeed it is no wonder, for the thickness of the fog hid the Light from the Eyes of the Mariners, and almost every night there were Signals of Distress made, but it was impossible for us to give them any Assistance, without Danger of being lost ourselves. A great many Pieces of Wreck float on the Water, but we have not yet been able to get any Account of what Ships are lost'		880214	SIBI HJ 6.2.1784 p2
ROBERT & SALLY	1784 26 Mar	Brown master, from London for Lancaster, was lost near Scilly		880216	SATIS SIBI CM 14.4.1784 p2
Unknown	1785 Sept	An unidentified vessel was wrecked			SATIS
EXPEDITION	1785 Nov	Expedition of Dublin, Collins master, drove onto rocks and went to pieces. Her crew were on the rocks for several hours before being rescued and taken to St Marys by a French vessel			SATIS
JANUS	1787 Feb	Janus was wrecked 'The Janus from Dunkirk to Cape Francois is totally lost off Scilly, the crew saved'		1208787	SATIS HER 167801
DOWSON	1788 4th Jan	Stranded/total loss – Liverpool to ? Pastscape gives the date of loss as 24.12.1787	Sailing Vessel	859158	SIBI Pastscape

Vessel	Loss	Detail	Type	NRHE UID	Source
MARY	1788 21 Jan	*Stranded among the Isles of Scilly, en route from Truro for Swansea* Mary, Hughes master, from Truro for Swansea, was lost at Scilly		880224	SC SATIS
ANN	1789 Mar	Lost in Scilly 'The Ann, Grant from Newfoundland and Vigo to Dartmouth is lost at Scilly'	Sailing Vessel	880232	WoS HER 167760
FANNY	1790	*Stranded on the rocks off St. Mary's, Swansea for Falmouth*			SC
Unknown	1792 24 Jan	Three brigs lost on the same day. All were sheltering in Grimsby but were blown to sea at night in a gale 'and all probably lost'. 1 Liverpool to Lynn, 2 Bristol to London 3 Seville to London	Brigs (x3)	1336443	SIBI
JAMES	1794 Mar	Bieters master, from Caernarfon for London, foundered after being run down HER gives master as Pieters	Sailing Vessel	880236	SATIS HER 167761
RECOVERY	1795 May	The Brig recovery of Bristol, Bowen master, from Savannah for Falmouth, ran onto rocks near St Marys and filled with water Note SIBI says reported lost 2 June	Brig	880239	SATIS SIBI
MARGARET	1796 Oct	Chisolm master, from Liverpool for Charleston, was lost Lost on the Western Rocks mid Oct	 Sailing Vessel	880064	SATIS SIBI
ALBION	1797 Jan	Johnson master, from Ipswich for Bristol 'the Albion, Johnson, from Ipswich to Bristol, was lost at Scilly.'		880066	SATIS SIBI CM 14.1.1797 p2
MARY & BETSY	1798 12 Dec	The sloop Mary and Betsy was lost after being abandoned by her crew SIBI & HER call her Mary & Betsey 'The sloop Mary and Betsey of Cardigan was lost at Scilly on the 12th instant, after being deserted by the crew'	Sloop	880072	SATIS SIBI HER 167404
LARK	1799 Feb	…From Newport for Waterford, was lost but the crew were saved 'The cargo is expected to be saved' 'Lark, Newport, from Waterford to Portsmouth was lost'		880073	SATIS SIBI AP&J 4.3.1799 p3
CAROLINE	1799 Apr	Ellis master, from St Michaels for London, foundered at Scilly	Sailing Vessel	880075	SATIS SIBI
THOMAS AND WILLIAM	1801 Jan	*The sloop Thomas & William, Jenkins master, from Neath for Falmouth, was lost at Scilly* Stranded Total loss	Sloop	880077	SC SATIS LC 31.1.1801 SIBI HER 167408
PADSTOW	1804 24 Dec	*The Padstow, of Padstow, Stephens, from Cardiff, with iron, to London, is totally loot (sic): perhaps part of the cargo will be saved, the crew were saved in their boat.*	Sailing vessel	878573	RCG 29.12.1804 p3

