Maritime & Coastguard Agency

SS Richard Montgomery: Survey Report 2021

June 2022

Contents

Abbreviations

CD	Chart Datum
Cefas	Centre for Environment, Fisheries and Aquaculture
DfT	Department for Transport
EAG	Expert Advisory Group
GPS	Global Positioning System
IHO	International Hydrographic Organization
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 2021 survey.

1.2 Survey Overview

1.2.1 The 2021 survey data was gathered from the area identified by the black dotted box in Figure 1.

1.2.2 The results of the 2021 survey show that the wreck and the surrounding seabed remained relatively stable between the 2020 and 2021 surveys, with no changes exceeding the agreed parameters. Further surveys have been undertaken as part of ongoing works undertaken by Department for Transport (DfT) and Ministry of Defence (MOD) but these are not included in this summary.

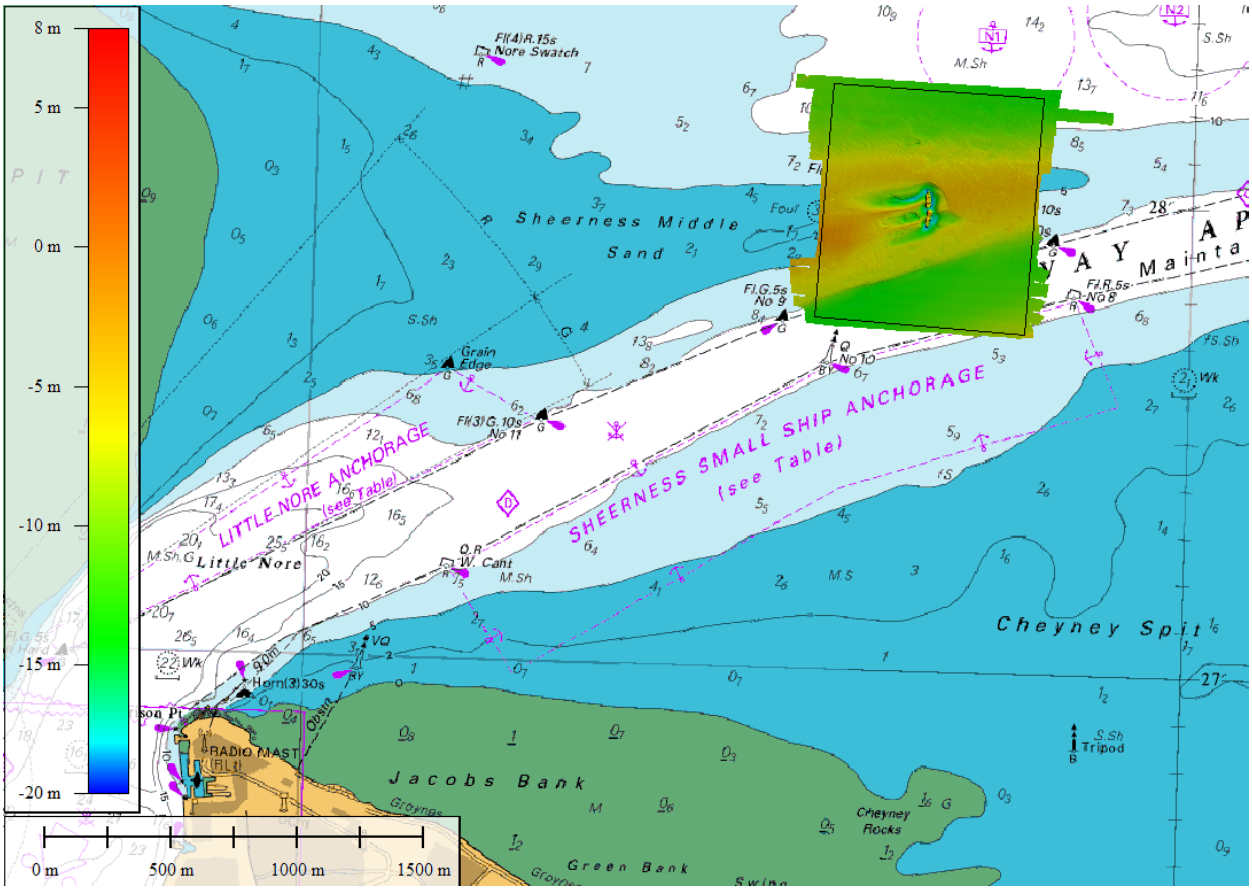

Figure 1 SSRM 2021 survey location and extent.

1.3 Key Results

1.3.1 As in previous years, the 2021 survey covered the entire wreck and surrounding seabed in detail.

1.3.2 There are no significant differences on the wreck between the 2020 and the 2021 surveys.

1.3.3 Over the whole of the wreck six key areas, and 96 specific features, have been used in successive surveys as comparison points for quantifying change and deterioration. No significant changes were detected in any of the key areas with most showing little, if any, discernible change since the previous survey. The only exception was the bridge deck that continues its downward deflection.

1.3.4 The seabed measured during the August 2020 survey was compared to the seabed measured during the 2021 survey.

1.3.5 In the wider survey area, 72 seabed objects have been noted in previous surveys, with no obvious changes noted in the survey.

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, the water was too shallow for the heavily laden vessel and, as the tide fell, the SSRM dragged its anchor and ran 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 2 below, taken from North approach).

Figure 2 Photograph of the SSRM's three masts above the water – right to left: fore mast, main mast and mizzen mast

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 marked on Admiralty Charts, the prohibited area being delineated by four lit cardinal buoys and twelve red danger buoys. The wreck is also 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 wreck are undertaken to provide information on its condition, to identify any changes or deterioration and to inform future management strategy. The survey results are shared with the independent Expert Advisory Group (EAG) formed in 2017 to advise the 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 September 2021 SSRM survey findings, including a comparison with the 2020 survey dataset. 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. Figure 3 below shows the six key areas of search.

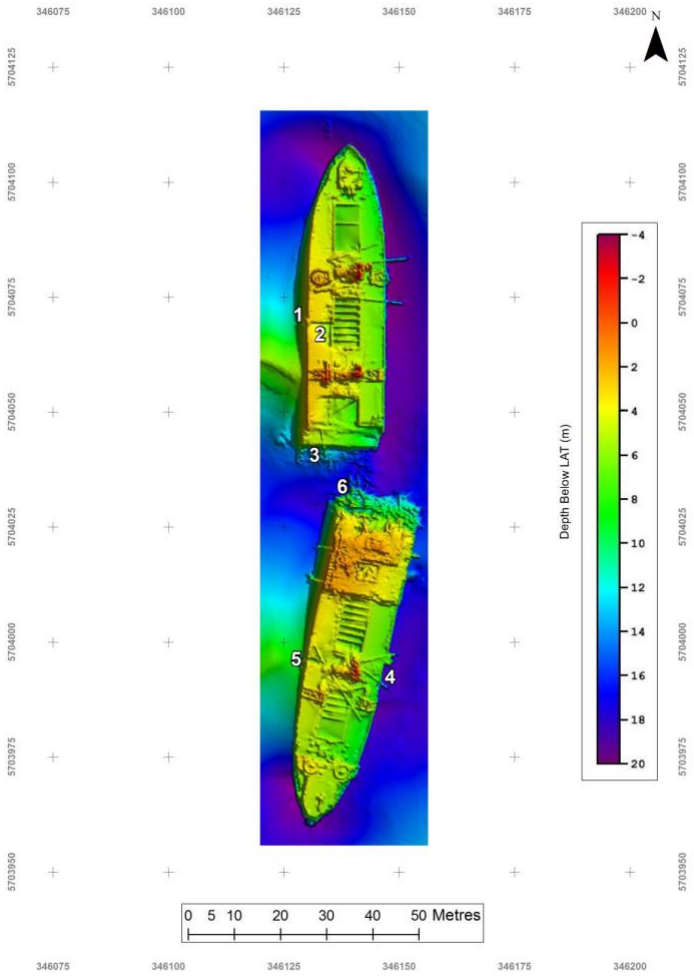

Figure 3 Six Key Areas monitored through SSRM annual surveys.

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.

3 The Survey

3.1 Survey Requirements

3.1.1. The Scope of Work included the following objectives:

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

b) A MBES survey of the seafloor in the immediate vicinity of the wreck.

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 January 2020) 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 the previous survey.

3.2 Survey Area

3.2.1 The survey area is shown by the dotted black line in Figure 1.

3.3 Survey Operations

3.3.1 The MBES survey of the SSRM wreck took place between 04/09/2021 and 08/09/2021. The laser scanning of the masts and additional multibeam data acquisition was conducted on 06/09/2021 and 07/09/2021.

3.3.2 The multibeam survey and the laser scanning operations were conducted using the EGS Watchful which is a permanently mobilised shallow draft inshore survey vessel operating under the Maritime and Coastguard Agency (MCA) Workboat Code Category 2.

3.4 MBES

3.4.1 The MBES data was collected at high tide using the following equipment:

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 QPS QINSy acquisition/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

Table 1: EGS Watchful equipment specifications used for data collection in 2021 SSRM survey.

3.4.2 The MBES data was processed, and position corrected using a post processed kinematic Global Positioning System (GPS) data solution which allowed for a highly accurate and precise dataset.

3.4.3 The data was reduced to chart datum using the same Vertical Offshore Reference Frame (VORF) value of 41.845m as in the previous surveys to allow for a direct comparison. The data was cleaned to remove any outliers and noise within the dataset, and a full density georeferenced point cloud XYZ was exported.

3.4.4 The surrounding seabed data was processed with CUBE methodologies and surface grids were produced all of which adhere to International Hydrographic Organization (IHO) Special Order. These surfaces were used to produce contours, surface difference plots and shaded bathymetric imagery. Figure 2 shows the August 2019 MBES of the surrounding seabed.

3.4.5 The cleaned point cloud analysis was initially carried out in Cloud Compare where advanced point cloud light shading allows for an effective visual inspection of the wreck data points. Historical datasets can be viewed simultaneously to allow areas of change to be highlighted.

3.4.6 Data profiles have been taken from CARIS (hydrographic software processing system) subset which allows accurate and spatially comparable data slices to be analysed. In the CARIS HIPS & SIPS software subset vertical and horizontal changes can be quantified and reported.

3.4.7 Throughout this report, all point cloud images have been generated in Cloud Compare. Surface difference plots were generated in QINSy Qimera and all historical profile comparisons have been made in CARIS HIPS & SIPS.

