Maritime & Coastguard Agency

# SS Richard Montgomery: Survey Report 2019

# Contents

# Abbreviations

| | |
|---|---|
| CD | Chart Datum |
| 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 |
| 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 2019 survey.

## 1.2 Survey Overview

1.2.1 The 2019 survey data was gathered from the area identified by the black box in Figure 1.

1.2.2 The comparisons between this survey's data and the preceding surveys indicated that no changes had occurred between January and August 2019 and only a very few and minor changes existed between the January 2019 and 2017 datasets.

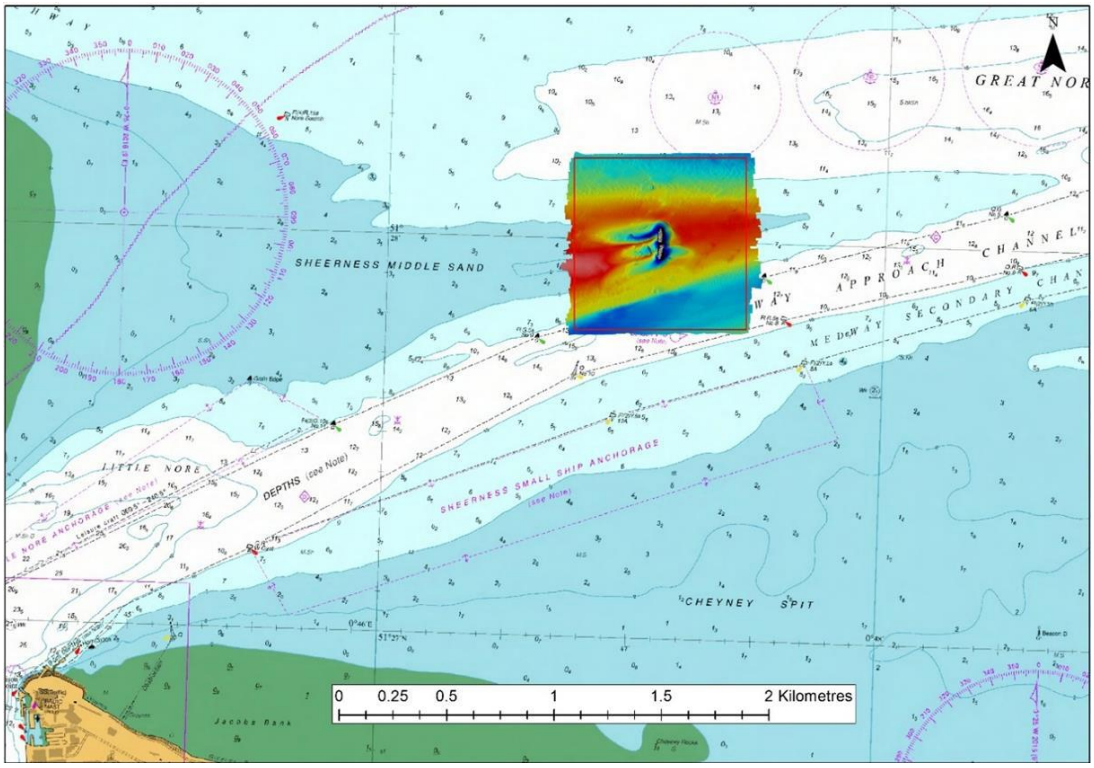


*Figure 1 SSRM 2019 survey location and extent.*

## 1.3 Key Results

1.3.1 As in previous years, the 2019 survey covered the entire wreck and surrounding seabed in detail.

1.3.2 No changes occurred between January and August 2019 and only a very few and minor changes existed between the January 2019 and 2017 data sets.

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 in 2019. The only exception was the bridge deck that continues its downward deflection.

1.3.4 The seabed measured during the 2019 survey was compared to the seabed measured during the 2017 survey. There was little change in the seabed, except for the area southwest of the wreck where the seabed has deepened by over 1 metre because of the migration of the shoal bank.

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 2019 survey findings, including a comparison with the 2018 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.

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.