Vessel	Loss	Detail	Type	NRHE UID	Source
HARVEY	1805	The brig Harvey was wrecked	Brig		SATIS
DUCK	1807 Mar	Stranded on the Isles of Scilly, while bound from Padstow for Falmouth *'Went ashore and filled'* *'The brig Duck, Billing master from St Ives to Falmouth, with Pilchards. Got on shore, on the 9th instant at Scilly'*		878579	SC SATIS PL 19.3.1807 p3 SL 18.3.1807 p3
HARRIET & ANN	1807 22 Dec	Wilkins master, foundered off Scilly 'The Harriet and Ann. Wilkins master, with copper ore for Wales, foundered about 16 leagues SW of the Lizard …crew … landed at Scilly'		878587	SATIS SIBI HJ 23.12.1807
Unknown	1808 20 Nov	A brig went onto the rocks in a heavy north-easterly gale	Brig		SATIS
COMMERCE	1809 3 Nov	Stranded total loss 'The Commerce Rands, from Gibralter to London, has been on shore and must discharge to repair'	Sailing vessel		SIBI LL 3.11.1809 p1
RUNTER	1809 19 Nov	Stranded total loss 'The Runter, Thomas, from Cork to Truro, struck on some rocks at Scilly the 19th instant, and sank; but has since been raised and towed in. Crew and cargo saved'	Sailing vessel		SIBI CM 2.12.1809 p2
GOOD INTENT	1814 Feb?	Burnt and sunk off Isles of Scilly as a result of privateer action, Newport for Teignmouth '…the brig Good Intent of and bound to Teignmouth , Samual Tamlin master, from Newport, with coals…'	Sailing vessel	1217705	SC SATIS SIBI HC 27.11.1814 p4
MARGARET & ELIZABETH	1815 Apr	From London to St Michael's was lost at St Mary's 175 tons		878611	SATIS CM 8.4.1815 p2 SIBI
ELIZABETH	1815 29 Oct	Total loss 'The Elizabeth, Marshall, from Havre for Liverpool, has been on shore at Scilly, got off, and is discharging her cargo to repair'	Sailing vessel	878656	SIBI SL 13.11.1815 p3
Unknown	1816 Jan	*The finding of deals, spars, a hen coop, and other wreckage indicated that a vessel had been lost within the Islands.*	Sailing vessel	1344750	SATIS
LINNET	1817 Aug	Stranded on Crow Bar while waiting to enter St. Mary's 'The sloop Linnet of Cardigan was lost off the Crow on the 2nd inst. Crew saved'		878615	SC SIoS CM 18.8.1817 p2
Unknown	1818 Jan	Lost in Scilly	Cutter	878618	WoS
MARY	1819 Nov	Lost in Scilly	Sailing Vessel	878660	WoS

Vessel	Loss	Detail	Type	NRHE UID	Source
SHANNON	1820 Jan	Wrecked among the Isles of Scilly, Newport for Dartmouth 'Dartmouth, Jan 23 – The Shannon, of this port, from Newport, was driven on shore at St Mary's, and wrecked; *The crew and cargo were saved'*	Sailing vessel	1224224	SC SATIS SL 25.1.1820 p1
Unknown	1820 Oct	Lost in Crow Sound	Sailing vessel		WoS
CATHERINA MARIA	1827 Nov	'On the 16th Inst. part of the log book belonging to the Danish Galliot Catherina Maria, Fredrickson master, from Newport, was found in broken chest on St Martin's… On the 28th Oct she had been in sight of Land's End, so it was thought she had been lost that night on the Seven Stones'	Galliot	878633	SATIS LC 24.11.1827 p3
PROSPER	1829 Oct	French brig, from Marseilles for Rouen struck the crow	Brig	878642	SATIS SIBI
LIBANUS	1830 Dec	The ship Libanus was lost but the crew were saved	Ship	878647	SATIS SIBI
COMMERCE	1830 Dec	The Marlborough spoke the Commerce… in a very leaky state with her mainmast gone close by the board and her sails torn in pieces, her foremast sprung … the crew were induced to scuttle and abandon her. They were taken on board the packet in a very exhausted state. 'The Commerce, from Dartmouth to Gibraltar, was abandoned on the 11th instant, having lost her mainmast, &c. and being very leaky'		1208639	SIBI RCG 18.12.1830 EM 20.12.1830 p5
PROSPEROUS	1836 Mar	Lost in Scilly	Cutter	878665	WoS
VICTORIA	1838 14 Feb	Victoria of Exeter wrecked on Crow Bar. Cardiff to Newcastle with iron. Six crew members rescued. The schooner Victoria of Exeter…got on Crow Bar where the waves swept right over her. The crew were taken off by gigs… 'On the 15th instant the schooner Victoria, Adams, from Newport for Newcastle … struck on the bar and has since become a wreck'	Schooner	878671	RCG 23.2.1838 SATIS NL 24.2.1838 p3