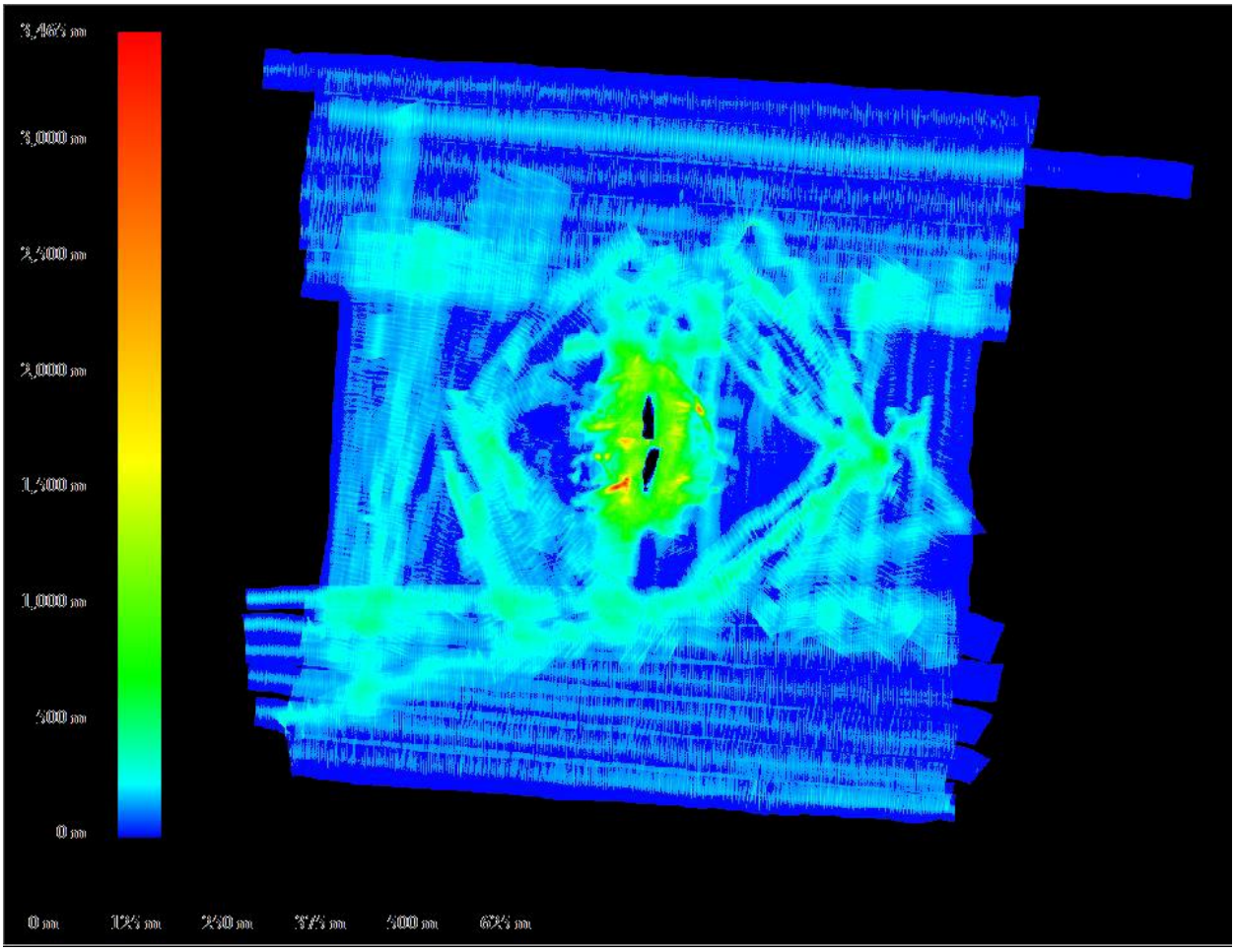

Figure 2 – Density plot of surrounding seabed MBES survey.

3.5 Laser Scanning

3.5.1 The laser scanning was conducted at low tide using a Norbit iWBMS iLIDAR Laser, and the data was acquired by Norbit WBMS GUI. Multiple lines were run in various directions within the vicinity of the wreck to achieve full coverage and data density around the masts. The laser data was also reduced using a Post-Processed Kinematic (PPK) solution and exported to a separate georeferenced full density point cloud (Figure 5).

3.5.2 In addition to laser scan data, photographs were taken to add to the available information on the condition of the exposed masts. Figure 6 shows the masts above the water.

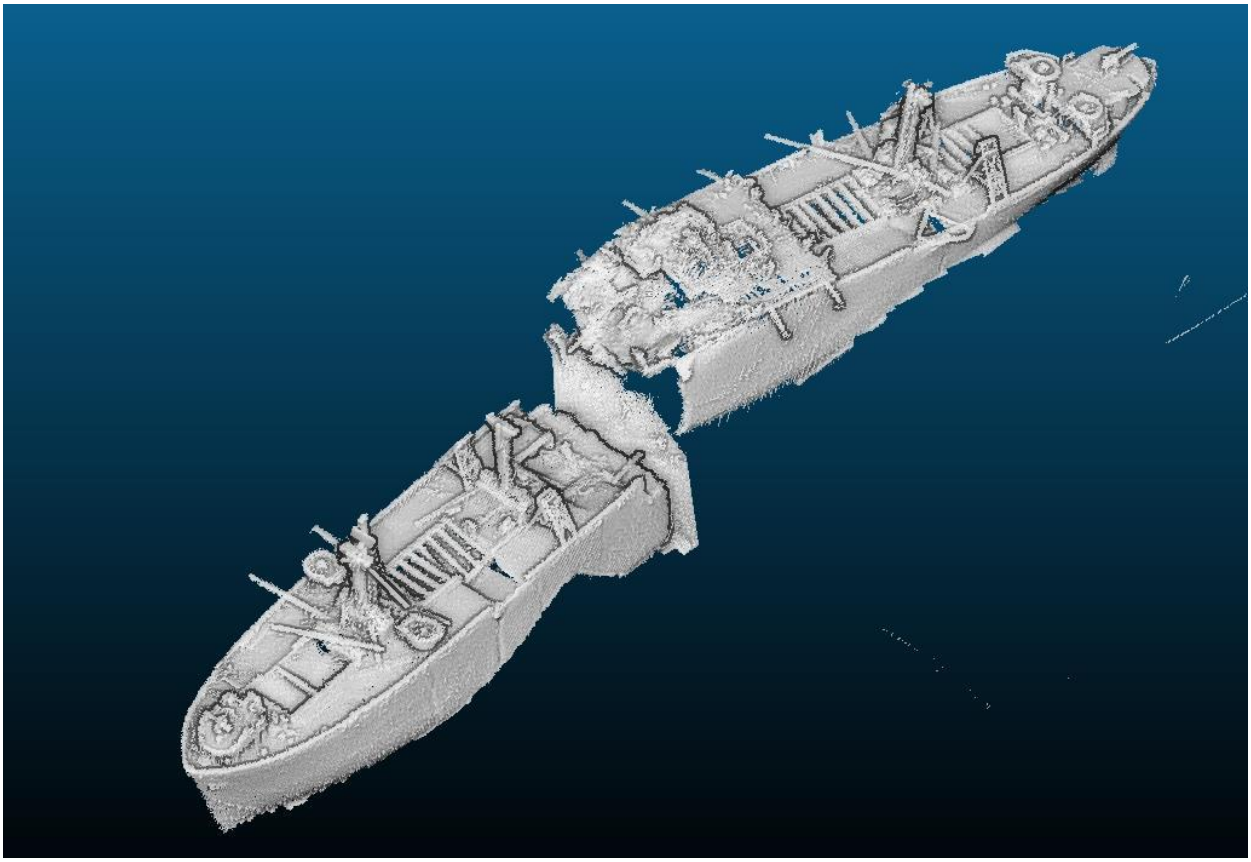

Figure 5 SSRM overview from the north west.

Figure 6 SSRM overview from the east.

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 Using the six key areas of analysis (see below), the results of the survey demonstrate that, in general terms, there has been little or no change in the position of the main body of either the forward or aft sections of the wreck.

4.1.3 There has also been little change if any in the individual features of the wreck, discussed individually below.

4.1.4 Key Area 1, crack in hull (port side, forward section). "*Analysis of the large crack in the hull on the forward port side of the wreck suggests that the extent of the crack has remained static since the September 2020 survey was completed*" (Figure 7).

4.1.5

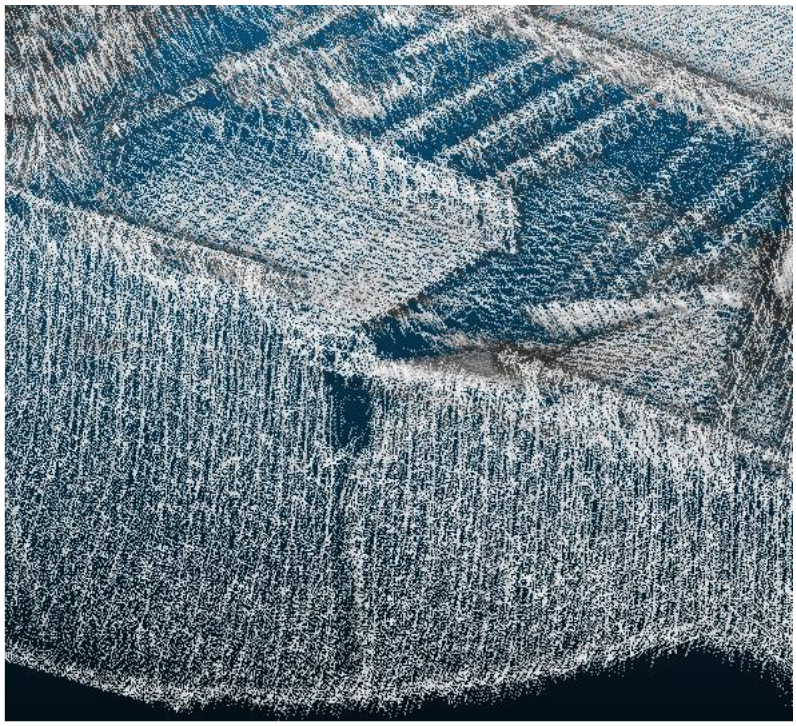

Figure 7 – Image of Key Area 1, crack in hull.

4.1.6 Key Area 2, partial collapse of cargo hold deck (port side). "*No discernible differences have been seen in the initial analysis between the September 2020 and September 2021 surveys*" (Figure 8).

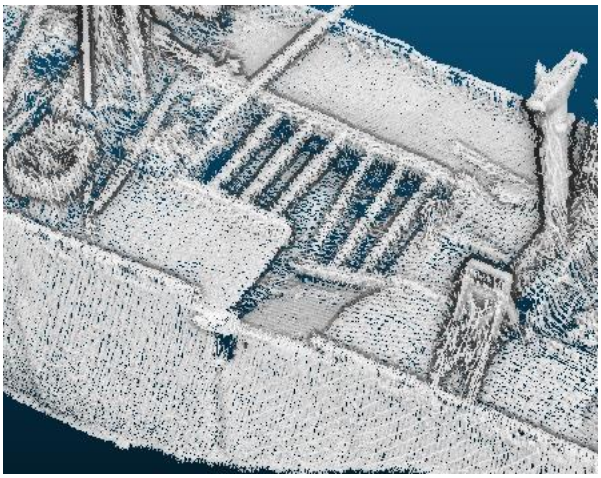

Figure 8 – Image of Key Area 2: partial collapse of cargo hold deck (port side).

4.1.7 Key Area 3, Port Side Aperture in Aft Part of Forward Section. "*Comparisons between the September 2021 and September 2020 datasets show no obvious changes in this area.*" (Figure 9).

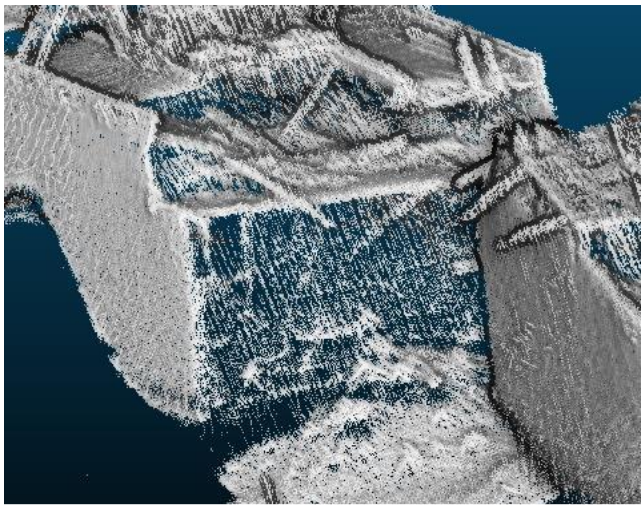

Figure 9 – Image of Key Area 3: port side aperture (aft part of forward section).