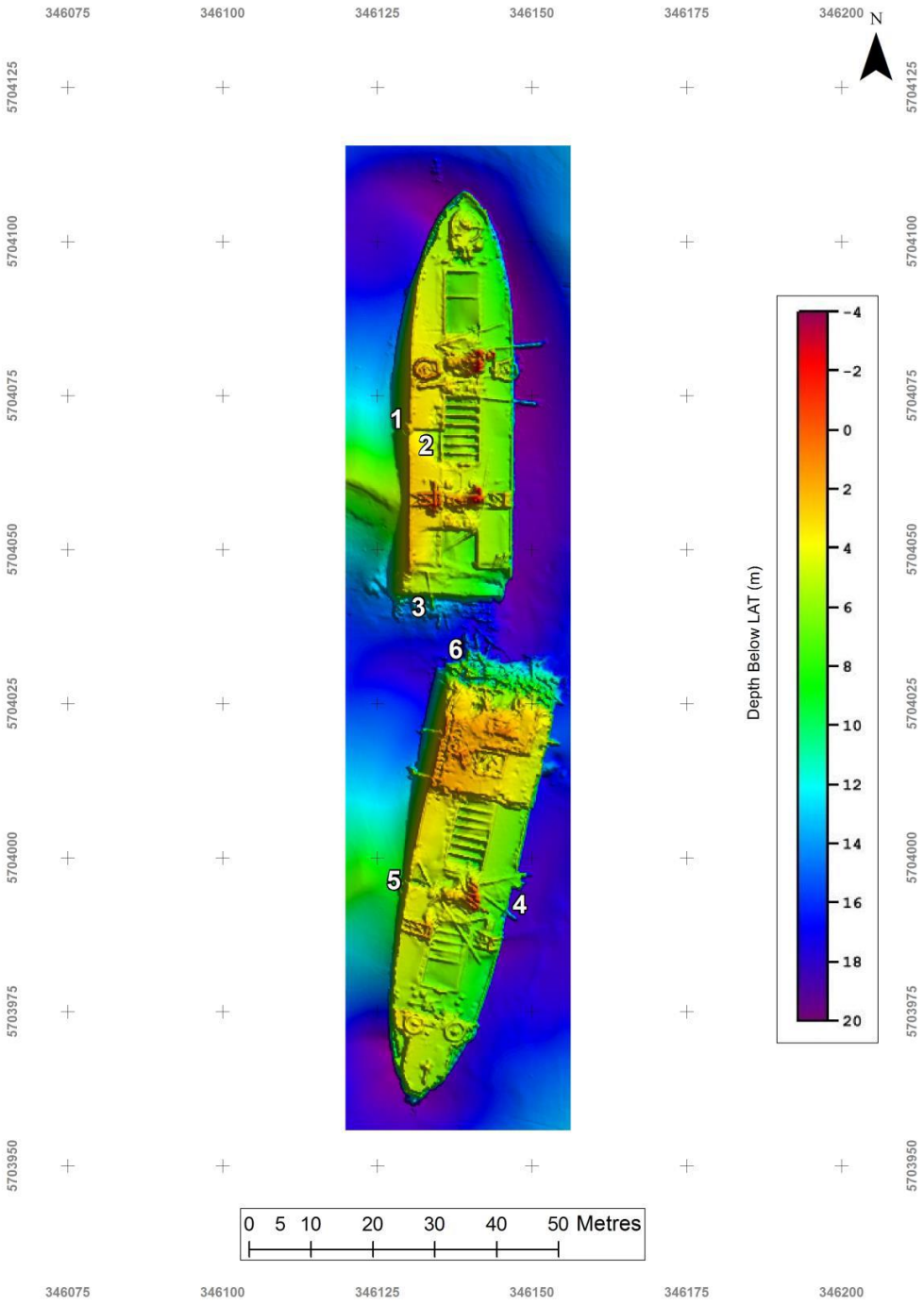


*Figure 3 Six Key Areas monitored through SSRM annual surveys.*

# 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 around 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 2017) 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 black line in Figure 1.

## 3.3 Survey Operations

3.3.1 The MBES and laser scanning survey of the SSRM wreck took place between 05/08/2019 and 06/08/2019.

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 | V5 Applanix POS MV 320 |
| Secondary Horizontal & Vertical Positioning | C&C Technologies C-NAV 2050 DGPS |
| Primary Heading Sensor | V5 Applanix POS MV 320 |
| Acquisition / Processing | Kongsberg SIS (v4.3.2)<br>QPS QINSy Navigation Software (v18.8.4.1) |
| Multibeam echosounder (MBES) | Kongsberg 2040C Dual Head (dual head, dual swath) |
| MBES Motion reference unit | V5 Applanix POS MV 320 |
| Sound Velocity | Valeport Swift SV Profiler |
| Acquisition / Processing | Kongsberg SIS (v4.3.2)<br>QPS QINSy acquisition/processing software (v18.8.4.1) |
| Laser Scanning | Carlson Merlin<br>V5 Applanix POS MV 320<br>QPS QINSy acquisition software (v18.8.4.1) |

*Table 1 EGS Watchful equipment specifications used for data collection in 2019 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 (CD) 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 4 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.