Vessel	Loss	Detail	Type	NRHE UID	Source
PLENTY	1840 3 Dec	'Shipwreck and Loss of Life – We regret to state that Mr. Parker, of Topsham, has received an account of the loss of his vessel, the Scilly Isles, all the crew having perished on their way from Newport with a cargo of iron. There were five on board, three of whom were brothers, of the name Gray, belonging to Starcross. The vessel was insured.' 'Scilly, Dec. 8; The **Plenty**, (of Exeter), from Newport, struck the Seven Stones on the 2nd inst.; crew supposed to have drowned. She was fallen in with after beating over the rocks and taken in tow by a pilot boat, but sank about a mile from the eastward island.' 'The Plenty of Exeter, Robert Gray master, with a cargo of iron, consigned to Messrs Poole and Co. Dover, was lost during the late gale, and the whole of the crew perished' Nothing found about Poole & Co to date	built as a Stone Boat in 1817. It was significantly enlarged in 1838 to 100 tons, 66.2 ft. x 16.45 ft. x 10.45 ft.	1124610	BM 26.12.1840, p7 Times: Saturday, December 12, 1840, Issue 17539: SIoS DT 26.12.1840 p8

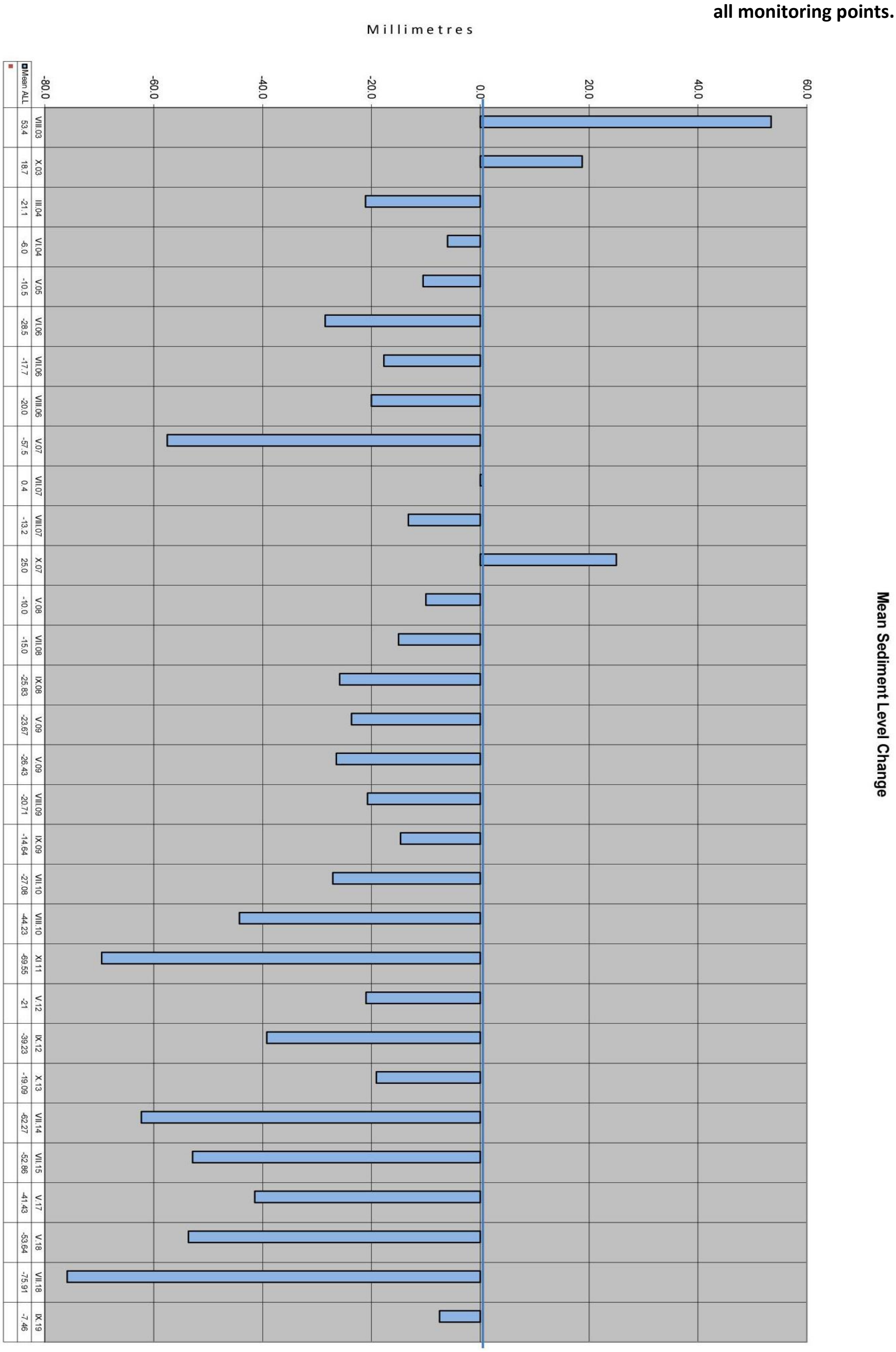
Entries highlighted thus are a wreck originally selected as a candidate but later rejected as more information was found. The reason for rejection is highlighted in grey.