4.1.8 Key Area 4, severe splitting of hull (starboard side aft section*). "Little if any change is evident between the September 2021 data and the September 2020 data". (Figure 10)*

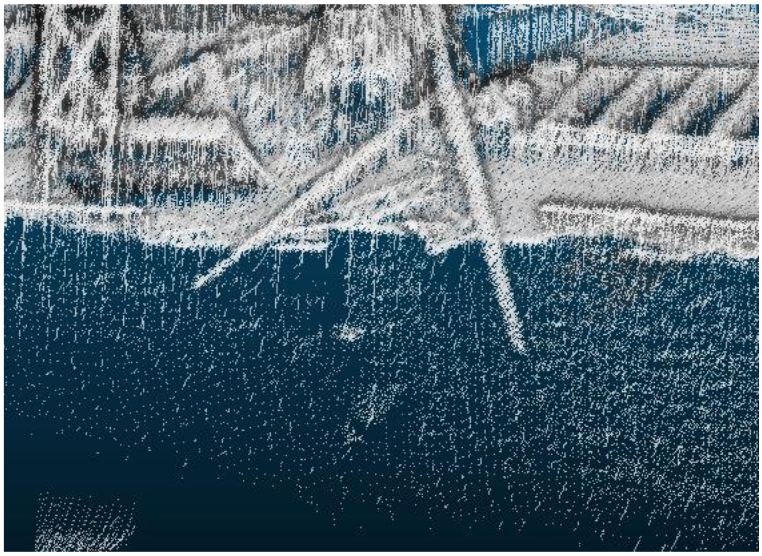

Figure 10 – Image of Key Area 4: severe splitting of hull (starboard side aft section).

4.1.9 Key Area 5, split in deck and hull plating (port side aft section). "*This split was clearly observed in the August 2019 dataset and September 2021. Although this split had shown some evidence of increasing in size between the January and August 2019 surveys, little difference is evident between the September 2020 and September 2021 surveys*". (Figure 11).

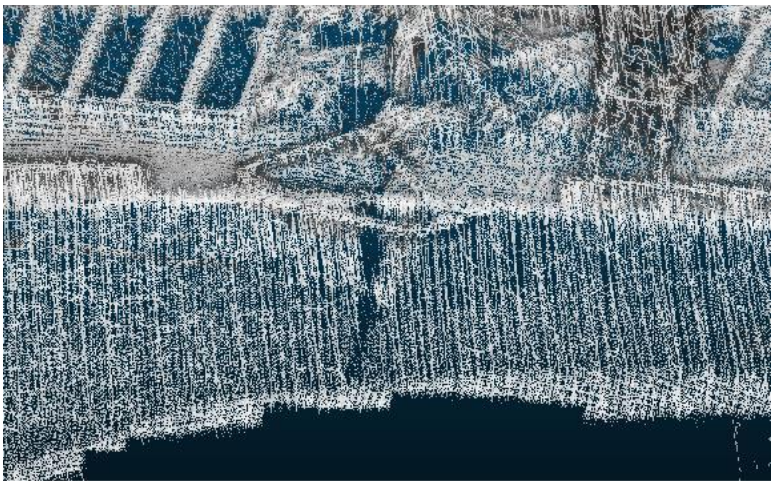

Figure 11 – Key Area 5: split in deck and hullplating (starboard side, aft section).

4.1.10 Key Area 6, collapsing bridge deck area. "*This section of the vessel was identified in 2015 to have seen the greatest amount of degradation since the previous annual survey. The speed of change was not apparent between the January and August 2019 surveys and similarly, little change is immediately evident between the September 2021 survey and the September 2020 survey*" (Figure 12).

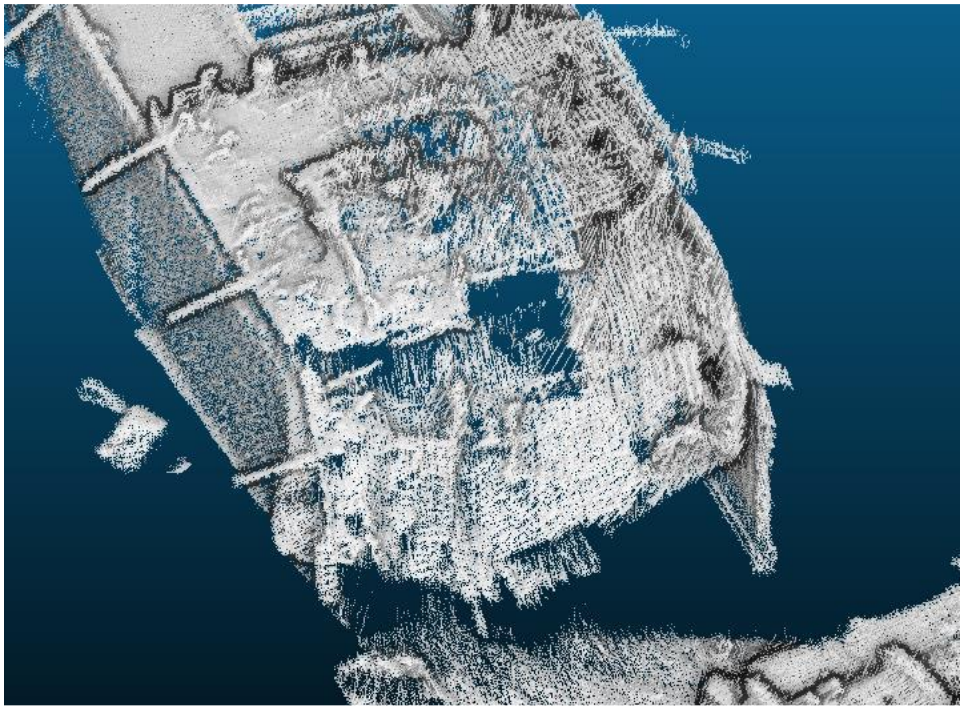

Figure 12 – Key Area 6: collapsing bridge deck area.

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 Figure 13.

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 13).

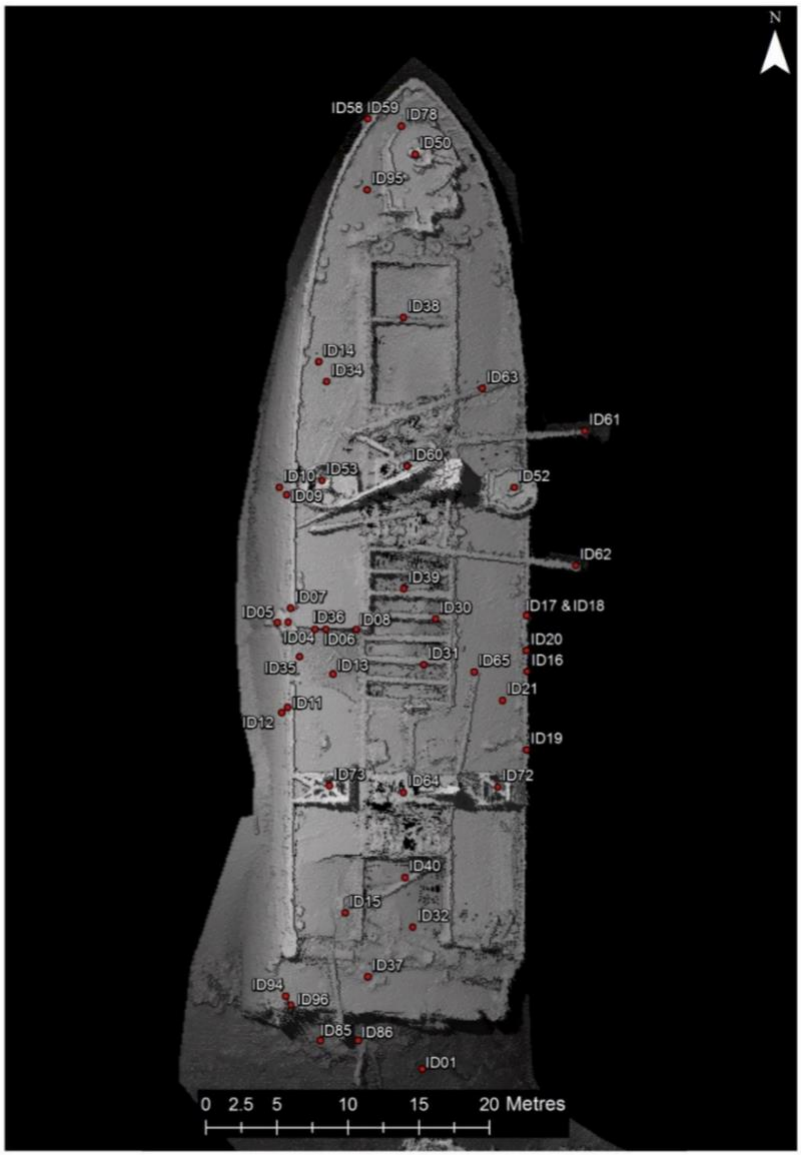

Figure 13 ID features on Forward section

4.2.3 Key Areas 1 & 2 (ID04 & ID08)– crack in hull and partial collapse of cargo hold deck (port side)

4.2.4 The crack in the hull is at the location shown in Figure 14. 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. As above, there is no discernible changes in Key Area 2.

