Maritime & Coastguard Agency

SS Richard Montgomery: Survey Report 2022

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Abbreviations

CD	Chart Datum
Cefas	Centre for Environment, Fisheries and Aquaculture
DfT	Department for Transport
EAG	Expert Advisory Group
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IHO	International Hydrographic Organization
LIDAR	Light Detection and Ranging
MBES	Multibeam Echo Sounder
MCA	Maritime and Coastguard Agency
MOD	Ministry of Defence
NEQ	Net Explosive Quantity
PPK	Post-processed kinematic
SSRM	SS Richard Montgomery
VORF	Vertical Offshore Reference Frame
VTS	Vessel Traffic monitoring Service

1 Executive Summary

1.1 Background

1.1.1 The SS Richard Montgomery (SSRM) was a US Liberty Ship which went aground in the Thames Estuary in August 1944 whilst carrying a cargo of munitions. Although immediate efforts were made to salvage the cargo, the vessel broke in two, flooded and sank before the salvage operations could be completed.

1.1.2 The wreck lies adjacent to the Medway Approach Channel and is approximately 1.5 miles from the town of Sheerness and 5 miles from Southend. Around 1,400 tons of explosives remain on board the wreck which is designated under section 2 of the Protection of Wrecks Act 1973.

1.1.3 Surveys of the wreck are undertaken to provide information on its condition, to identify any changes or deterioration and to inform future management of the wreck. This report details the results of the 2022 survey.

1.2 Survey Overview

1.2.1 This report primarily compared the data from the most recent survey (October 2022) with that gathered during the previous full survey conducted in September 2021.

1.2.2 The survey was conducted between 9 October 2022 and 12 October 2022.

1.3 Key Results

1.3.1 The ‘tween deck space of Hold 2 (ID008) appears to have either partially collapsed or buckled on the starboard side. This does not appear to be recent and has only been uncovered due to the enhanced ensonification of Hold 2.

1.3.2 The area of the unsupported section of bridge superstructure at the forward end of the rear section (IDs 043,045 and 046) has been dropping over the past several surveys and continues to do so, with an inevitable slip of accumulated debris.

1.3.3 The area of seafloor between the two portions of wreck has gained volume due to the slip of debris from the bridge.

1.3.4 The seabed updates include that the banks to the west of the wreck are the most active with 1.5m movement east and 1.4m movement north reported in areas. There was a vertical displacement of up to 2m with an average site accretion of 0.6m.

2 Introduction

2.1 Background

2.1.1 The SS Richard Montgomery (SSRM) was a US Liberty Ship of the EC2-S-C1 class, constructed by the St. John's River Shipbuilding Company in Jacksonville, Florida in 1943. In August 1944, the ship left the US with a cargo of munitions and travelled across the Atlantic in convoy bound for the UK and then on to France.

2.1.2 On arrival in the Thames Estuary on 20 August 1944, orders were received to anchor off Great Nore. Unfortunately, this was too shallow for the heavily laden vessel and, as the tide fell, the SSRM dragged its anchor and went aground on Sheerness Middle Sand, a sandbank running east from the Isle of Grain and to the north of the Medway Approach Channel. By that evening, the vessel was already reported to be badly hogged (curved-up in the centre and sagging at the ends) and an explosive like sound was heard. This sound was the steel hull plates splitting forward of the bridge.

2.1.3 On 23 August, stevedores from Gravesend were engaged to discharge the cargo. However, on the afternoon of the following day, the ship's hull cracked even further, and the bow holds flooded. By 8 September, the ship broke its back completely. Divers reported that the crack extended down both sides of the hull, with the vessel clearly open on the starboard side, but the cargo discharge continued. Royal Navy personnel were brought in to finish the cargo removal, but they were hampered by deteriorating weather and safety fears as the vessel gradually sank. The salvage operation was abandoned with approximately 1,400 tons Net Explosive Quantity (NEQ) of munitions remaining within the forward section of the vessel in holds 1, 2 and 3.

2.1.4 The vessel remains on Sheerness Middle Sand, lying in two sections in its own scour pit and sitting on exposed bedrock which is believed to be London Clay. The SSRM lies across the tide and all three masts are visible above the water at all states of the tide (see Figure 1 below).

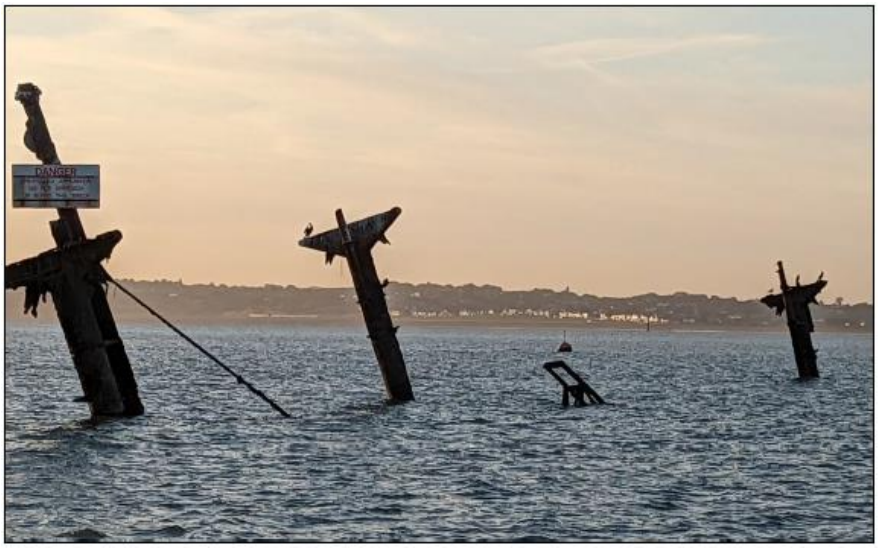

Figure 1: Photograph of the SSRM's three masts above the water.

2.2 Management

2.2.1 The SSRM wreck is designated as a dangerous wreck under section 2 of the Protection of Wrecks Act 1973. There is a prohibited area around the wreck, and it is an offence to enter within this area without the written permission of the Secretary of State for Transport. The wreck is clearly marked on the relevant Admiralty Charts, the prohibited area is marked with four lit cardinal buoys and twelve red danger buoys, and the wreck is under 24hr surveillance by Medway Vessel Traffic Monitoring Service (VTS).

2.2.2 Although the wreck is thought to be stable if left undisturbed, it is routinely monitored. Regular surveys of the SSRM are undertaken to provide information on its condition, identify any changes or deterioration and inform future management strategy. The survey results are shared with the independent Expert Advisory Group (EAG) formed in 2017 to advise DfT on managing the SSRM. There are plans to reduce the height of the three masts, which should prevent further deflection of the connected decks, minimise future potential deterioration and mitigate the risk of collapse onto the decking below.

2.2.3 A variety of methods have been used to monitor the wreck. Since 2002, multibeam sonar technology has been the favoured method of survey. Although occasional diving operations are carried out on the wreck (most recently in 2013), multibeam sonar is faster, more cost-effective and provides greater levels of detail, repeatability, and reliability than diver surveys. This is in part due to the very poor visibility and high tidal range in the Thames Estuary which makes diving operations very challenging.

2.3 This Report

2.3.1 This report is a summary of the October 2022 SSRM survey findings. This is a full survey and compares the result from the last full survey in 2021. The year-on-year comparisons of survey data are used to help identify and quantify any deterioration of the wreck and it provides a longer view of the condition and rate of deterioration of the wreck structure.

2.3.2 The data analysis covers the entirety of the wreck and identifies 96 features on the wreck which have been used in successive surveys as markers for measuring levels of change. Of these, there are six areas which have repeatedly demonstrated levels of accelerated deterioration and are therefore a specific focus of each survey.

2.3.3 This report also includes the results of the surrounding seabed survey. The seabed survey aims to identify changes in the local seafloor topography that may have implications for the wreck's stability or for the neighbouring Medway Approach Channel. It also aims to locate items of debris on the seabed within the survey area, including debris that may have originated from the wreck and debris from other sources.

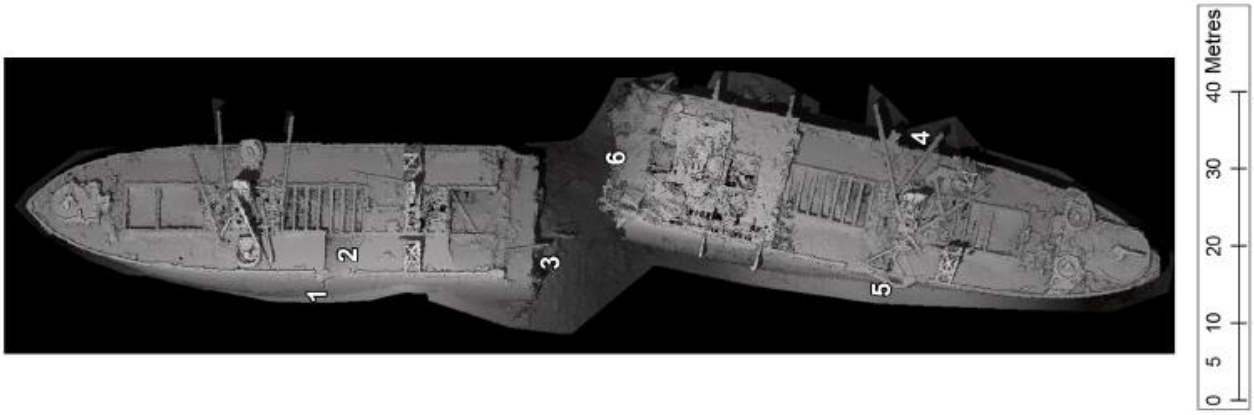

Figure 2: SSRM top-down image showing the 6 Key Areas.

3 The Survey

3.1 Survey Requirements

3.1.1 The Scope of Work as defined by the MCA included the following objectives:

a) Comprehensive Multibeam Echosounder (MBES) survey of the entire wreck.

b) MBES survey of the prohibited area and the seabed out to at least 400m distant from the wreck, including the edge of the dredged channel in the vicinity of the prohibited area.

c) Laser scan survey of the masts and other structures which are visible above the waterline.

d) Process the data and directly compare it to previous survey data (from September 2021) to identify and highlight any areas of structural change or deterioration.

e) Produce a detailed survey report which includes details of any changes noted and comparisons with results from previous surveys.

3.2 Survey Area

3.2.1 This survey is a snapshot survey, and the survey area is shown by the dotted black line in Figure 3.

3.3 Survey Operations

3.3.1 The MBES survey and laser scanning of the SSRM and seabed took place on 9, 11, and 12 October 2022 coinciding with the spring tides. On Sunday 9 October surveying focused outside the exclusion zone.

3.3.2 Tuesday 11 October saw the collection of laser data along with MBES surveying within the exclusion zone. Survey operations concluded on Wednesday 12 October with 4 hours downtime while awaiting on tide.