Sources

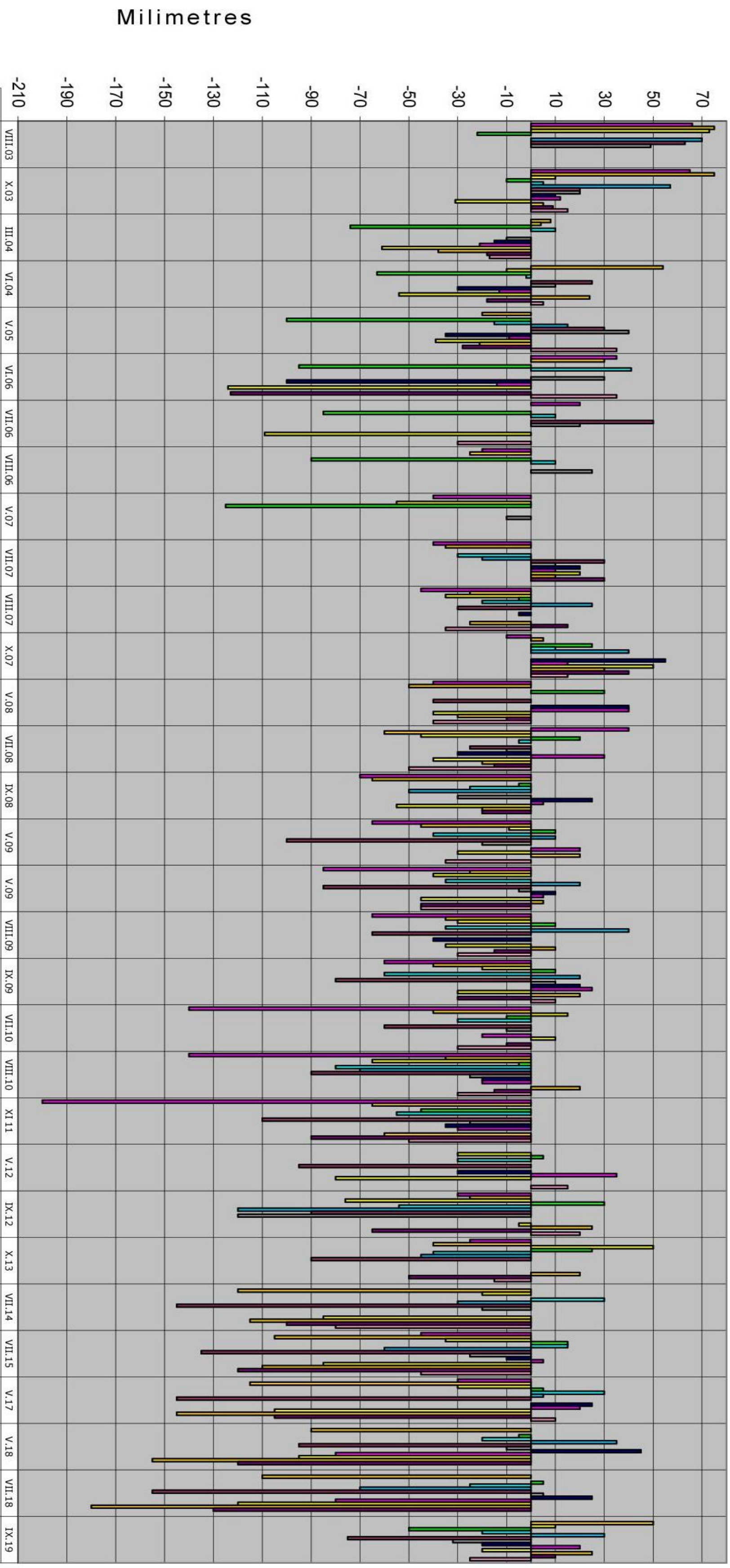
AP&J	Aberdeen Press and Journal
BM	Bristol Mercury
CC	Chester Chronicle
CM	Caledonian Mercury
DT	Dover Telegraph and Cinque Ports General Advertiser
EM	Evening Mail
HER	Cornwall and Isles of Scilly HER
HJ	Hibernian Journal; or, Chronical of Liberty
LC	London Courier & Evening Gazette
LL	Lloyd's List
NL	Northern Liberator
PL	Public Ledger & Daily Advertiser
RCG	Royal Cornwall Gazette
SATIS	Shipwrecks Around the Isles of Scilly (IoS Museum Publication No 3)
SIBI	Shipwreck Index of the British Isles (Larn 1995)
SC	Research by Serena Cant in (Camidge, et al., 2018)
SL	Star London
SIoS	Shipwrecks and Maritime History in and Around the Isles of Scilly (Cumming & Stevens 2016)
T	A Survey of the Scilly Islands (Troutbeck 1796)
WoS	The Wrecks of Scilly (Larn, 2010)