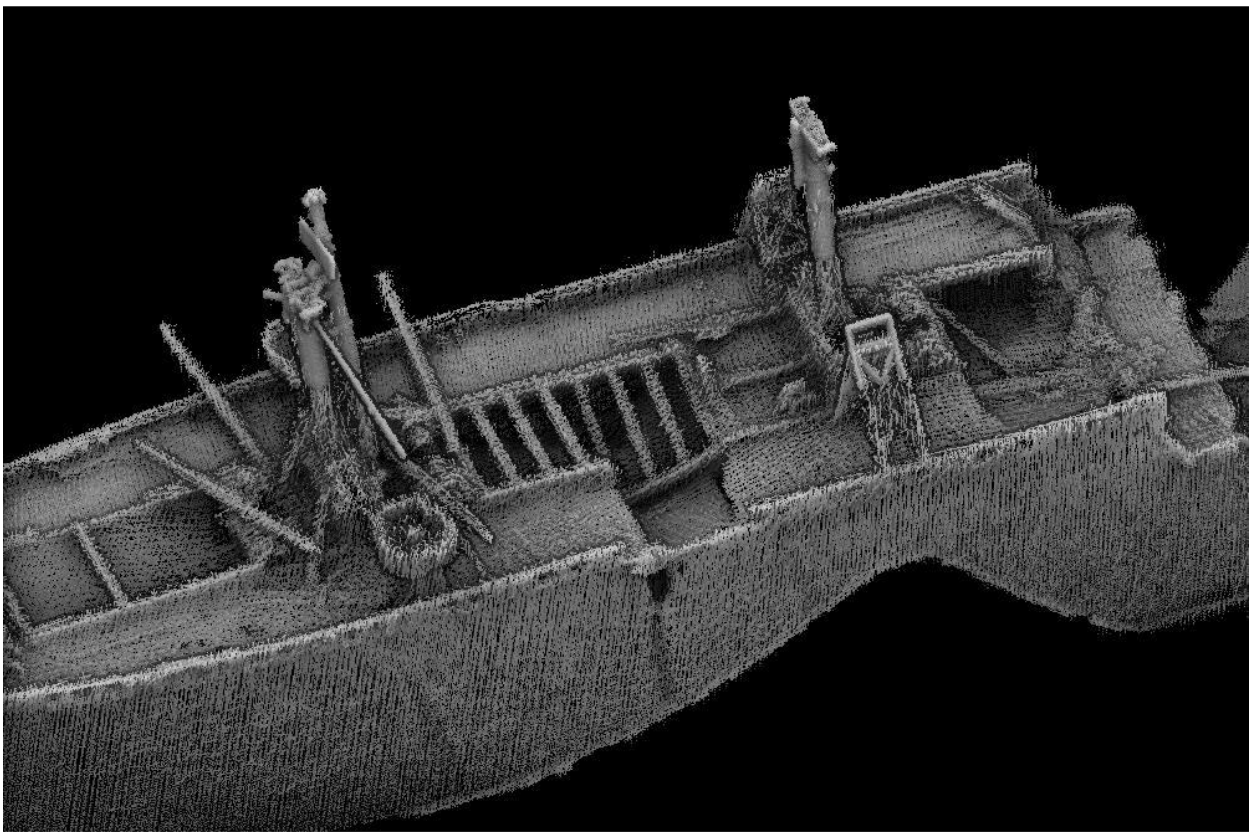

Figure 14 – Crack in Hull September 2021

4.2.5 Note the extreme bulging outward of the hull plates on the starboard side although this bulging does seem to have remained stable over the last few surveys (Figure 15). 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.

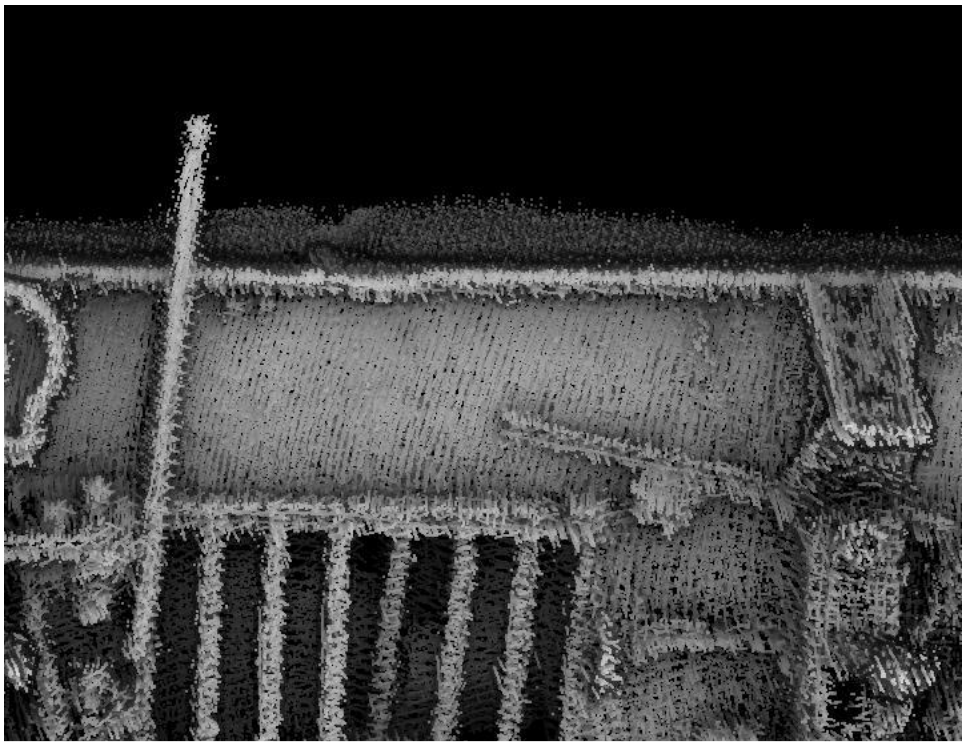

Figure 15 – Bulging in Hull Plating at hold 2

4.2.6 Key Area 3 (ID96)– Port side aperture

4.2.7 The apertures on the bulkhead at frame 88 at the aft end of the forward section are clearly visible in the 2021 dataset although there is no appreciable difference between this survey and that from September 2020 (Figure 16).

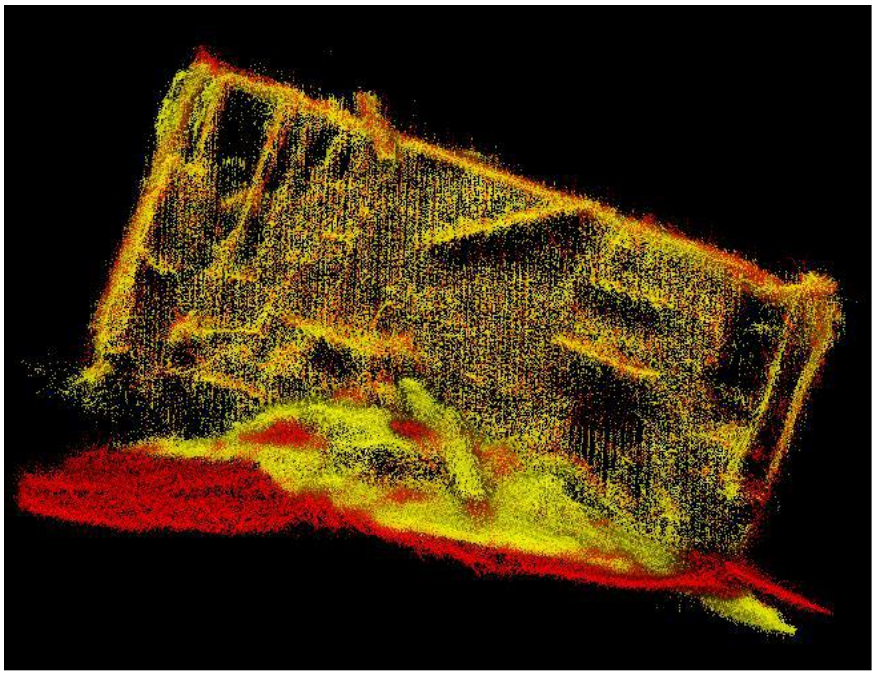

Figure 16 – Key Area 3: Apertures on Bulkhead 88 (Port Side).

4.2.8 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 2020. However, whether the returns are from cargo in the hold or sediment surrounding them cannot be ascertained.

4.2.9 Key Areas 4 & 5 (ID22 and ID24 & ID25)– Splitting of hull, and split in deck and hull

4.2.10 Key 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).

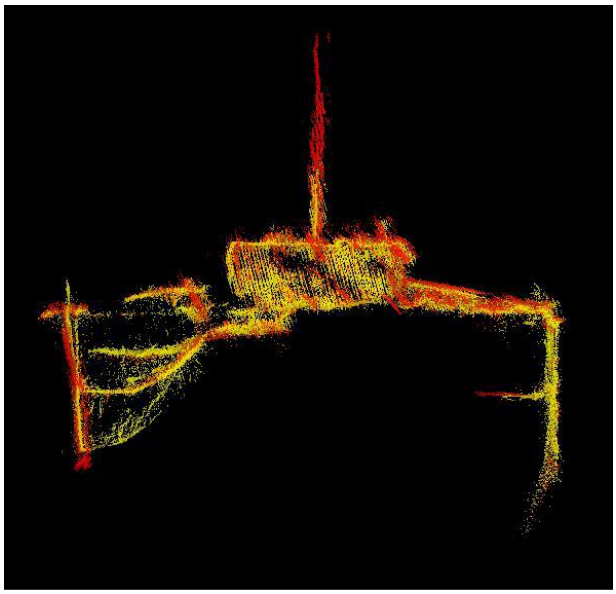

Figure 17 – Cross-section through split hull (Yellow: 2020 survey and red 2021 survey).

4.2.11 No noticeable change has occurred to the angles or orientation of the wreck between the September 2020 survey and the September 2021 survey although, some variation is apparent to the sediment in hold 4 and the collapsing bridge deck. In Figure 18, 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.

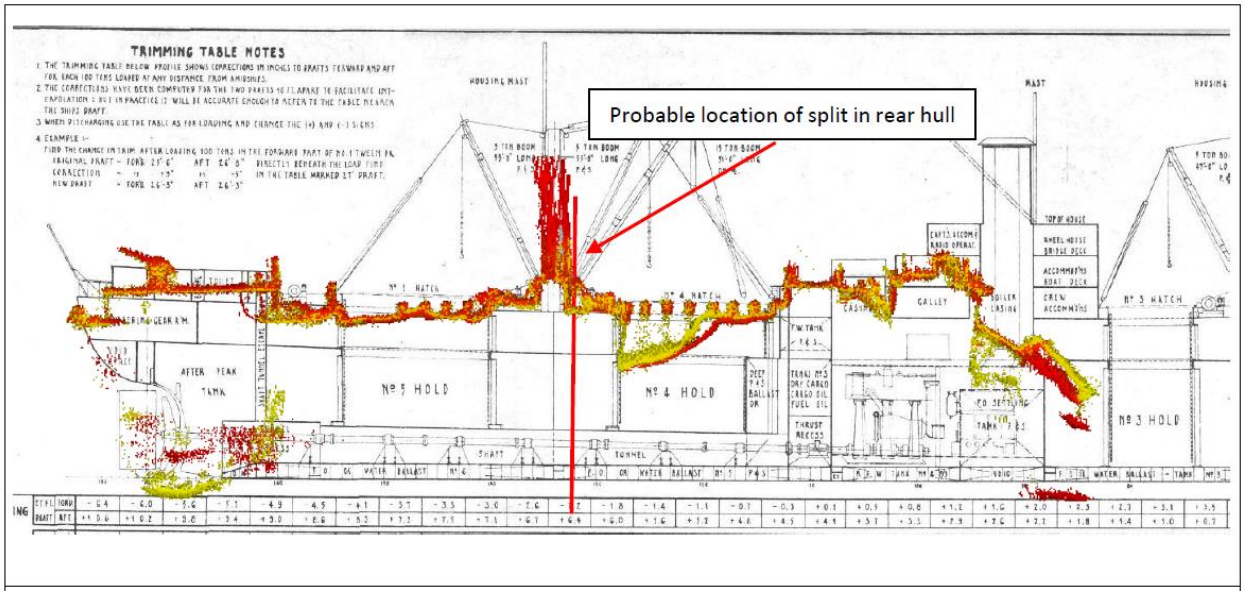

Figure 18 - Longitudinal profile through the stern section. Yellow: 2020 survey and red 2021 survey.

4.2.12 Key Area 6 (ID43, ID45, ID46)– Collapsing bridge deck

4.2.13 This area was left unsupported when the ship broke in two in 1944. Consequently, it has been adversely 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 2020 and the 2021 surveys.

4.2.14 Key Area 6 is particularly difficult to survey as the numerous angular protrusions can affect the returning data, which is why the results cannot be entirely conclusive (Figure 19). However, the upper deck is more robust, and for that reason is used to measure the possible deflection.