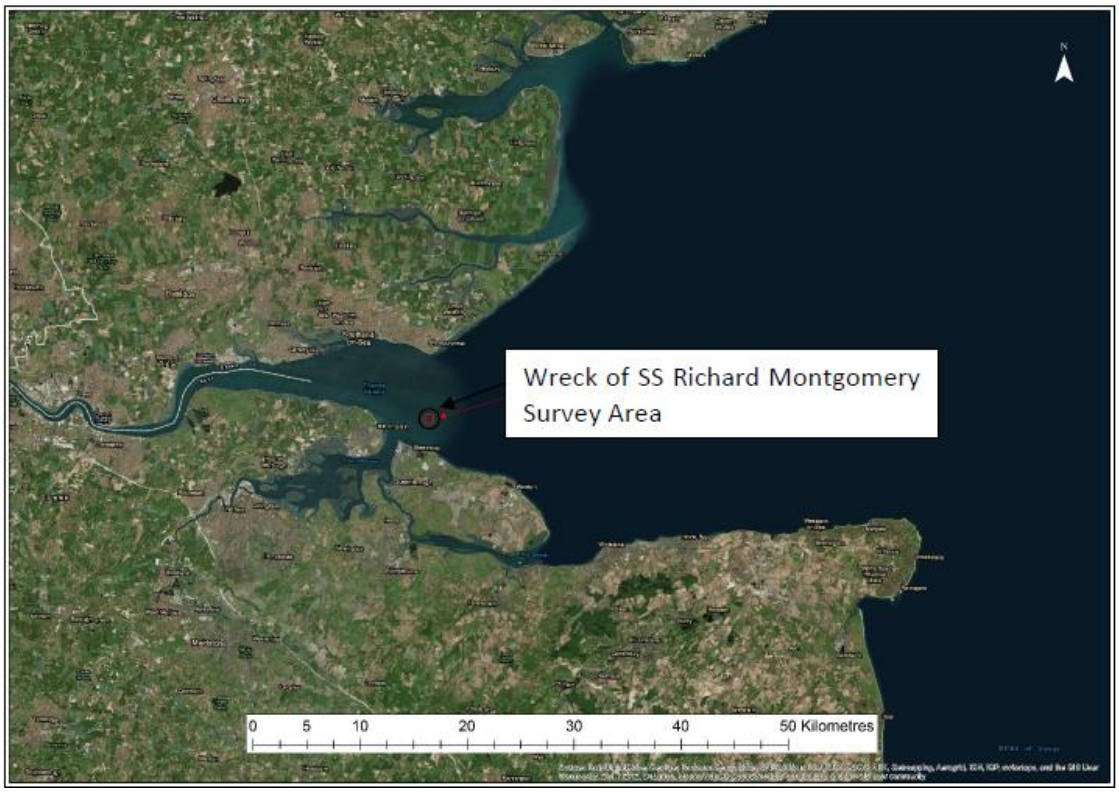

Figure 3: Location of the Wreck of SS Richard Montgomery.

3.4 MBES

3.4.1 The MBES data was collected with a NORBIT iWBMS MBES.

Table 1: EGS Watchful equipment specifications used for data collection in 2022 SSRM survey.

Equipment Specifications – EGS Watchful	
Primary Horizontal & Vertical Positioning	1 x Integrated V5 Applanix POS MV Wavemaster II
Primary Heading Sensor	1 x Integrated V5 Applanix POS MV Wavemaster II
Acquisition / Processing	1 x Norbit WBMS GUI 1 x BeamworX NavAQ acquisition software 1 x BeamworX AutoPatch calibration software 1 x BeamworX AutoClean processing software 1 x Caris HIPS/SIPS processing software
Multibeam echosounder (MBES)	1 x NORBIT iWBMS MBES
MBES Motion reference unit	1 x V5 Applanix POS MV Wavemaster II
Sound Velocity Measurement	1 x Integrated AML Mini SVS Sound Velocity Profiler 2 x Valeport Mini SVP Sound Velocity Profiler
Laser Scanner System	1 x NORBIT iWBMS iLIDAR Laser
Acquisition	1 x NORBIT WBMS GUI

3.4.2 Global Navigation Satellite System (GNSS) data was acquired using the POSMV WaveMaster which is integrated with the Norbit iWBMS MBES system. The recorded GNSS data were post processed using Applanix's POSPac MMS in single base mode to create an SBET for each day's survey. The corrected horizontal and vertical positions, relative to ETRS89, were combined with the UK Hydrographic Office (UKHO) Vertical Offshore Reference Frame (VORF) model to reduce the bathymetry data to chart datum. BeamworX NavAQ was set up to receive ETRS89 GNSS positions and project the data in UTM31N.

3.4.3 When post processed in POS Pac the Applanix POS MV provides positions for each sounding in the swath with uncertainties better than ±0.05m.

3.4.4 Vertical positions from the Applanix POS MV were combined in BeamworX NavAQ with the single point VORF separation value allowing tidally reduced elevations to be output directly from BeamworX NavAQ.

3.4.5 The manufacturer's quoted capable vertical uncertainty values for the Applanix POS MV system are less than ±0.05m, when post processed in Applanix POSPac MMS software.

3.4.6 IHO Special Order position and depth uncertainty standards (9 or more valid soundings within a 1m bin) were adhered to throughout the survey operations. IHO Special Order sounding density requirements were also met throughout the survey. The seabed was consistently covered by 50 or more valid soundings per 1m bin as shown in Figure 6a below. The wreck itself has over 4,000 soundings per 1m bin and the Light Detection and Ranging (LIDAR) accounting for the red spots at 50,000/$m2$.

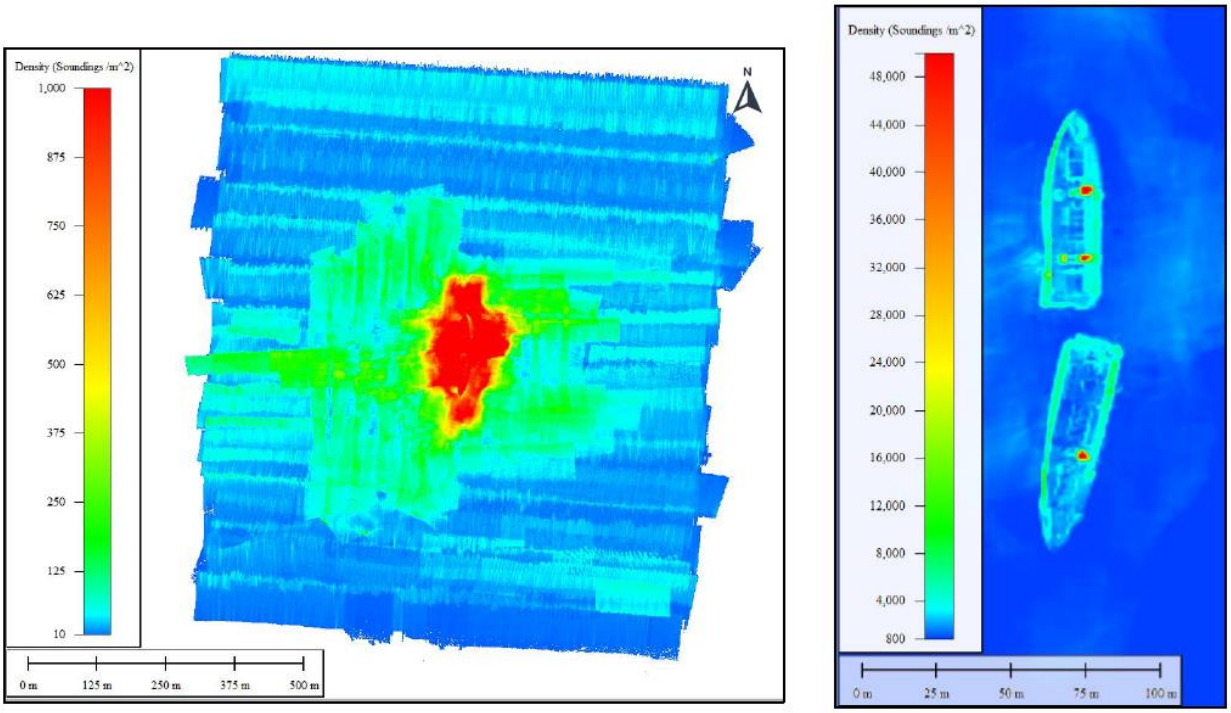

Figure 4: Density plot of surrounding seabed MBES survey.

3.5 Laser Scanning

3.5.1 The laser data indicates no changes between the September 2021 full survey and this survey.

3.5.2 Laser scan lines were acquired by the EGS Watchful. Multiple lines were run in various directions within the vicinity of the wreck to achieve full coverage and data density around the masts.

3.5.3 In addition to laser scan data, photographs such as Figure 9 were taken to add to the available information on the condition of the exposed masts.

3.5.4 The laser data from the September 2021 survey was overlain on the data gathered on this survey show the three masts are well defined within the laser data and show good correlation with the 2021 data. The cross sections show no change between 2021 and 2022 datasets.

4 Results – The Wreck

4.1 Overview

4.1.1 This section of the report details the output of the survey data acquired from the wreck. It combines the results of the survey data and uses various tools to analyse the data and identify areas of change. This includes cross-sections through the data and surface difference analysis.

4.1.2 Several features across the wreck have been highlighted during previous surveys as areas of significant structural change. No significant changes were identified in any of these locations. The only area where there has been noticeable change is on the collapsing bridge deck which is most likely due to a slip of debris than movement in the deck.

4.1.3 Key Area 1, crack in the hull (Port side, forward section).

4.1.4 Key Area 2, Collapse of cargo Hold 2 deck (Port side, forward section).

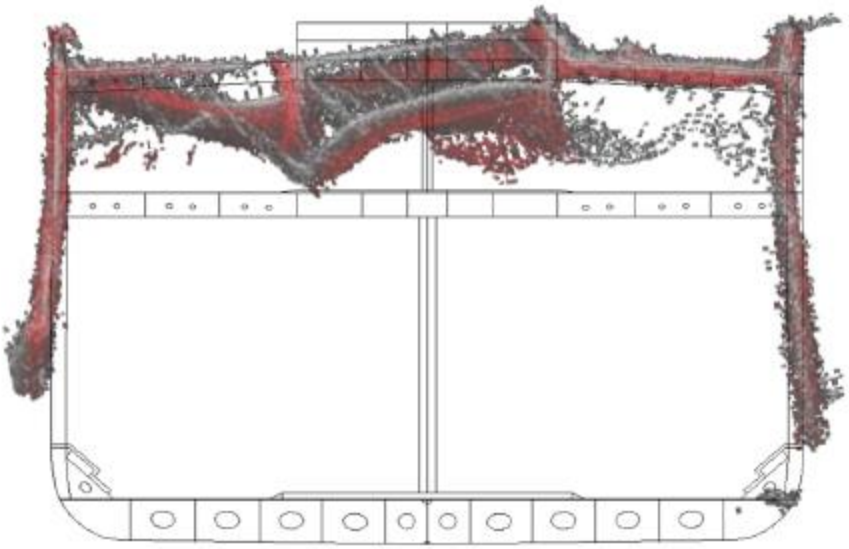

Figure 5: Crack in the hull (port side, forward section) and collapse of cargo Hold 2 deck (port side, forward section).

4.1.5 Key area 3, Aperture (Aft end, forward section).

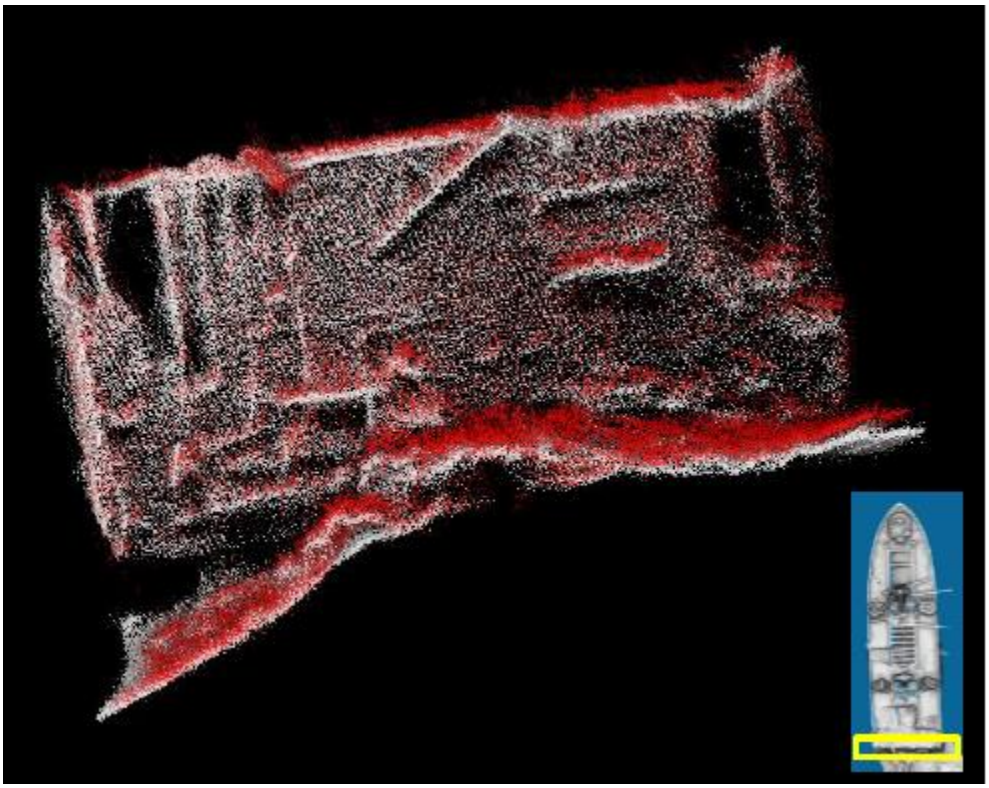

Figure 6: Aperture (Aft end, forward section).