Appendix V – Colossus Sediment Level Data

Colossus **sediment level change 2003-2019 showing change as the mean of all monitoring points.**



***Colossus* sediment level change 2003-2019 showing data for each individual monitoring point. Blank entries indicate a missing or unfound point.**



	VIII.03	X.03	III.04	VI.04	V.05	VI.06	VII.06	VIII.06	V.07	VII.07	VIII.07	X.07	V.08	VII.08	IX.08	V.09
M1	66	65			0	35	20	-20	-40	-40	-45	-10	-40	40	-70	-65
M2	75	75	8	54	-20	30		-25		-35	-25	5	-50	-60	-65	-45
M3	73	10	4	-10	0				-55		-35		0	-45		-9
M4	-22	-10	-74	-63	-100	-95	-85	-90	-125		-5	25	30	20	-5	10
M5		5	10	-2	-15	41	10	10		-30	-20	10	0	-5	-25	-40
M6	70	57			15					-20	25	40	0	0	-50	10
M7	63	20		25	30		50			30	-30		-40	-25		-100
M8	49	20	-10	10	40	30	20	25	-10	10	0		0	-10	-30	-20
M10		10	-15	-30	-35	-100				20	-5	55	40	-30	25	
M11		12	-21	-13	-9	-14				10	0	15	40	30	5	20
M12		-31	-61	-54	-39	-124	-109			20	0	50	-40	-40	-55	-30
M13		5	-38	24	-21					10	-25	30	-30	-20	-20	20
M14		9	-18	-18	-28	-123				30	15	40	-10	-15	-20	
M15		15	-17	5	35	35	-30			0	-35	15	-40	-50	0	-35

	V.09	VIII.09	IX.09	VII.10	VIII.10	XI 11	V.12	IX.12	X.13	VII.14	VII.15	V.17	V.18	VII.18	IX.19
M1	-85	-65	-60	-140	-140	-200		-30	-25		-45	-30			
M2	-25	-35	-40	-40	-35	-65	0	-25	-40	-120	-105	-115	-90	-110	50
M3	-40	-30	-20	15	-65		-30	-76	50	-20	-35	-30			10
M4	0	10	10	-10	-5	-45	5	30	25		15	5	-5	5	-50
M5	-35	-35	-60	-30	-80	-55	-30	-54	-40	30	15	30	-20	-25	-20
M6	20	40	20		-70			-120	-45	-30	-60	5	35	-70	30
M7	-85	-65	-80	-60	-90	-110	-95	-90	-90	-145	-135	-145	-95	-155	-75
M8	-5	0	10	-10	-25	-25		-120	0	-20	-25	0	-10	5	-32
M10	10	-40	20	0	-20	-35	-30	0		0	-10	25	45	25	-20
M11	5	0	25	-20	-20	-30	35				5	20	-80	-80	20
M12	-45	-35	-30	10			-80	-5		-85	-85	-105	-95	-120	-20
M13	5	10	20		20	-60		25	20	-115	-110	-145	-155	-180	25
M14	-45	-15	-30	-10	-15	-90	0	-65	-50	-100	-120	-105	-120	-130	10
M15	-45	-30	10	-30	-30	-50	15	20	-15	-80	-45	10			-25