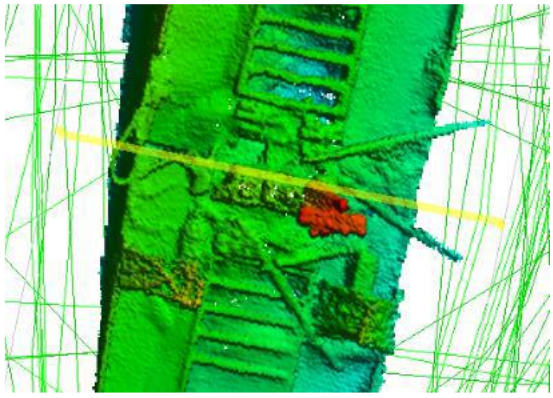

Figure 19 – Key Area 6: orientation of split deck.

4.2.15 The lack of change on the wreck is evident from the good agreement of the 2020 and 2021 surveys. One change that is apparent is the slight raise in the seafloor to the east (port side) of the wreck. In Figures 20 and 21 below, yellow (2020) and red (2021) points along the long unsupported section of deck agree very well at the top but, vary significantly towards the right 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.

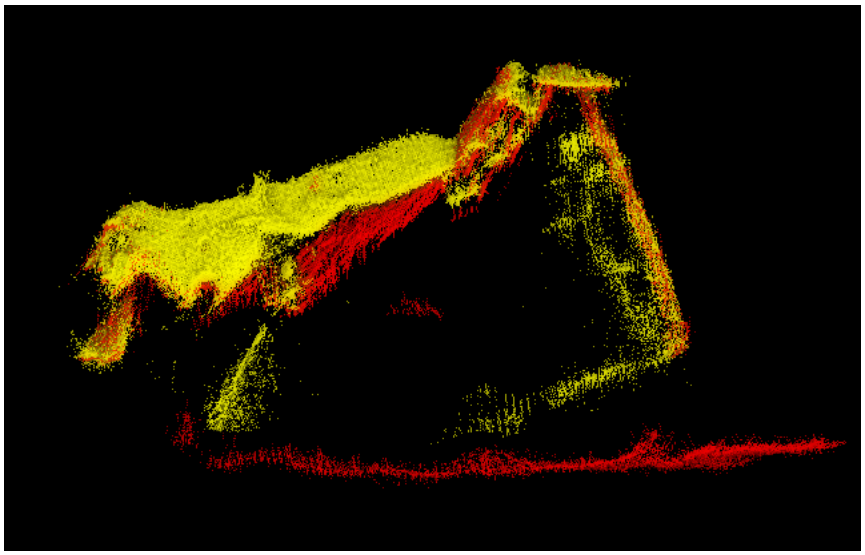

Figure 20 – Profile through bridge deck area (yellow: 2020 survey, red: 2021 survey)

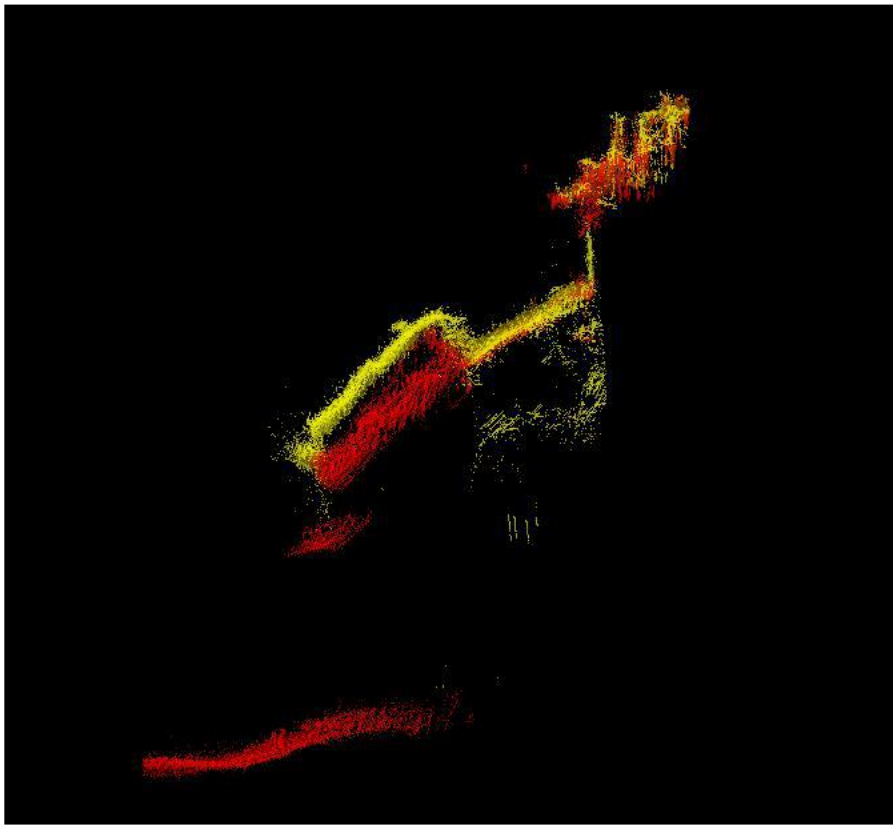

Figure 21 – Longitudinal cross-section showing area of continued change (yellow: 2020 survey, red: 2021 survey)

4.3 Debris Between the Hull Sections

4.3.1 There has been no appreciable difference in the debris between the bow and stern section. In Figure 22 below the only appreciable difference is the pipe (or similar structure) sticking out from the debris pile at the base of the front section which has rotated so that its free end is now some 2m lower than it was a year ago. The pipe is identified in the image below by a yellow circle with the 2020 position in yellow and the 2021 position in red.

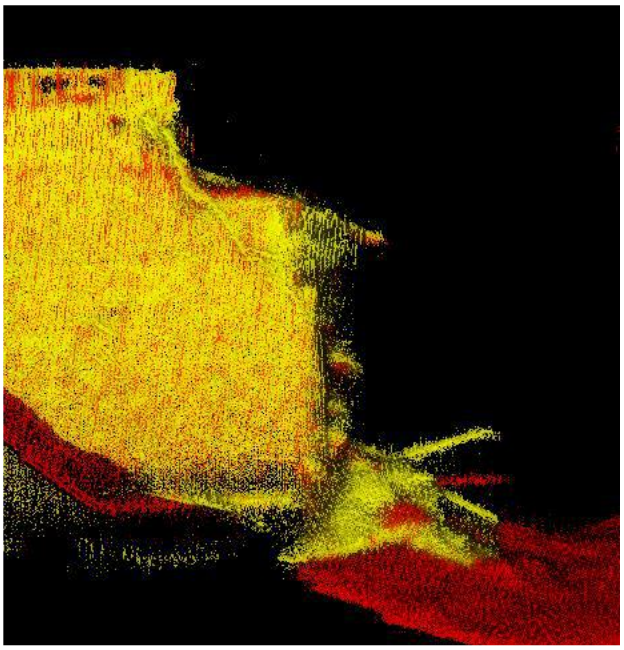

Figure 22 - Side view of rear of forward section of the SSRM showing the downward rotation of the pipe extending from the debris pile. (yellow: 2020 survey, red 2021 survey)

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 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 also 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 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 this is indicative of all the sediment visible in the data as imaged through the open hatch. (Figures 23 and 24).

4.4.6 Notably there is no indication that the Second Deck has collapsed. There is no indication that the Second Deck hatch covers have collapsed, although it is an unlikely possibility, they have and 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 daily.

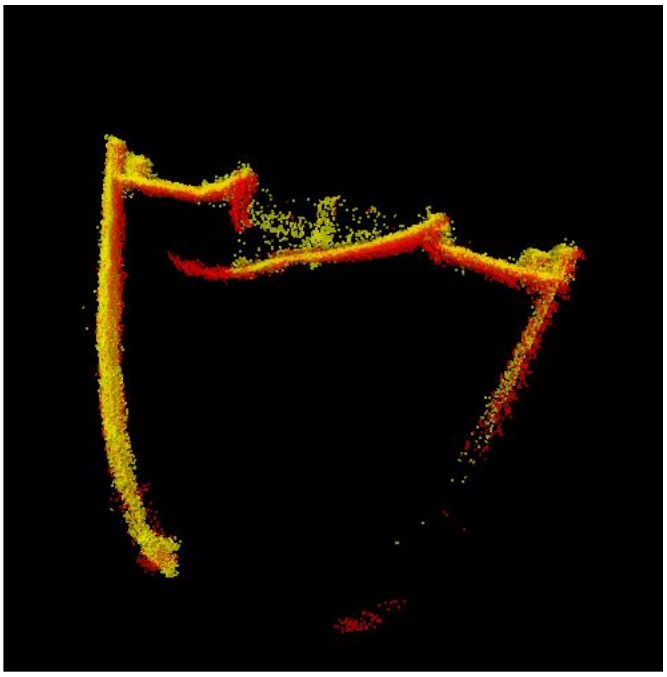

Figure 23 – Cross-section at frame 17-18, forward of the Number 1 Hatch (yellow:2020 survey, red: 2021 survey).

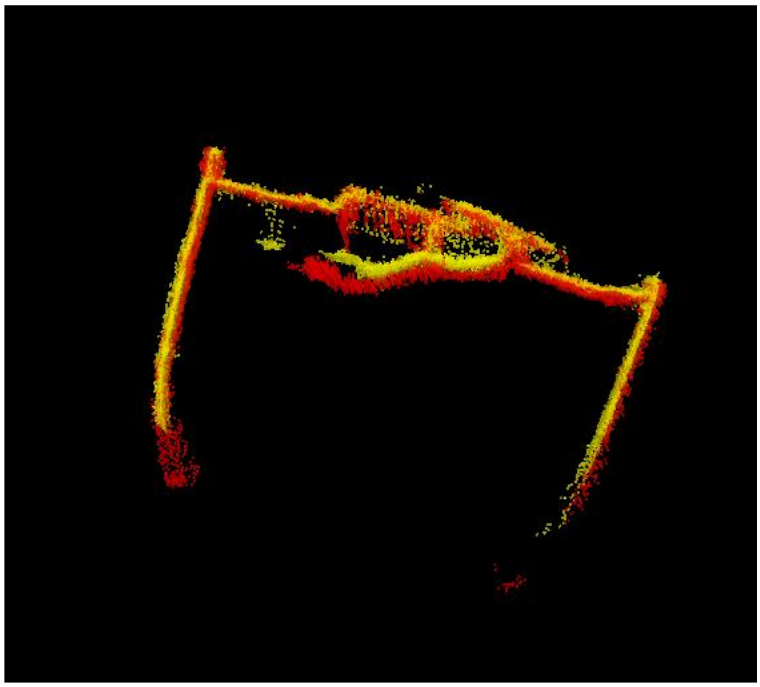

Figure 24 – Cross-section through frame 32, aft end of No. 1 Hatch (yellow: 2020 survey, red: 2021 survey)

Hold 2:

4.4.7 As with hold 1, the outer hatch cover of Hold 2 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. 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 starboard side is not filled. Again, there is no indication that the second deck or the lower hatch covers have failed as there is no slump in the sediment. (Figures 25 and 26).

4.4.8 In Figure 27 the sediment in the ‘tween deck space of hold 2 is visible. In this area, unlike the forward 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 hull – see the data as collected through the split in the hull in Figure 27, although this could also be the result of data inaccuracies caused by poor acoustic properties of the sound passing through the narrow gap.