4.1.6 Key Area 4, Split in the hull (Starboard side, aft section near the aft mast house).

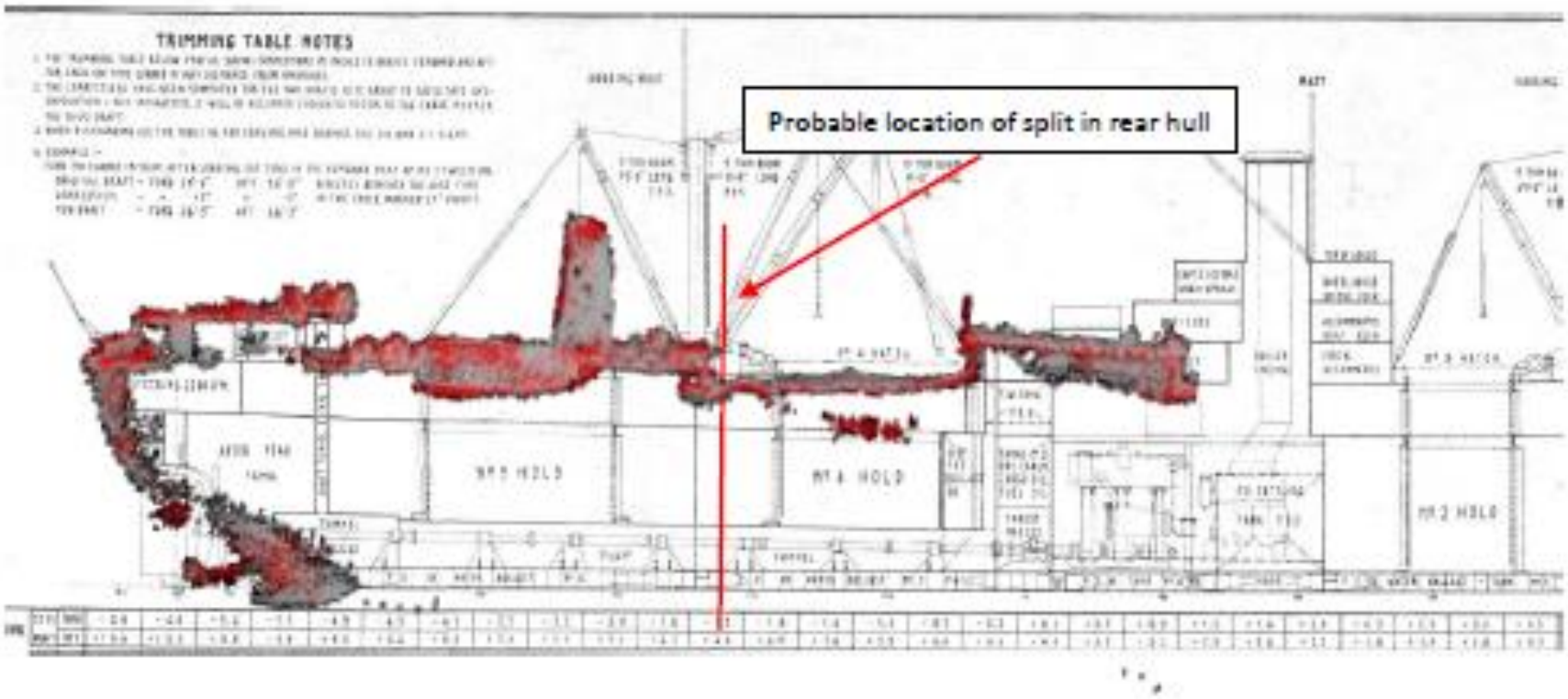

Figure 7: Longitudinal profile through the stern section.

4.1.7 Key Area 5, Split in deck and split in the hull (Aft section, port side)

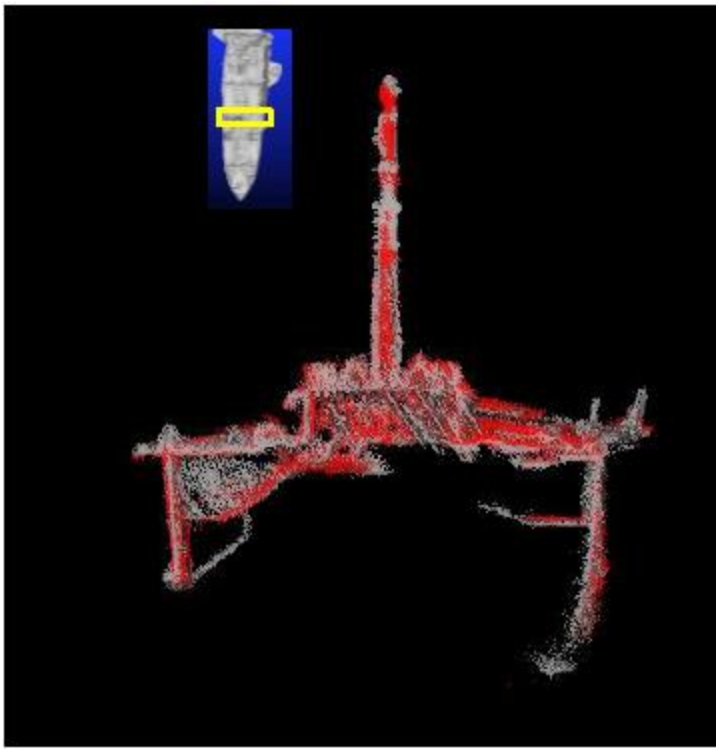

Figure 8: Split in deck and split in the hull (Aft section, port side).

4.1.8 Key Area 6, Boiler room casing, collapsing bridge deck and the collapsing boat deck (Forward end, aft section).

4.2 Key Areas and Features

4.2.1 Over the whole of the wreck, 96 specific features have been used in successive surveys as comparison points for quantifying change and deterioration. The location of these features is given in Figures 9 & 10.

4.2.2 In addition to the 96 features the six Key Areas that have been highlighted in previous surveys as areas of significant structural change are monitored in each survey.

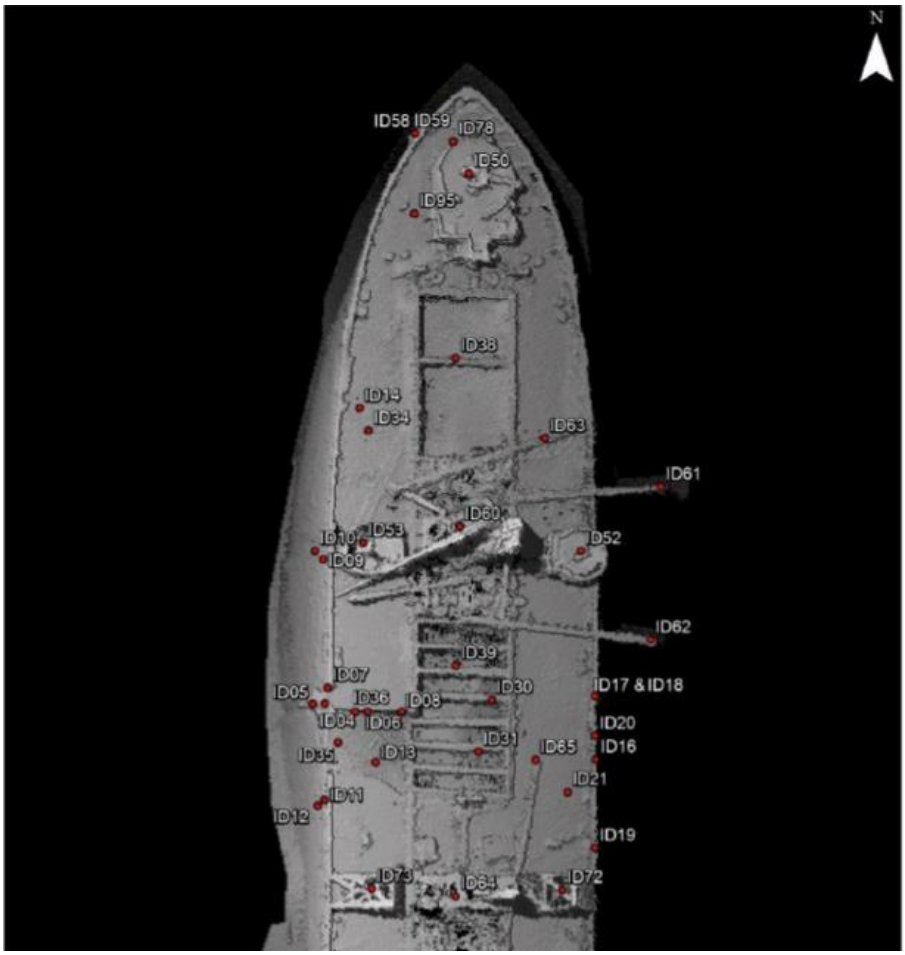

Figure 9: ID features on the Forward section.

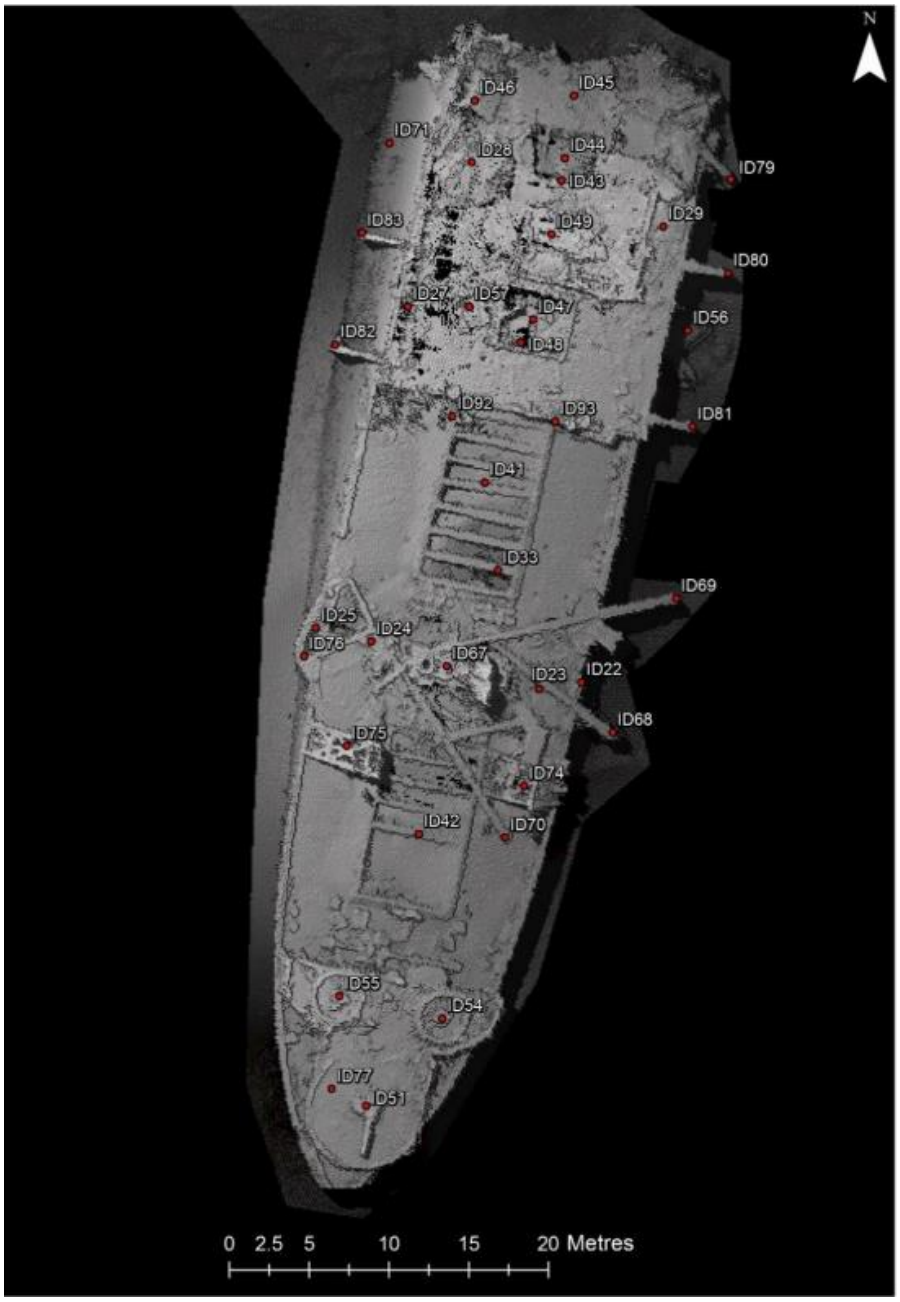

Figure 10: ID features on the Astern section.