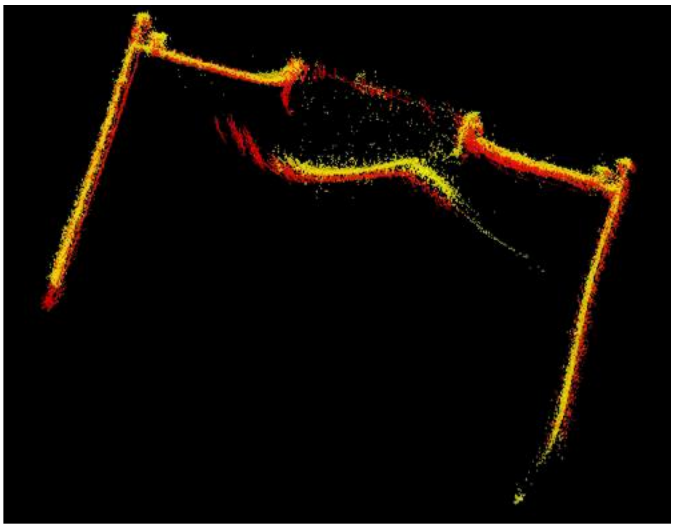

Figure 25 – Cross-section of hull at frame 46, forward end of No. 2 Hatch (yellow 2020 survey, red: 2021 survey)

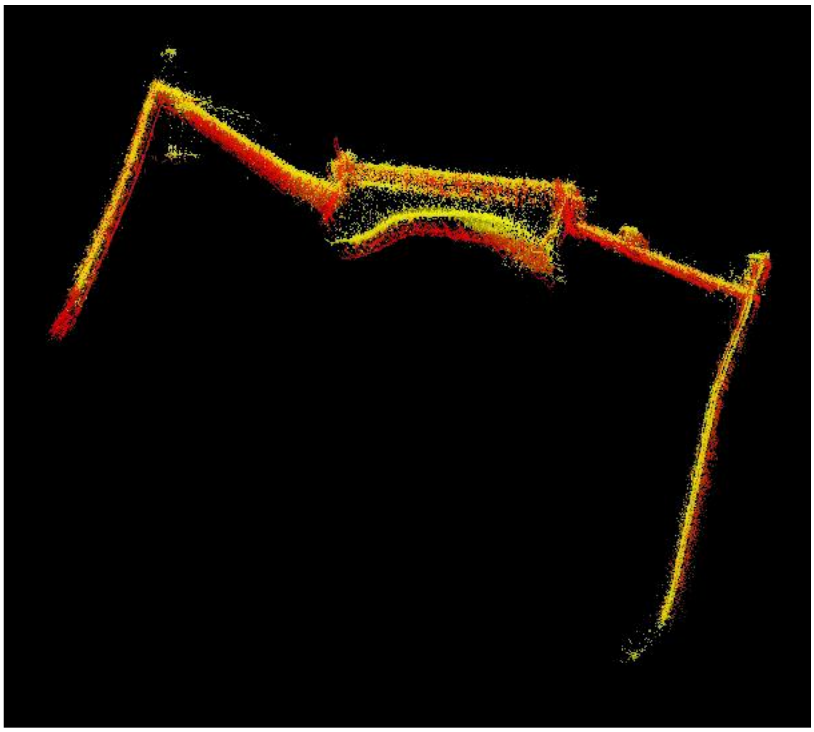

Figure 26 – Cross-section of hull at frame 60, aft end of No. 2 Hatch (yellow: 2020 survey, red: 2021 survey).

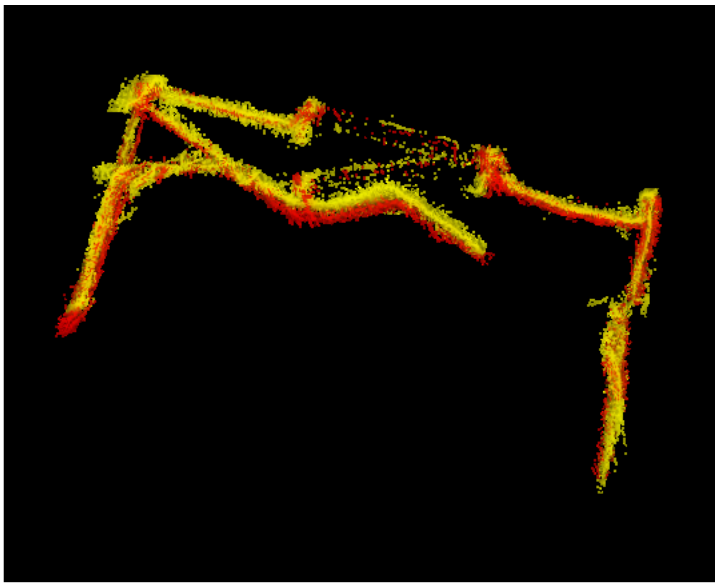

Figure 27 – Cross-section of hull at frame 54 where forward section of hull is breaking in two (yellow: 2020 survey, red: 2021 survey).

Hold 3:

4.4.9 The rearmost hold of the forward section. The rear bulkhead of this hold forms the rearmost part of the forward section, the vessel having broken in two immediately aft of that bulkhead. 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. (Figures 28 and 29).

4.4.10 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.

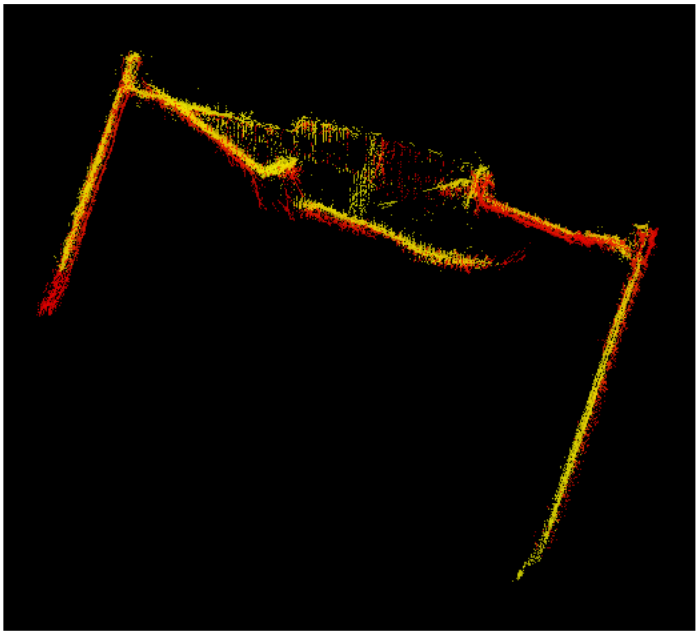

Figure 28 – Cross-section of hull at frame 73, forward edge of No. 3 Hatch (yellow: 2020 survey, red: 2021 survey).

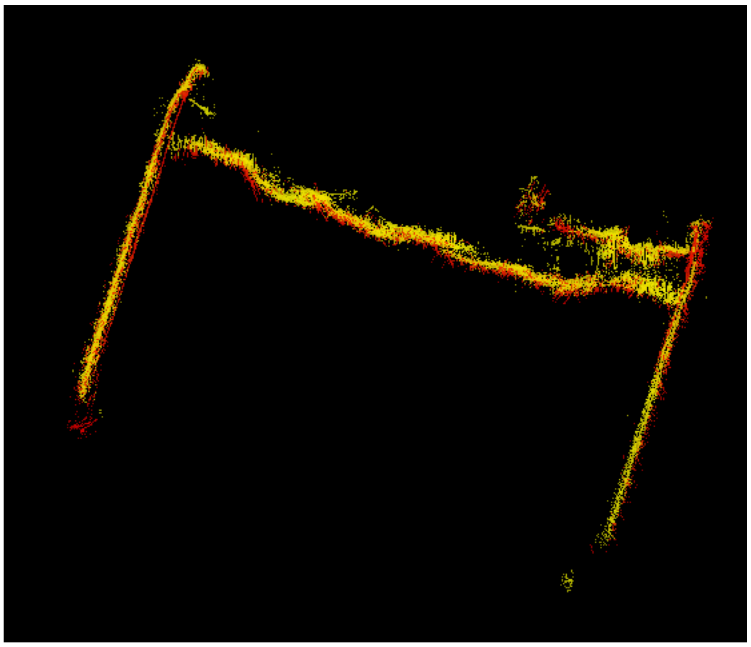

Figure 29 - Cross-section of hull at frame 82, aft of No. 3 Hatch (yellow: 2020 survey, red: 2021 survey).

Hold 4:

4.4.11 The most forward of the two holds in the aft section. Since the two stern holds are reported to have been emptied during salvage operations 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. (Figures 30, 31, 32 and 33).

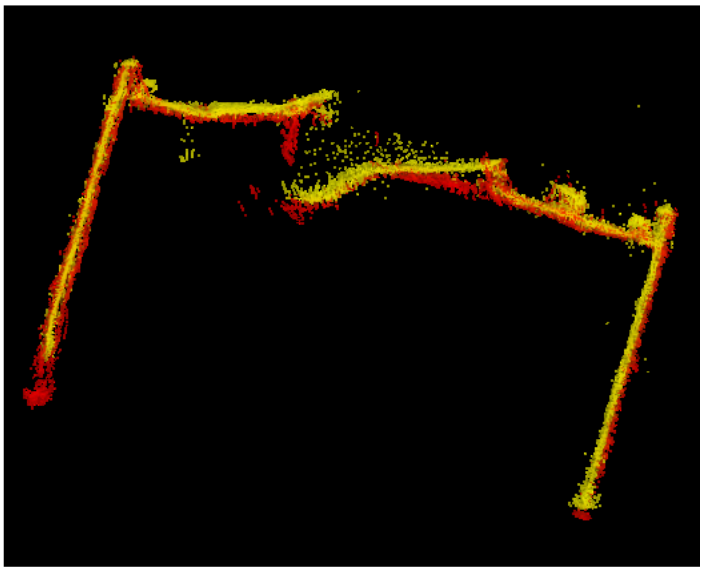

Figure 30 – Cross-section through frame 114 at the forward edge of No. 4 Hatch (yellow: 2020 survey, red: 2021 survey).

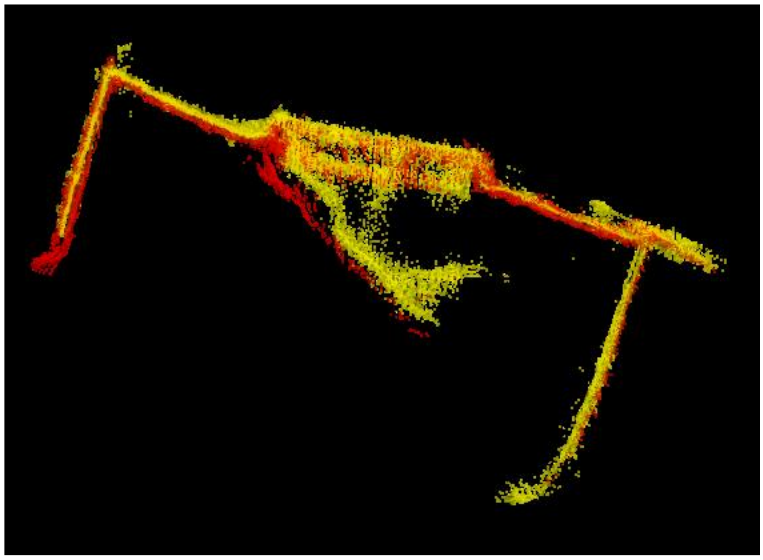

Figure 31 – Cross-section through frame 114 at the forward edge of No. 4 Hatch (yellow: 2020 survey, red: 2021 survey).

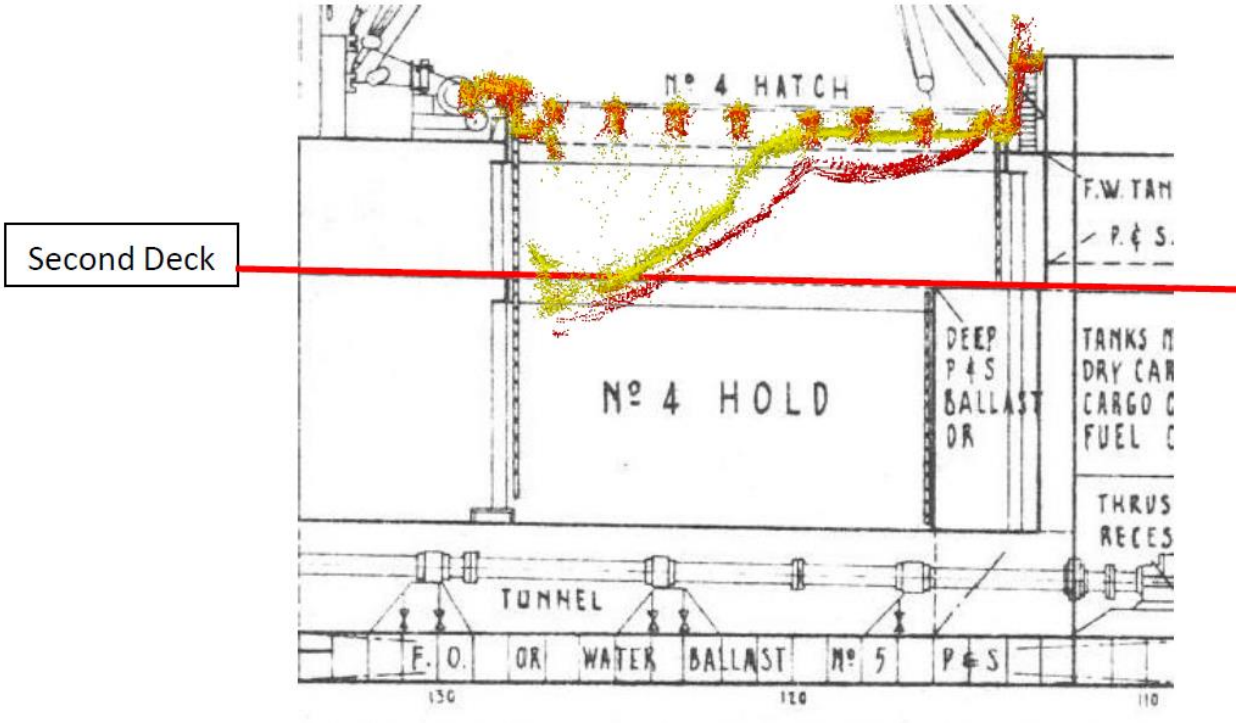

Figure 32 – Longitudinal section through No. 4 Hold (yellow: 2020 survey, red: 2021 survey).

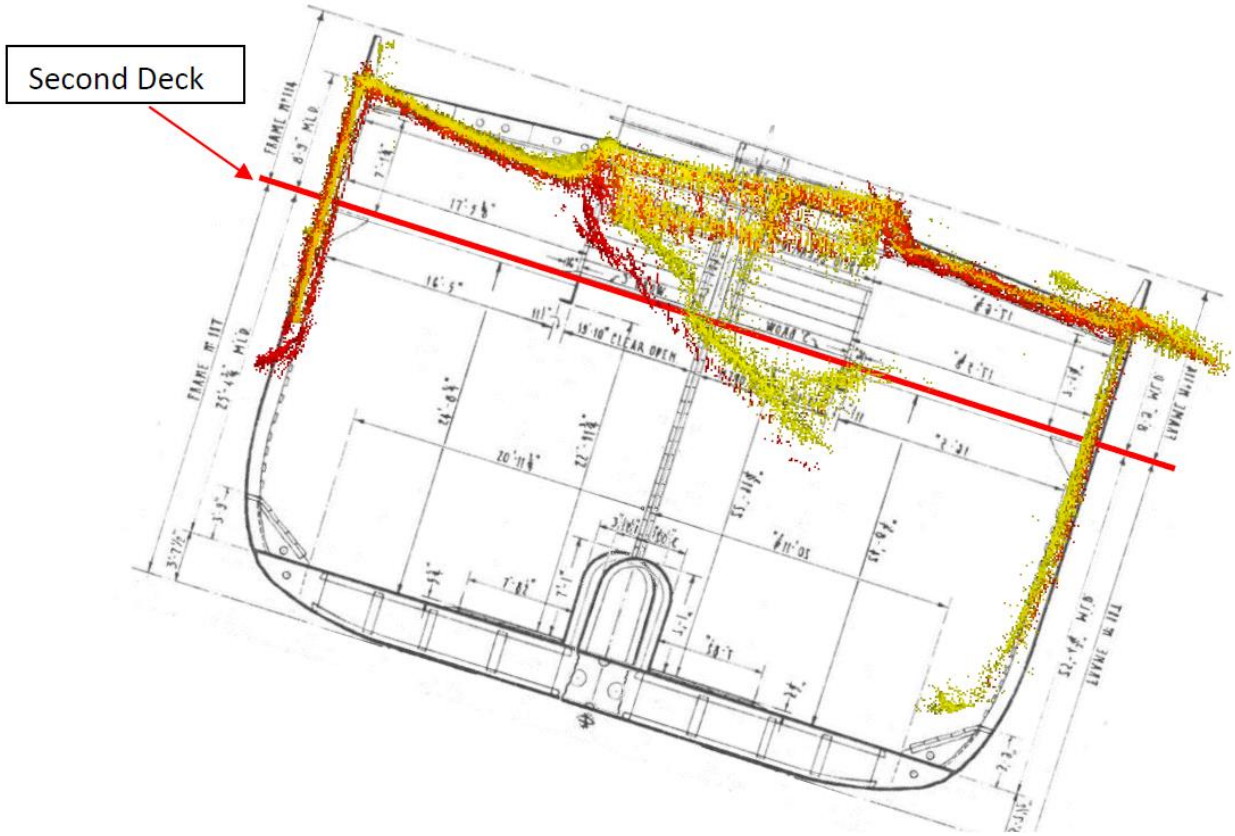

Figure 33 – Cross-section through frame 114 at the forward edge of No. 4 Hatch (yellow: 2020 survey, red: 2021 survey).

4.4.12 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 filled, and the port side remaining clear above the horizontal to the top of the hatch coaming. However, the rear of the hatch area shows a different story with the first (and only) indication that the Second Deck or the lower hatch covers have failed. Here the sediment layer descends below the level of the Second Deck confirming some form of collapse, probably a partial collapse of the lower hatch cover. This has happened at some time 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. The sediment has deepened slightly between 2020 and September 2021, but this does not seem to indicate any major further collapse. More likely a redistribution of the sediment by currents.

Hold 5:

4.4.13 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, except No. 4 Hold, there is no indication that the second deck or the lower hatch cover have collapsed.

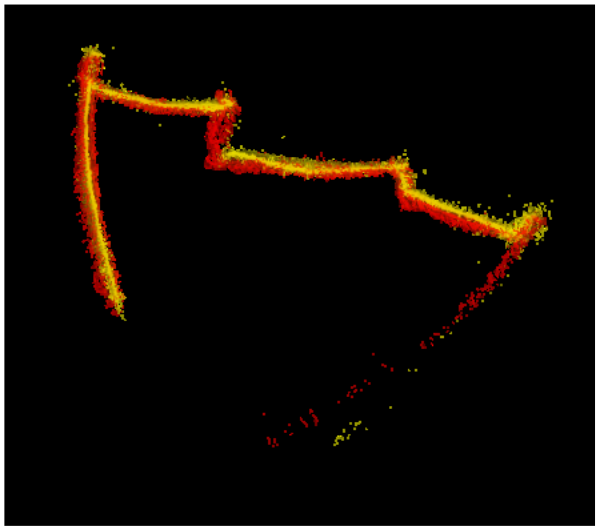

Figure 34 – Cross-section through hull at frame 154 (yellow: 2020 survey, Red: 2021 survey).

5 Seabed Survey 2021

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 The seabed survey fully covered the area of the survey identified below in Figure 35.

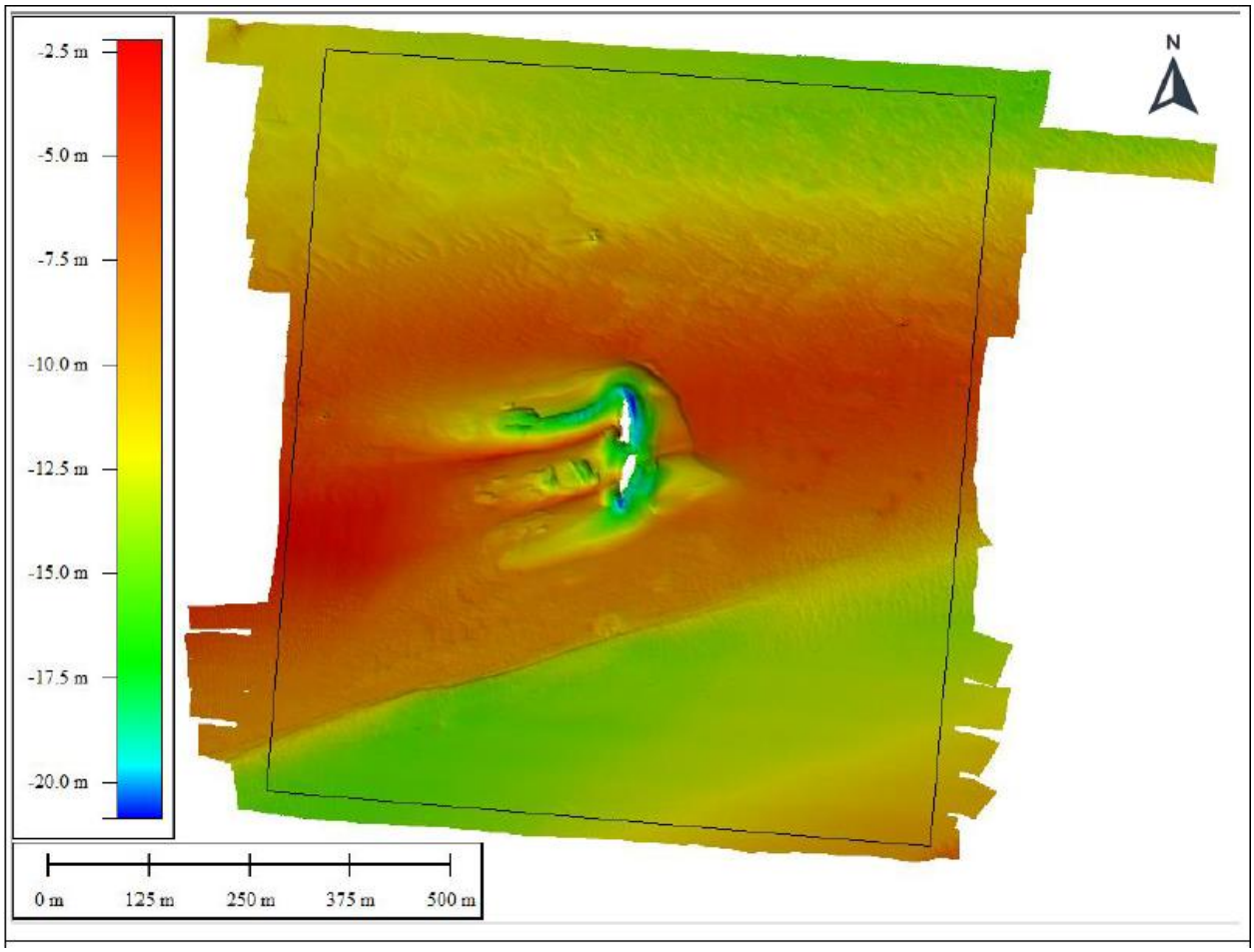

Figure 35 – Shaded relief plan of seabed survey area

5.1.2 Across the site, a difference plot was made between the 2020 and 2021 surveys. The results of this are shown in Figure 36 below. In general, there are only minor changes in the depths. However, the edge of the scour pit that extends to the east of the SSRM has migrated about 5m westwards as

indicated by the line of accretion to the east of the wreck. Similarly, a small hollow lying to the southeast of the wreck has been filled. Other changes are small movements to the edges of the scour pit to the west of the wreck and the migration of several sand waves. None of the seabed changes are considered to be significant.