4.2.3 Foot and Bow of the Stern

The degree to which to bow and stern may be being undercut as the supporting sediment is eroded away is a potential concern. For information on the seafloor please refer to 5.1. Figure 11 and Figure 12 below show profiles from the October 2022 survey overlaid on a Liberty Ship Plan. Although the data on the seafloor has been removed from the profiles, it can be seen in both cases that the bow and stern are both still resting on, or are slightly embedded in, the sediment so remain supported.

4.2.4 The stern generally shows less than 10cm change although there is evidence of some deposition at the rudder of potentially up to 1m. These small depositions/erosions of sediment at the bow and stern appear to be cyclical with sediment being eroded then deposited potentially in a short time period but leaving the overall depths essentially unchanged from year to year.

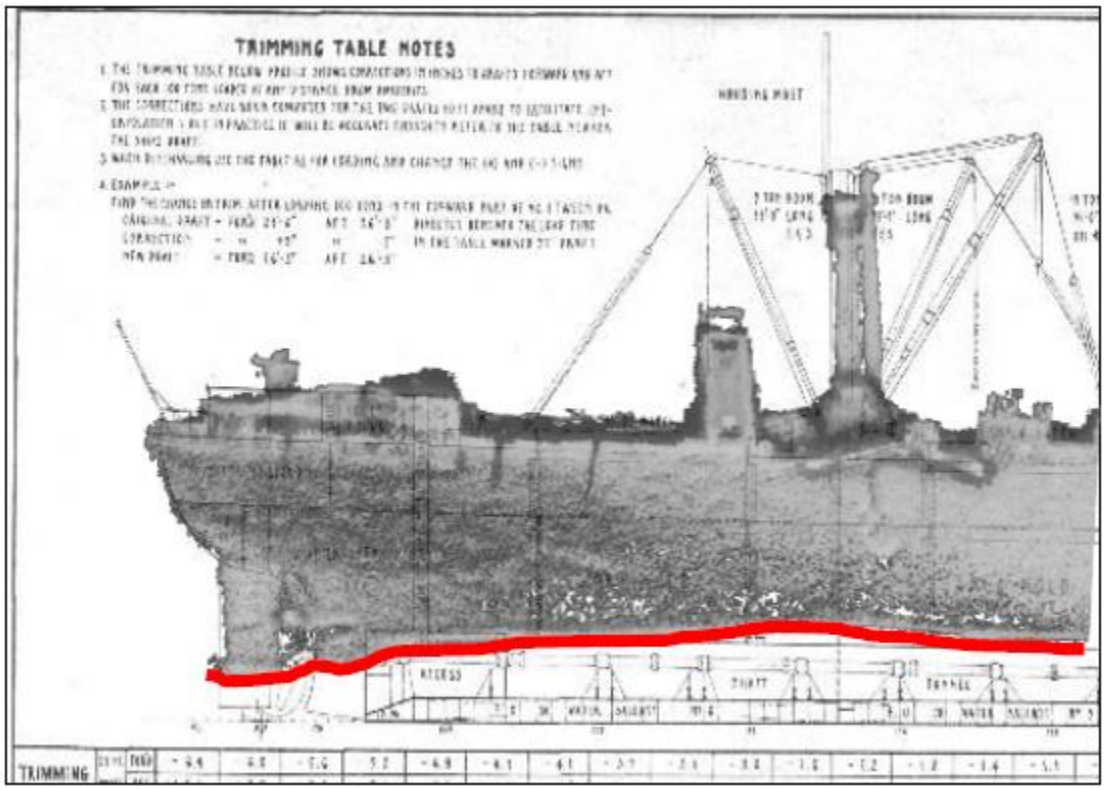

Figure 11: Profiles of the starboard Stern taken from October 2022 Survey data overlaid on a Liberty Ship's plan.

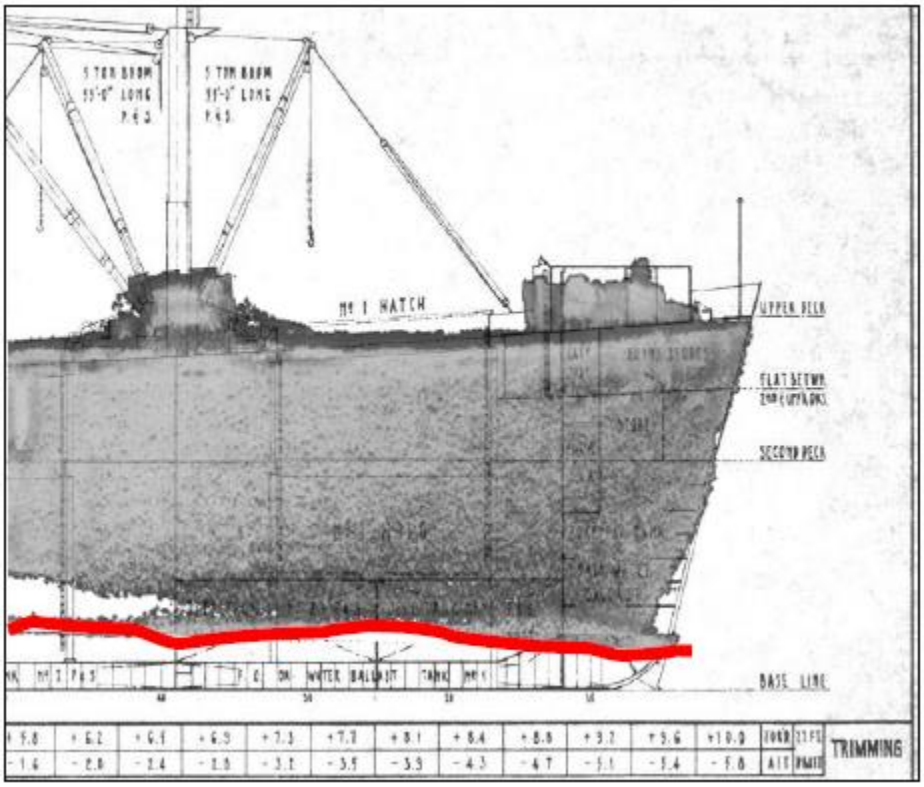

Figure 12: Profiles of the starboard bow taken from October 2022 survey data over laid on a Liberty ship's plan.

4.2.5 Key Areas 1 and 2 – Crack in Hull (ID04) and Collapse of Cargo Hold on Deck 2.

The forward section of the Richard Montgomery is seriously hogging around frame 53 almost exactly halfway along the No. 2 Hold Hatch. This hogging has resulted in a crack appearing on the upper part of the port side while the lower part of the starboard side is significantly buckled giving the appearance that the forward part of the wreck is splitting in two and pivoting about the starboard rim of Hold 2. The flexing of the upper deck has caused a portion of the upper deck and half of the No. 2 hatch cover supports to collapse through into the 'tween deck space.

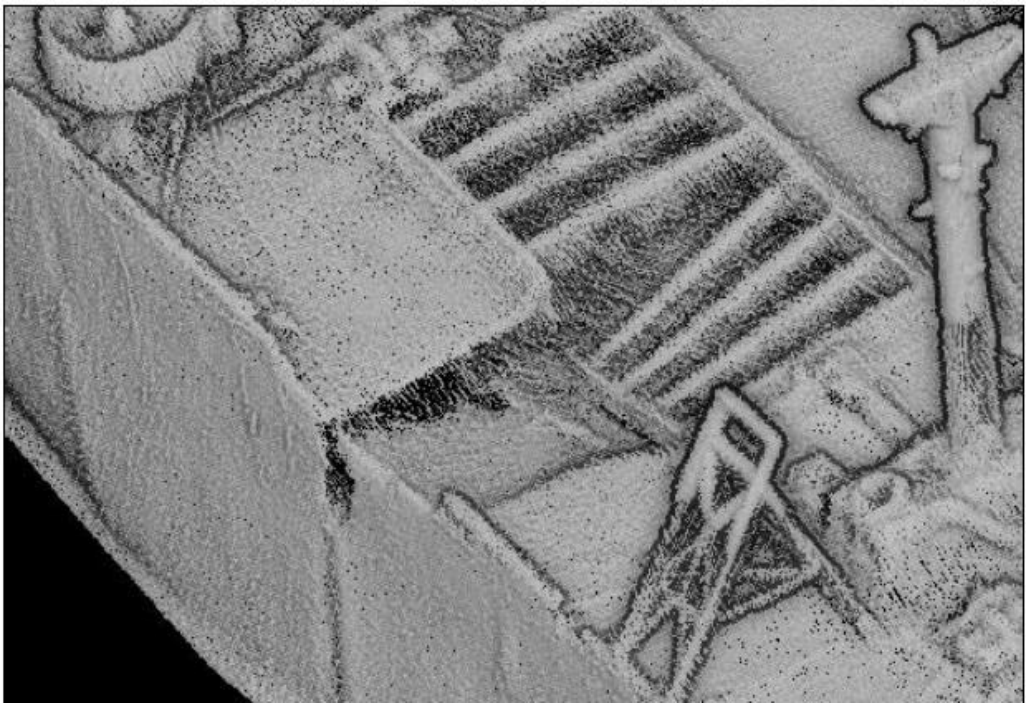

Figure 13: Crack in Hull (ID04) and Collapsed Upper Deck (ID 08) overview from the October 2022 dataset.

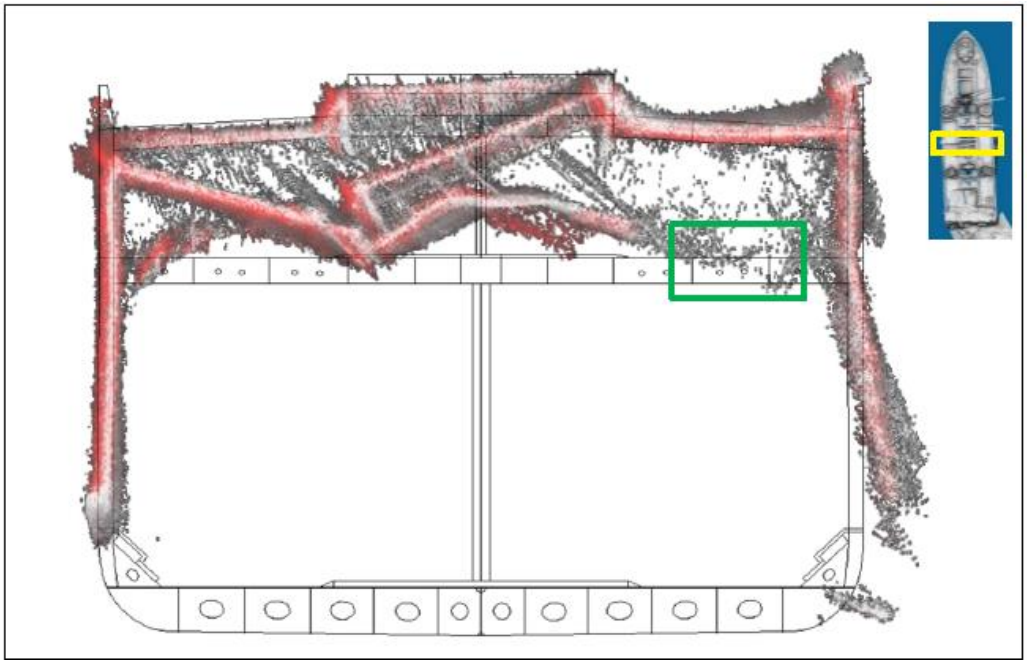

Figure 14: September 2022 (grey) and September 2021 (red) data overlaid on a Liberty Ship section.

Figure 15: Buckling of the Hull port side inward starboard outward. Red 2021 and Grey 2022 data.

4.2.6 Overlaying the 2022 and 2021 survey data on a section plan through a Liberty Ship shows the extent of the upper deck collapse as seen in Figure 14. The figure shows the location of the split and deck collapse with, on the left, both the non-collapsed deck and the collapsed deck. The collapsed upper deck and coaming to Hold 2's hatch have not quite fallen to the level of the second deck although it appears that the deck has collapsed until being supported by the sediment within the 'tween deck space.

4.2.7 The crack in the hull is at the location shown above in Figure 14 and enhanced in Figure 15. Of note is the sediment to the left (port side) that appears to extend deeper in the hull than the second deck level indicating that the second deck has been breached in this area – not surprisingly since the hull has split here and hence a tear in the second deck would be expected. How much sediment has entered the lower hold cannot be determined from this image though.

4.2.8 Also of note is the fact that the sediment in the 'tween deck space does not fill the space to the height of the starboard coaming of the hatch. In all other holds the sediment does fill the starboard side to the height of the hatch coaming. Why this has not happened here is not known but may be related to the crack in the hull on the starboard side allowing the sediment to wash out of this space rather than being trapped in it.

4.2.9 There is evidence, in Figure 14, for a breach/buckling of the lower deck (green box), however due to the lack of change to the rest of the deck plates and sediment level within the hold it is highly unlikely that this is recent and more likely down to this survey having ensonified the area better. Note the extreme bulging outward of the hull plates on the starboard side as seen in Figure 14. The bulge is limited to Hold 2 and the form of the hull returns to normal at the bulkheads at either end – potentially due to the greater strength afforded to the hull by the presence of the bulkheads. This bulging seems to have remained stable over the last few surveys.

4.2.10 Key Areas 3 – Aperture (ID96)

Figure 16 shows the apertures on the bulkhead at frame 88 at the aft end of the forward section, which are clearly visible in the 2022 dataset although there is no appreciable difference between this survey and that from September 2021.

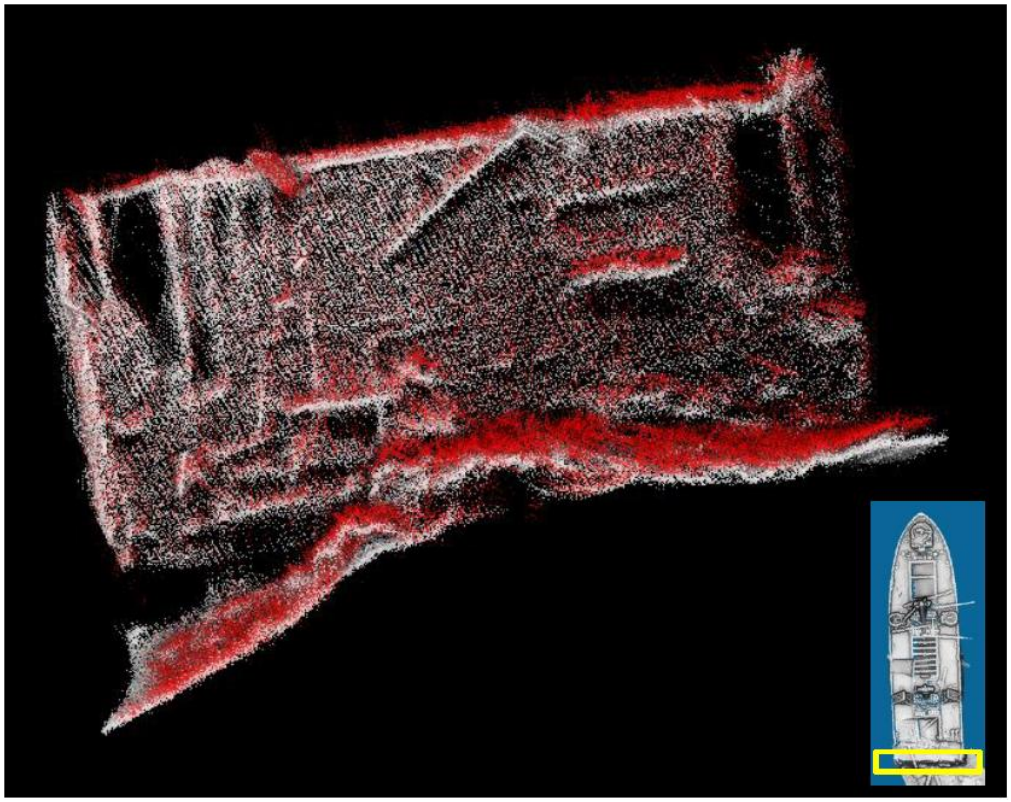

Figure 16: Aperture in the Bulkhead to rear of Hold 3. Grey October 2022, Red September 2021.

4.2.11 The poor quality of returns of objects obtained through the aperture mean it is not possible to identify them. The data collected during this survey shows very similar dimensions to what was gathered during the survey of September 2021. However, whether the returns are from cargo in the hold or sediment surrounding them cannot be ascertained.

4.2.12 Area 4 and 5 – Splitting of Hull (ID22) and split in Deck & Hull (ID24 & ID25)

Areas 4 and 5 represent the two ends of the same feature, namely a transverse crack across the rear hull section at about frame 134, the bulkhead between holds 4 and 5. Like the forward section, the rear section is hogging and potentially breaking in two about halfway along its length. The split appears to be occurring just forward of the mast with the mast remaining upright with respect to the stern part as it drops away from the forward part.

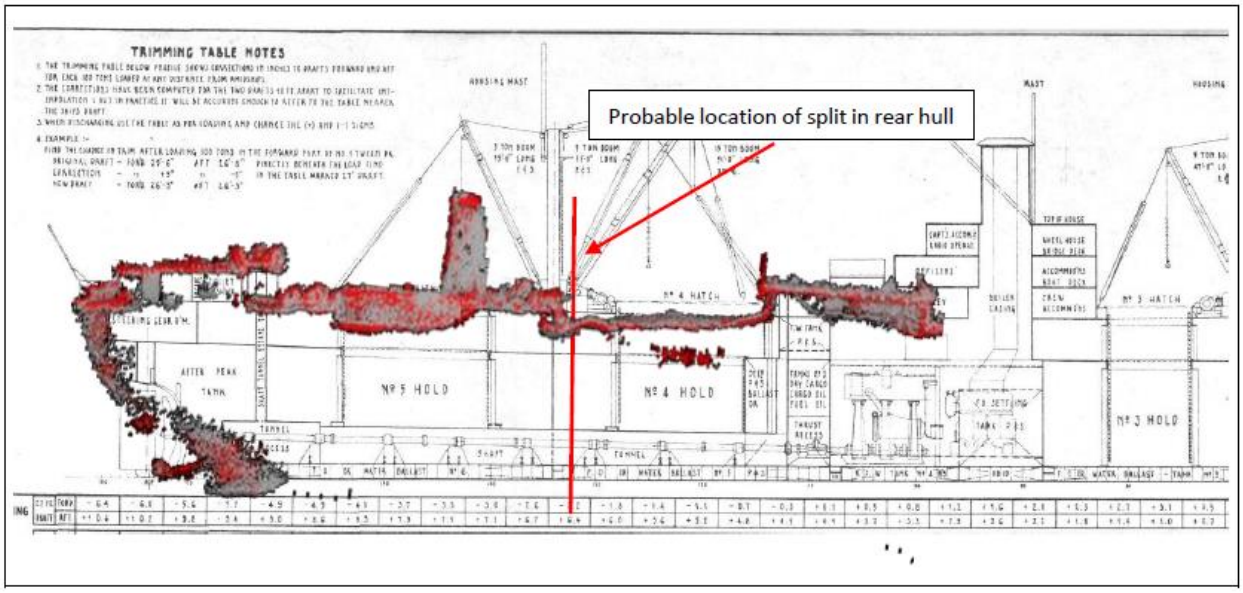

Figure 17: Longitudinal profile through the stern section. Grey October 2022, Red 2021.

4.2.13 No noticeable change has occurred to the angles or orientation of the wreck between the September 2021and October 2022 surveys although some variation is apparent to the sediment in Hold 4 and the collapsing Bridge deck. In Figure 17 above, the ship's plan has been positioned and orientated so the forward part of the stern aligns with the survey data showing how far below the plan the rear of the data lies.

4.2.14 Area 6 – Collapsing Bridge Deck Area (ID43, ID45 & ID46)

This area was left unsupported when the ship broke in two back in 1944. Consequently, it has been badly affected by wave and current action and is steadily collapsing and falling into the gap between the two halves of the vessel. This area has showed significant degradation in earlier surveys but there is only minor change between the 2021 and 2022 surveys although there appears to be some evidence of degradation and a slip of debris.

4.2.15 The area is difficult to survey accurately as the large number of angular protrusions create numerous echoes and multi path returns, creating a large amount of noise which makes picking out the real features hard. For this reason, the presence, or absence, of a given feature, especially internal structures within the void, are not conclusive of the actual feature existing or not. The main upper surface is more robust, and it is this area that has been used to assess the amount of change in this region.

4.2.16 In Figure 18 the change on the wreck is evident from the red areas indicating a higher spot in the 2021 survey whereas the pile on the sea floor is grey indicating a rise over the year.

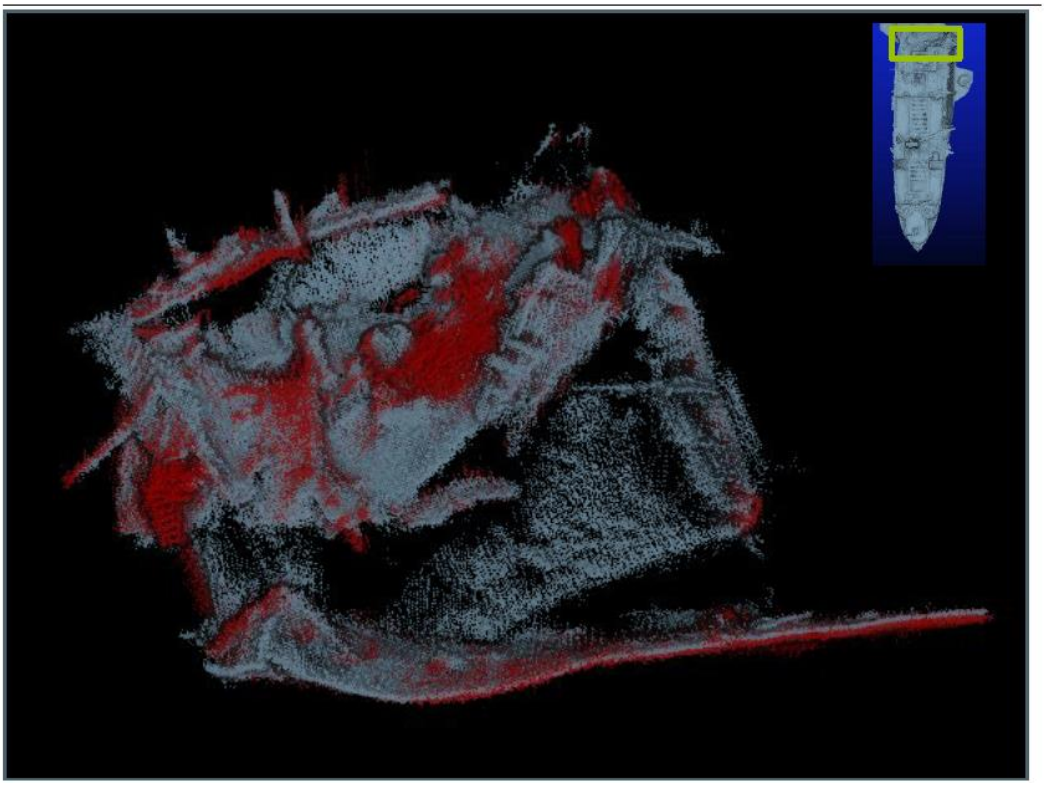

Figure 18: Profile through Bridge Deck Area. Grey 2022, Red 2021.