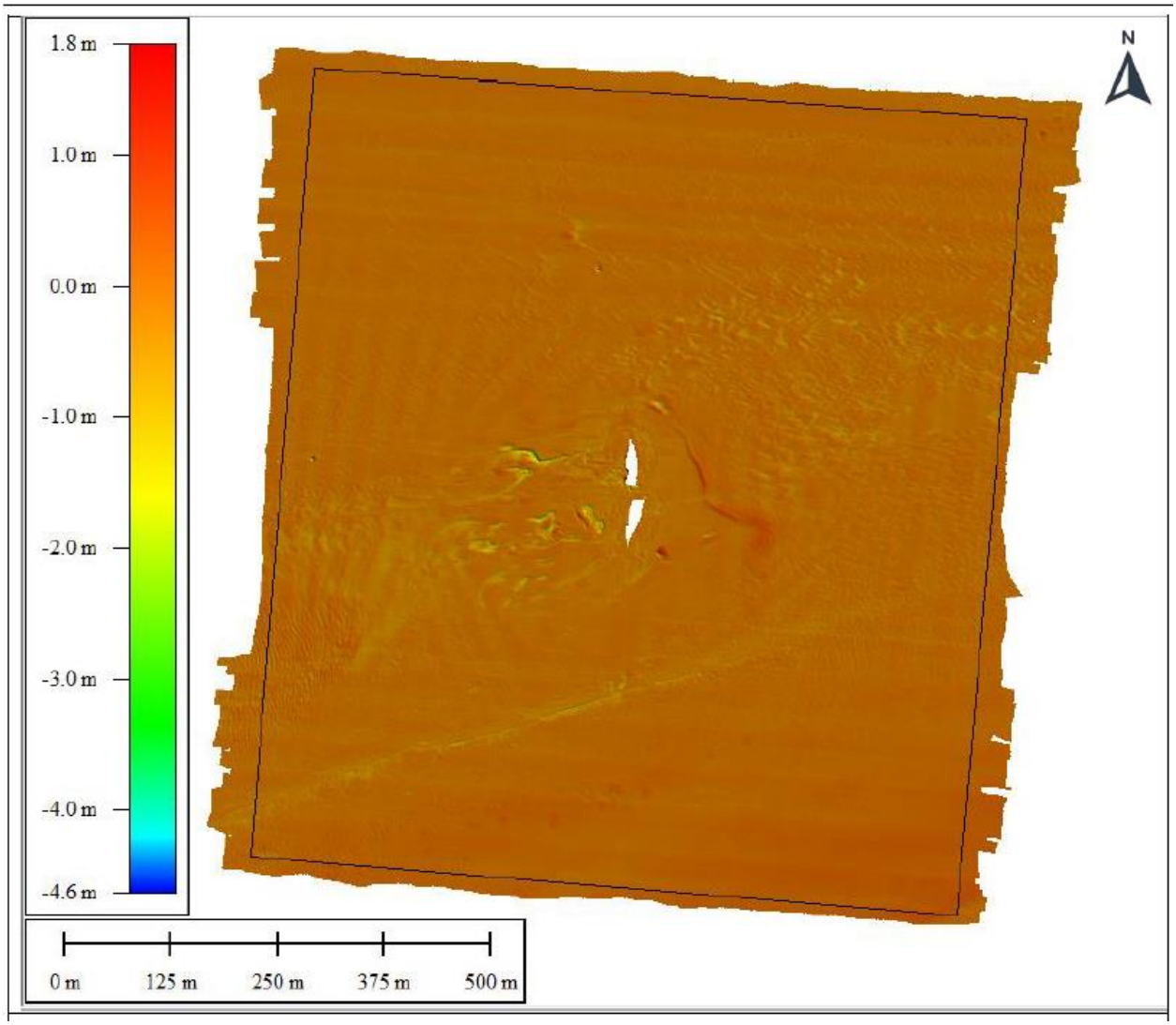

Figure 36 – Comparison of seabed surveys between 2020 and 2021.

5.1.3 The 66 seabed contacts from 2017 were compared against this year's bathymetry. Analysis of the 2021 dataset has added a further 2 targets to the contact list, while 7 items from the 2017 contact list are not apparent on the 2021 data. The seabed contacts, especially the smaller or lower lying ones, are subject to a pattern of being buried and uncovered by moving sediments. As a result, their presence or not in any year's data set is largely a function of the movement of sediment around and over them.

5.1.4 For analysis of the seabed between the sections of the hull, please see Section 4.3 and Figure 21 above.

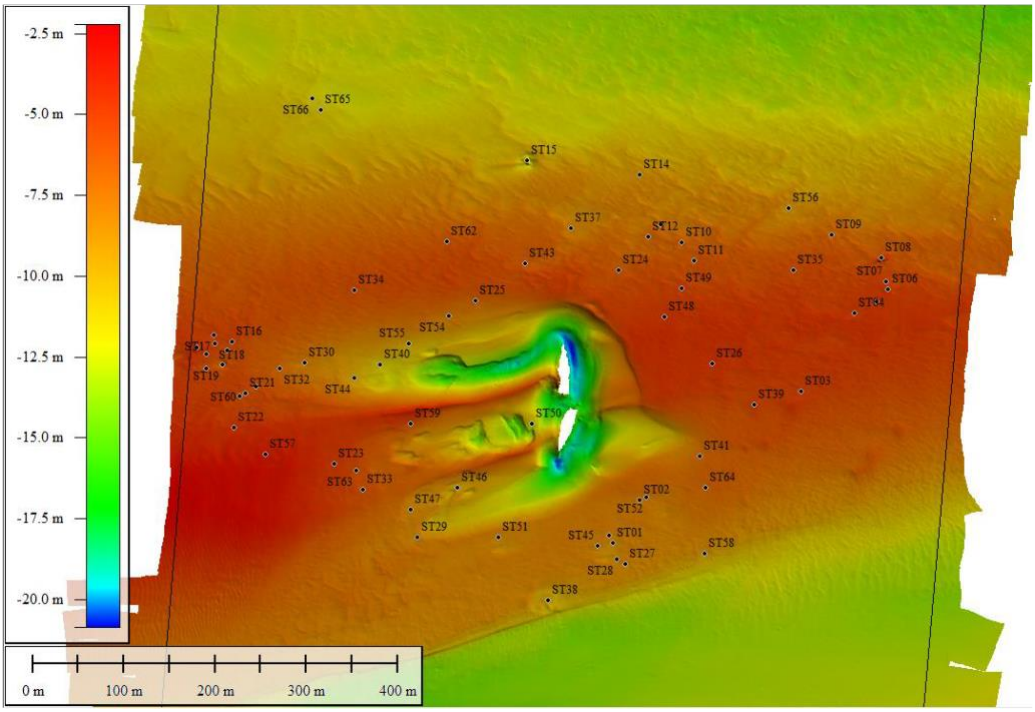

Figure 37 – Seabed reference points

5.2 Seabed between forward and aft sections

5.2.1 A surface difference plot shows evidence of a minor loss of material in the gap between the two sections. Whilst not immediately clear in the 3D point cloud data, a profile view in CARIS shows elevated debris that was previously overhanging but now has now broken off leading to a loss of elevation.

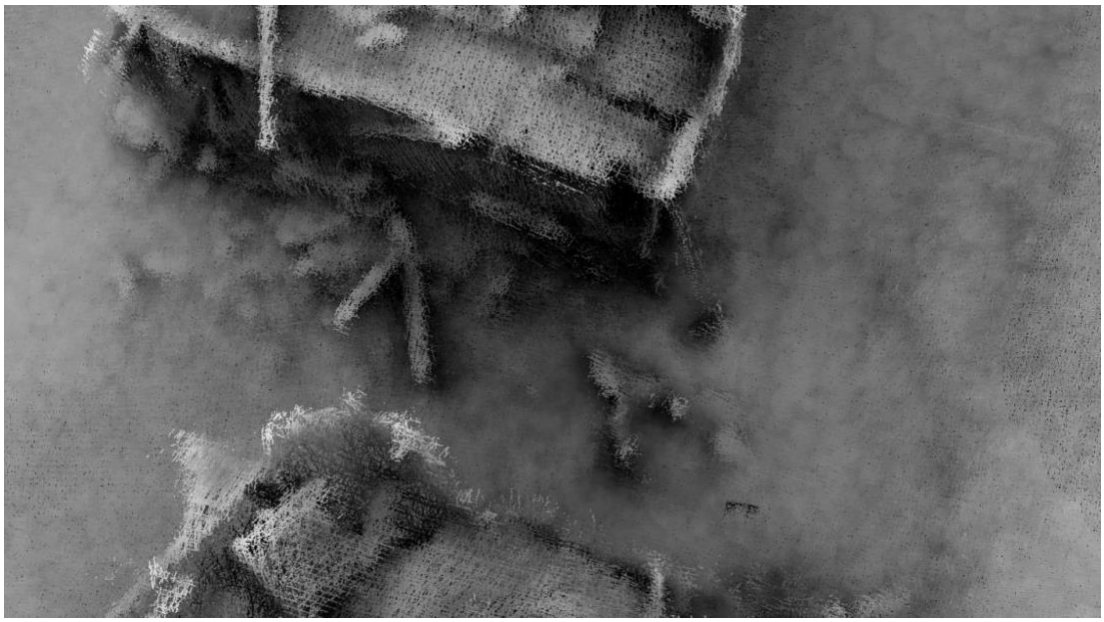

Figure 38 – Scan Between the Forward and Aft Hull Sections 2021

6 Conclusions

6.1.1 The September 2021 survey successfully covered all significant portions of the wreck with high quality MBES data. Although not completely conclusive, the overhanging portion of the wreck (starboard side of hull) was covered with a greater density of points than in all previous surveys assessed.

6.1.2 The comparisons between this survey's data and the preceding survey (September 2020) indicated that no significant changes had occurred. Indeed, the only area that showed any minor change was the unsupported bridge deck area that has continued to subside.

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