4.2.17 Figure 19 below shows a longitudinal cross section through the collapsing Bridge Deck area. The grey (2022) and red (2021) points along the long

unsupported section of deck agree very well at the top but vary significantly towards the left where it appears that the deck has collapsed to the lower floor level. This does not seem to have altered the general level of that section of wreckage, but it is possible that this structure may fail completely in the future and fall into the gap between the two halves of the ship.

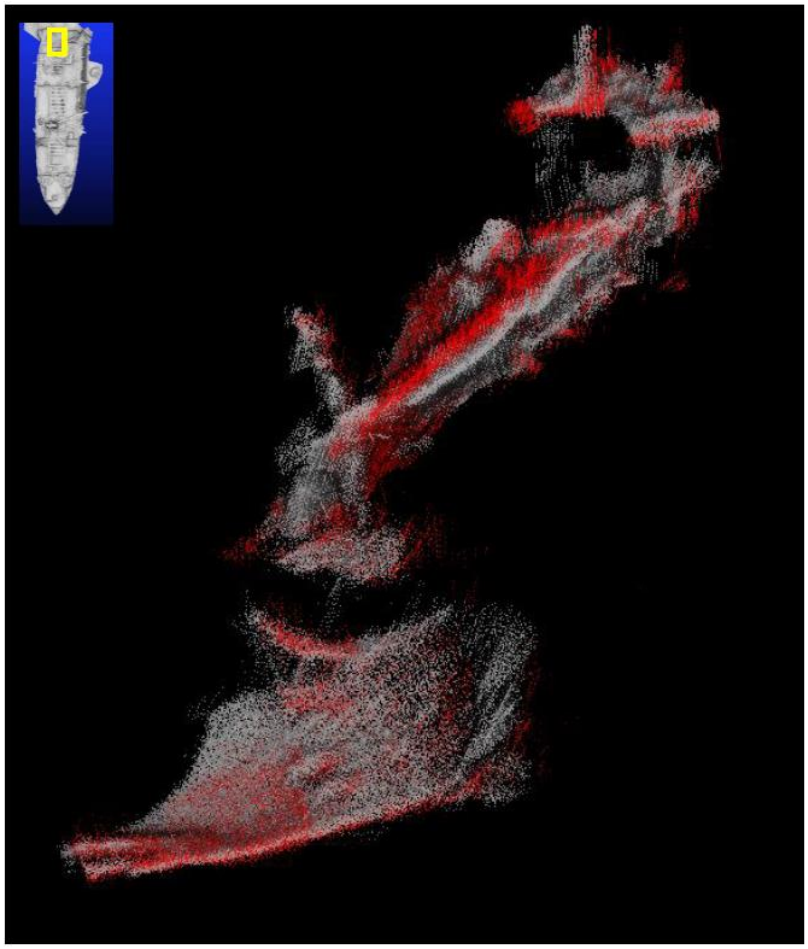

Figure 19: Longitudinal cross section through forward end of rear section showing area of continued change.

4.3 Debris Between the Hull Sections

4.3.1 There has been very limited appreciable difference in the debris between the bow and stern section. In Figure 20 below the only appreciable difference is that the pipe (or similar structure) sticking out from the debris pile at the base of the front section has rotated so that its free end is now no longer in the image. The pipe is identified in the image below by a yellow circle with the 2021 position in red.

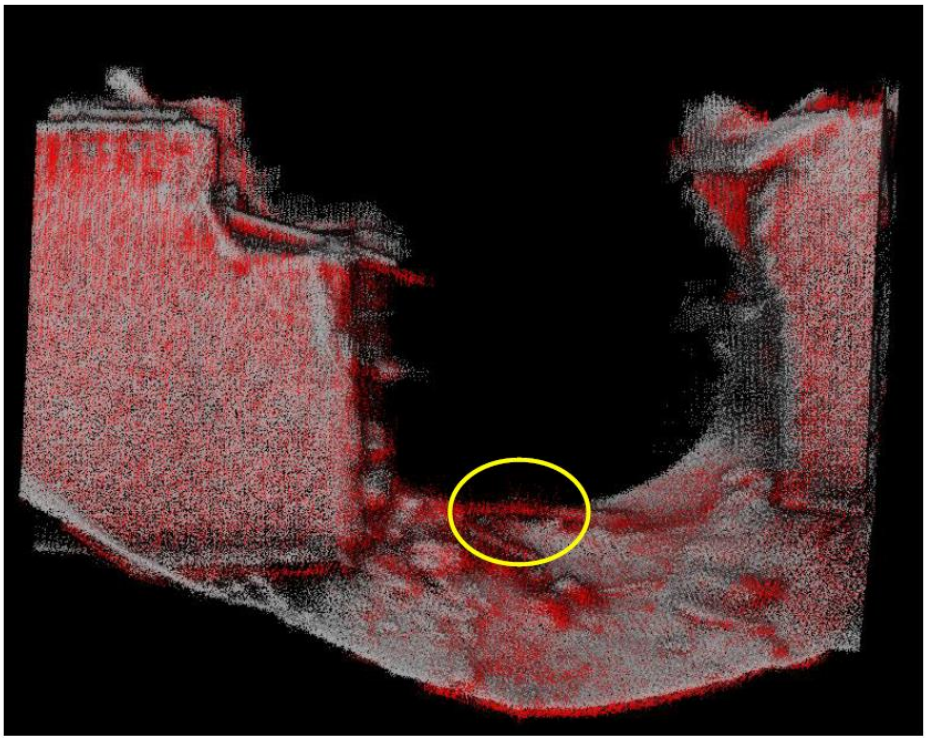

Figure 20: Longitudinal cross section through forward end of rear section showing area of continued change.

4.4 Cargo

4.4.1 When the SSRM grounded it was carrying some 6,127 imperial tons of cargo, mainly munitions. Of these, 2,954 tons were salvaged from the rear two holds (Holds 4 and 5) and a small portion from the No 3 Hold ‘tween deck space (area between two decks).

4.4.2 The small portion salved from the No 3 Hold ‘tween deck space was the 2 tons of bursters leaving 86 tons of fuses in 1,522 wooden cases and 117 tons of fin assemblies in 11,230 metal crates in this space. It is likely that the cylindrical debris seen in this area in previous surveys are some of the metal crates holding the tail fin assemblies.

4.4.3 All the holds on Liberty Ships are divided into a ‘tween deck area located between the Upper Deck and the Second Deck and the Lower Hold underneath the Second Deck. Hatch covers cover both the hatch on the Upper Deck and the opening through the Second Deck into the Lower Hold. With the possible exception of Hold 2 and the definite exception of Hold 4, all the sediment visible through the hatch openings is in the ‘tween deck space and not the Lower Hold.

4.4.4 Cargo was carried in the lower holds, in the ‘tween deck spaces and on the Upper Deck. Contemporary records indicate that the SSRM held cargo in all holds and all ‘tween deck spaces but only carried a very small amount on the Upper Deck.

Hold 1:

4.4.5 Hold 1 is the forward most of the five holds on the Liberty Ship and, in addition to the ‘tween deck space and the Lower Hold, Hold 1 also contained a third layer of storage at the bottom of the Lower Hold known as the Deep Tanks in which additional cargo or ballast could be carried.

4.4.6 The Hatch Cover is missing as are all but one of the Hatch Cover Supports. Sediment has settled in the ‘tween deck space to a considerable depth, filling the starboard side to the top of the starboard side hatch coaming. The port side remains clear above the horizontal from the starboard hatch coaming. Apart from some undulations in the sediment surface there is no difference between the level identified by the September 2021 and this survey. This is indicative of all the sediment visible in the data as imaged through the open hatch.

4.4.7 Notably there is no indication that the Second Deck nor the Second Deck hatch covers have collapsed. However, it is possible, but is very unlikely, that the sediment has filled both the ‘tween deck area and the Lower Hold. There has been a slight erosion of the sediment in the rear of the hatch area. However, this is likely to be cyclical event with sediment being washed in and out of the open hatch area possibly on a daily basis.

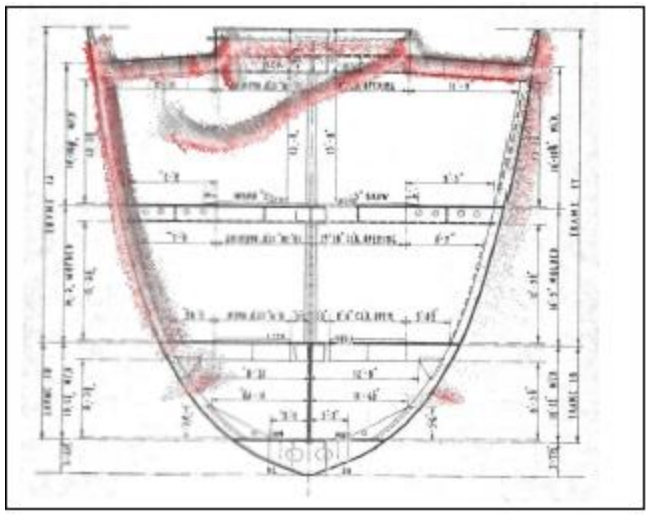

Figure 21: Cross section through the Hull at frames 17-18 at the forward end of No. 1 Hatch. Red September 2021, Grey October 2022.

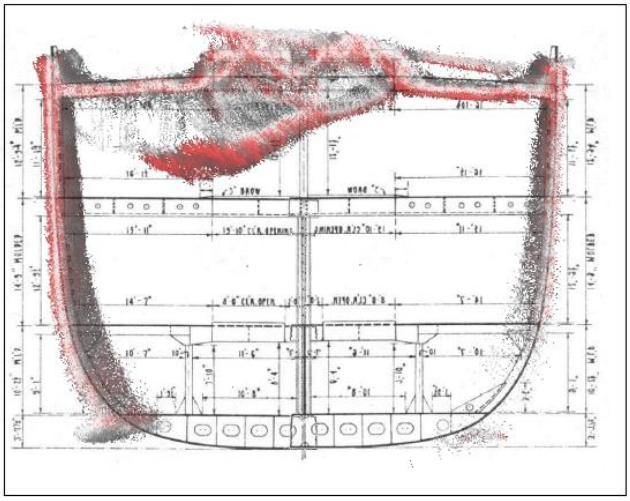

Figure 22: Cross section through the Hull at frame 32, the aft end of No. 1 Hatch. Red September 2021, Grey October 2022.

Hold 2:

4.4.8 The second from forward hold. As with Hold 1, the outer hatch cover is missing although all the cover supports are in place. The forward section of the wreck is splitting at frame 54, nearly mid-way along No.2 hatch, and this has resulted in part of the Upper Deck collapsing into the ‘tween deck space bringing the connected hatch cover supports with it. Sediment is visible through the open No. 2 Hatch and similarly to Hold 1, the sediment has filled the ‘tween deck space to a considerable depth although, unlike Hold 1, it appears that the sediment has not reached the port side hatch coaming and

the starboard side is not completely filled. Again, there is no indication that the second deck or the lower hatch covers have failed as there is no indicative slump in the sediment.

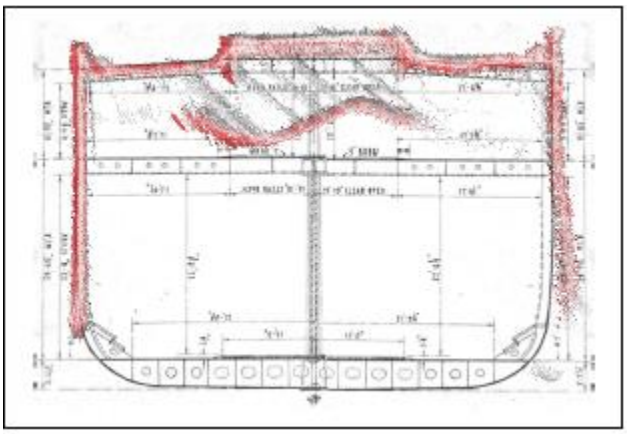

Figure 23: Cross section through the Hull at frame 46, the forward end of No. 2 Hatch. Red September 2021, Grey October 2022.

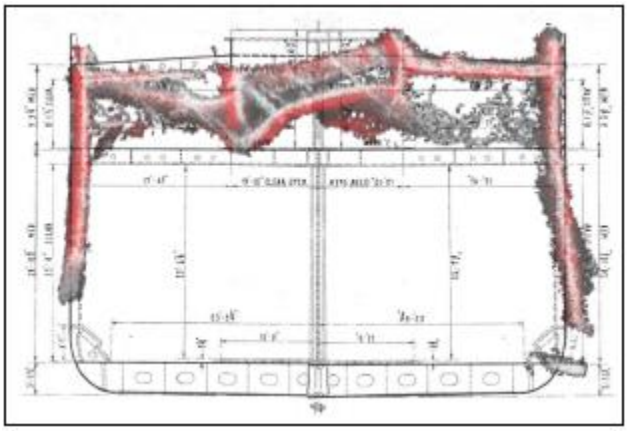

Figure 24: Cross section through the Hull at frame 60, the aft end of No. 2 Hatch. Red September 2021, Grey October 2022.

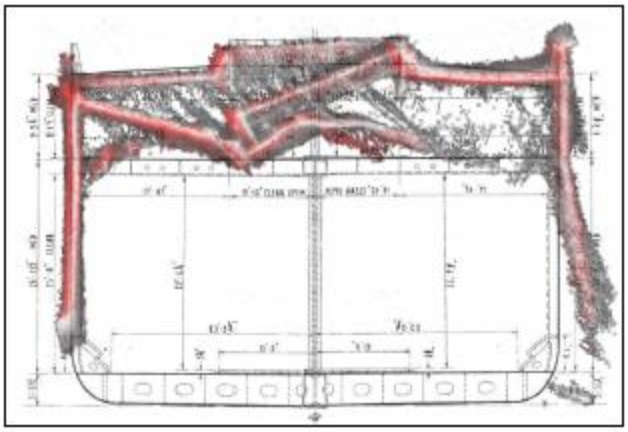

Figure 25: Cross section through the Hull at about frame 54, where the forward section is breaking in two. Red September 2021, Grey October 2022.

4.4.9 In Figure 25 above, the sediment in the ‘tween deck space of Hold 2 is visible. In this area, unlike the fore and aft ends of No. 2 Hatch, the sediment does not fill the ‘tween deck space. This may be due to the cracks in the hull sides at this location which could allow water to flush through and so remove the upper most sediment layers. It is also possible that the Second Deck has partially collapsed where it joins the port and starboard hull – see the data as collected through the split in the hull in Figure 25 above, although this could also be the result of poor acoustic properties caused by the sound passing through the narrow gap.

Hold 3:

4.4.10 The rearmost hold of the forward section. The rear bulkhead of this hold forms the rear of the forward section, the vessel having broken in two immediately aft. Although the Lower Hold remained with the forward section, the bulkhead at the rear of the ‘tween deck space and the section of the upper deck above it were carried away leaving this area open. The outer hatch cover has gone as have all the cover supports although there is a beam – possibly a cover support or part of the coaming lying on the starboard side.

4.4.11 Sediment accumulation is largely limited to the forward part that still retains the protection of the Upper Deck and, in common with all the forward holds there is no evidence that the Second Deck or the cover leading to the Lower Hold have collapsed. All sediment layers are higher than the second deck with no indicative slumps.

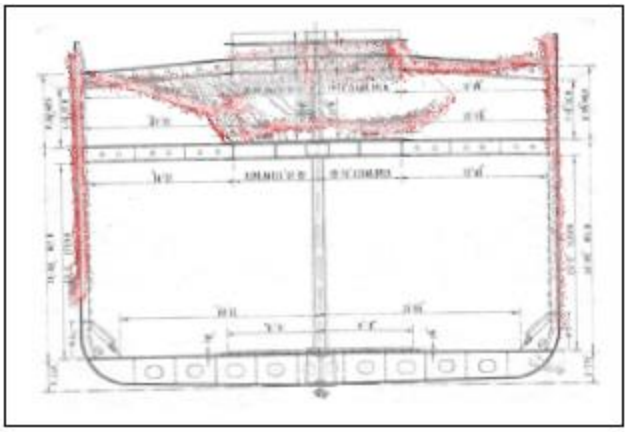

Figure 26: Cross section through the Hull at frame 73, the forward edge of No. 3 Hatch. Red September 2021, Grey October 2022.

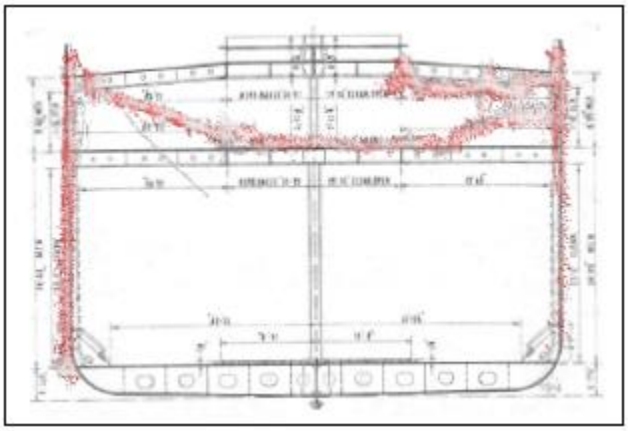

Figure 27: Cross section through the Hull at frame 82, the aft end of No. 3 Hatch. Red September 2021, Grey October 2022.

Hold 4:

4.4.12 The most forward of the two holds in the stern section. Since the two stern holds are reported to have been emptied during salvage operation conducted soon after the grounding it is not known if the lower hatch covers were replaced. However, since the upper Hatch supports are in place it seems likely that the salvors did replace the covers once they were finished.

4.4.13 The sediment in the forward part of No. 4 Hatch shows distinct similarities with that in No 1 hatch with the starboard side of the ‘tween deck space being completely filled and the port side remaining clear above the horizontal to the top of the hatch coaming.

4.4.14 The rear of the hatch area shows the sediment layer descending below the level of the Second Deck due to some form of collapse, probably a partial

collapse of the lower hatch cover which occurred between 2010 (where the survey showed the sediment above the Second Deck) and the 2017 survey where the sediment was just below the Second Deck, this has been included in profile. There has been a reduction in the slope of the sediment below the tween deck which indicates there has been some settling/ current distribution occurring.

4.4.15 Overall, there has been little change in the overall volume of sediment but rather a redistribution due to currents within the Hold between September 2021 and October 2022.

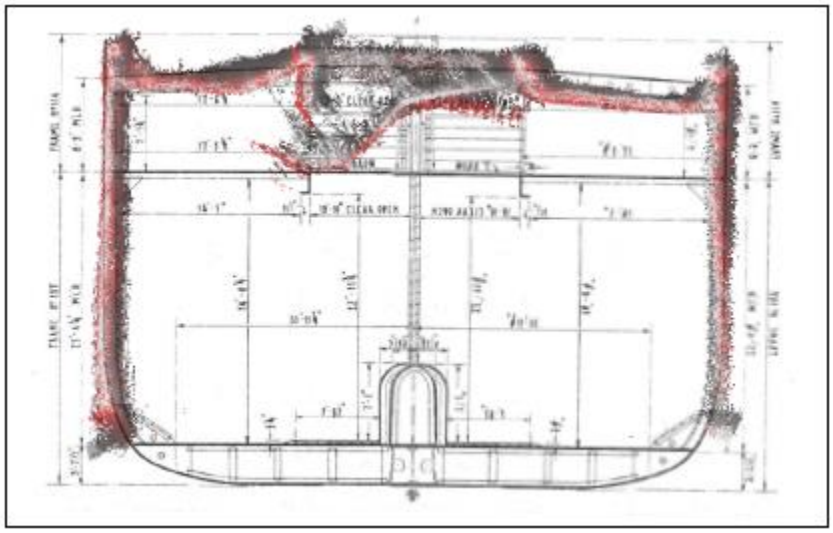

Figure 28: Cross section through the Hull at frame 114, the forward end of No. 4 Hatch. Red September 2021, Grey October 2022.

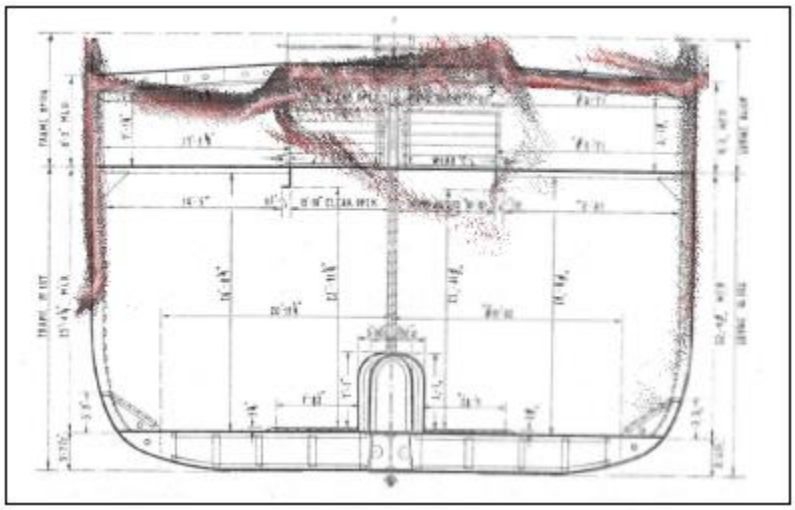

Figure 29: Cross section through the Hull at frame 114, the rear of No. 4 Hatch. Red September 2021, Grey October 2022.

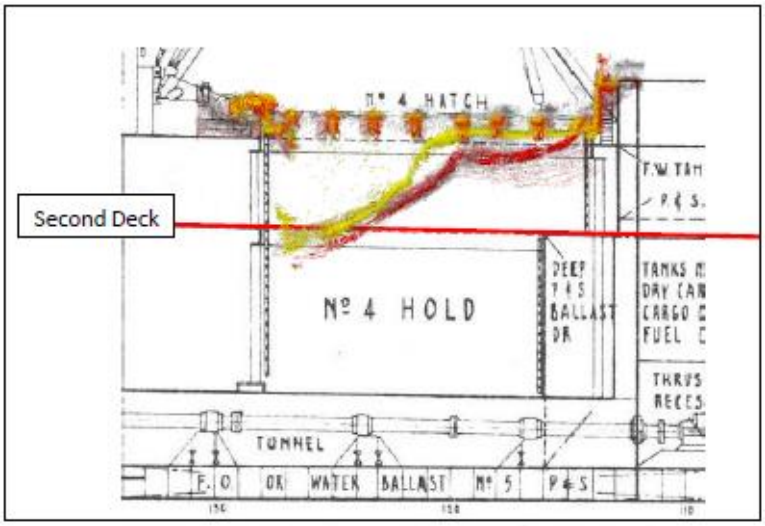

Figure 30: Longitudinal cross section through Hold 4. Yellow September 2020, Red September 2021, Grey October 2022.

Hold 5:

4.4.16 The rear most hold. The forward four of the six hatch cover supports remain in place. Sediment levels in the ‘tween deck space again follow the pattern of the other mainly intact holds in that the starboard side is filled while the port side remains clear above the level of the horizontal from the top of the hatch coaming. As with the other holds (apart from Hold 4), there is no indication that the second deck or the lower hatch cover have collapsed.

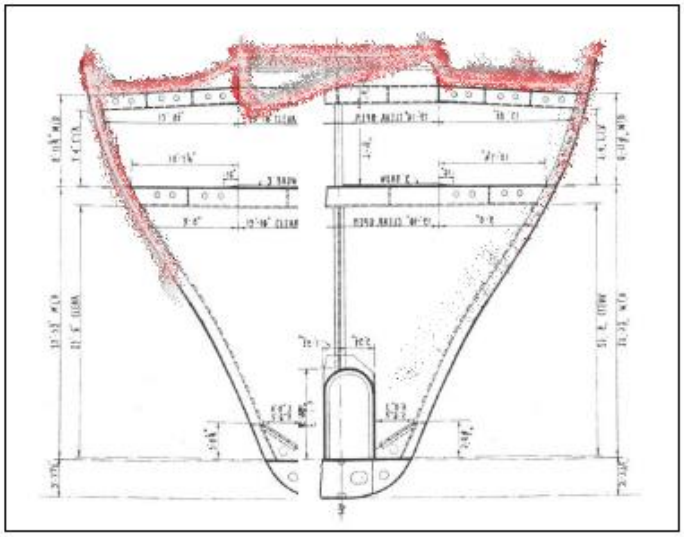

Figure 31: Cross section through the Hull at frame 154, the aft of No. 5 Hatch. Red September 2021, Grey October 2022.

5 Seabed Survey 2022

The seabed data collected is of high quality and adheres to IHO Special Order as per requirement. Previously identified seabed targets from the gazetteer of observations were overlain and the presence of the targets noted, and any new targets added.

5.1 General

5.1.1 An overview of the seabed surrounding the wreck of the SSRM is illustrated in Figure 32.

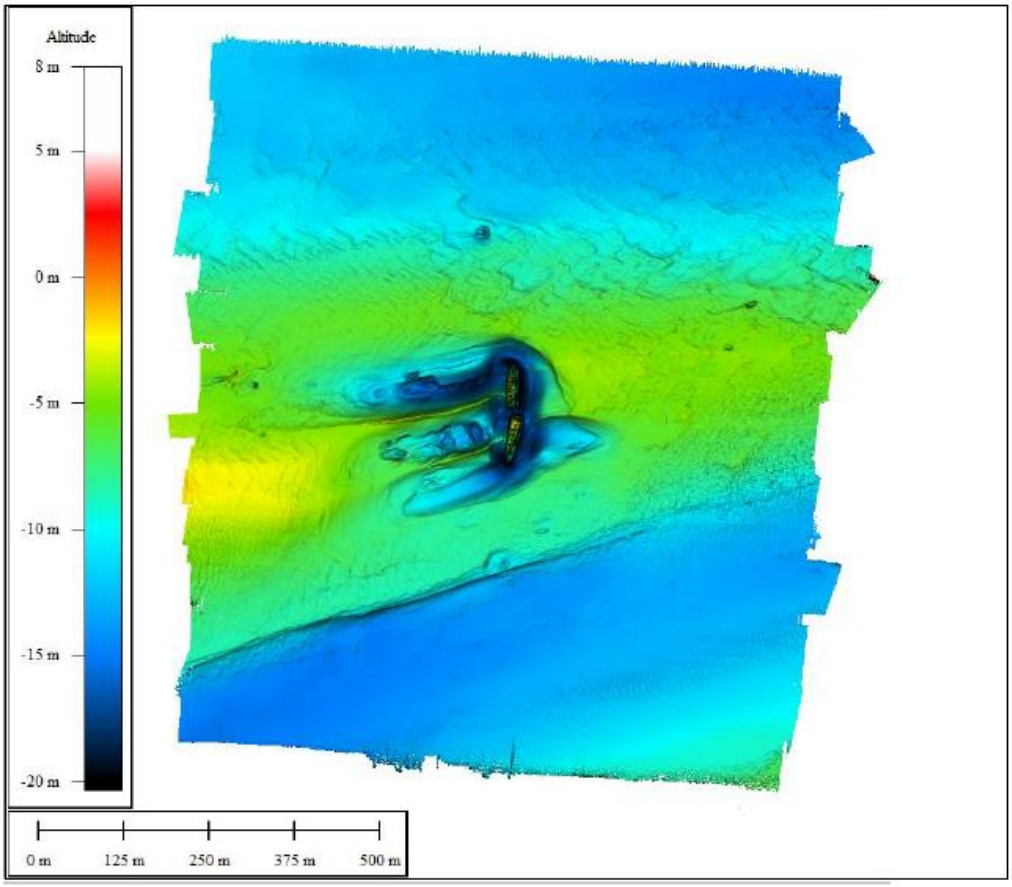

Figure 32: Shaded relief plan of seabed survey area.

5.1.2 The analysis of the results of the survey of the seabed around the wreck was carried out with the Cloud Compare functions cloud/mesh distance comparison. The September 2021 data was set as the reference and October 2022 data as the comparison.

5.1.3 Figure 33 shows the elevation displacement of the seafloor around the wreck has seen a general increase of around 0.4m between the 2021 and 2022 surveys with areas of greater accretion outside the scour basin with relative height differences in excess of 2m. There is some evidence of scouring in the valleys and ridges heading westward from the wreck with losses ranging from approximately 0.3m in the valleys to the west and the outer face of the scour pit to 1.25m on the north-eastern faces of the large dunes.

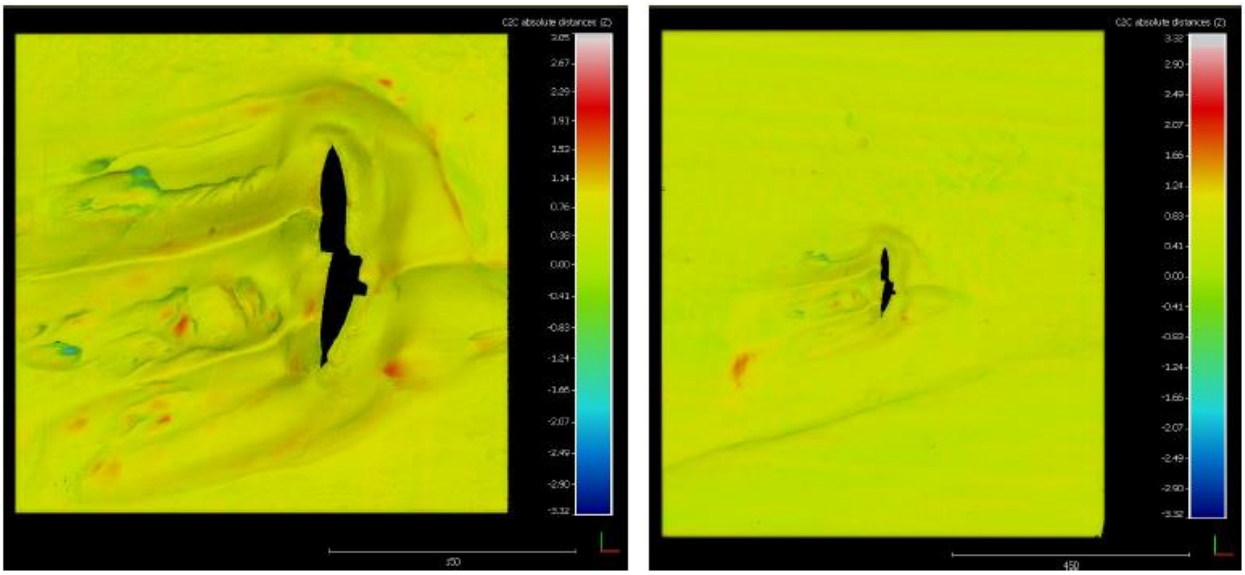

Figure 33: Shaded relief plan showing the wider seafloor around the survey area.

5.1.4 Changes to the wider seafloor are shown in Figure 33, the most significant of which being the accumulation of 2m of sediment at the end of the scour channels as a result of net sediment transport running east to west sediment accretion over the wider site is on average 0.4m. Other changes to the wider survey area include minor changes in the level of sediment in the sand waves to the north and west of the site and the erosion of the southern side of the channel by approximately 0.8m.

5.2 Seabed Contacts

5.2.1 The seabed contact list from 2017, with a total of 66 contacts, was compared against this year's bathymetry. Analysis of the 2022 dataset has added no further targets to the contact list, while 12 items from the 2017 contact list are not apparent on the 2022 data. The seabed contacts, especially the smaller or lower lying ones, are subject to a pattern of being buried an uncovered by moving sediments. Consequently, their presence or not in any particular year's data set is largely a function of the movement of sediment around and over them.

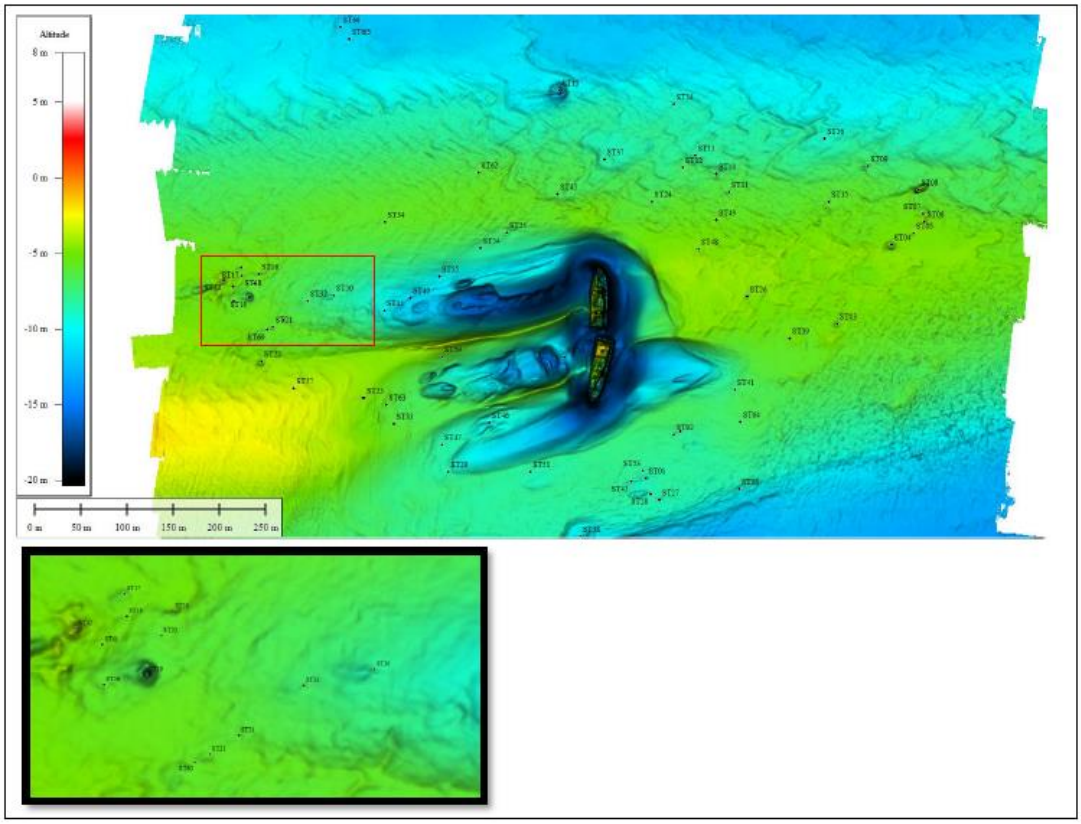

Figure 34: Seabed reference points.

6 Conclusions

6.1.1 The 2022 survey successfully covered all significant portions of the wreck with high quality MBES data. Although not completely ensonified, the overhanging portion of the wreck (starboard side of hull) was covered with a greater density of points than in all previous surveys assessed in addition to greater ensonification of the holds through the hatch coaming.

6.1.2 The comparisons between this survey's data and the preceding survey (September 2021 Full Survey) indicated that no significant changes had occurred. However there has been new sections of the wreck ensonified, including a potential breach in the 'tween no.2 Hold. Other than this the only area that showed any change was the unsupported Bridge Deck area that has continued to subside, causing some debris to slip adding debris pile between the wrecks.

6.1.3 The sea floor survey showed an overall accretion of approximately 0.4m of sediment, with over 2m being deposited in several areas around the scour pit. There is a continuation from prior reports of scour/removal of sediment with a net transport running east to west across the site.

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