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3.4.8 Throughout this report, all point cloud images have been generated in Cloud Compare. Surface difference plots were generated in QPS QUINSy Navigation software and all historical profile comparisons have been made in CARIS HIPS & SIPS.

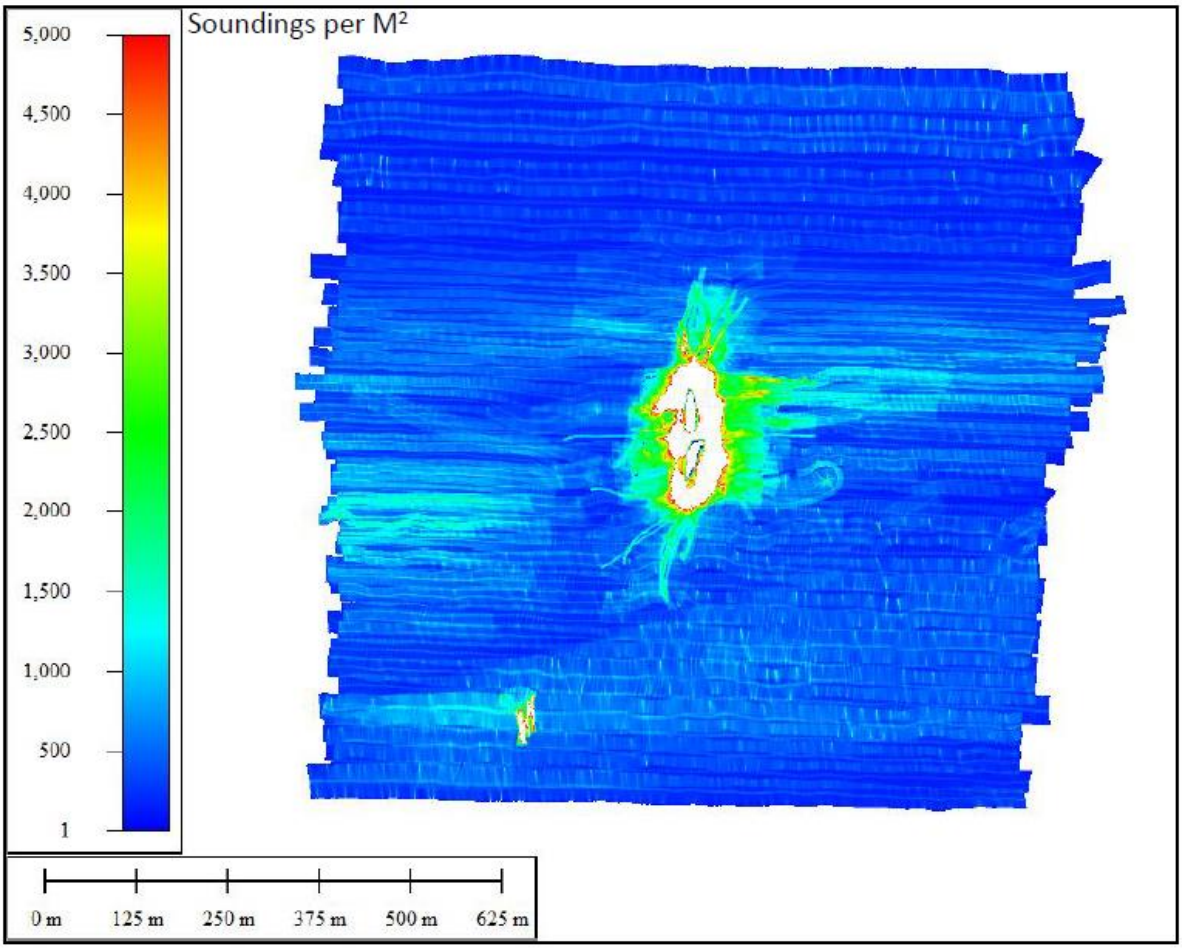


*Figure 4 Density plot of surrounding seabed MBES survey.*

## 3.5 Laser Scanning

3.5.1 The laser scanning was conducted at low tide using a Carlson Merlin Laser Scanner. 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 2 shows the masts above the water.

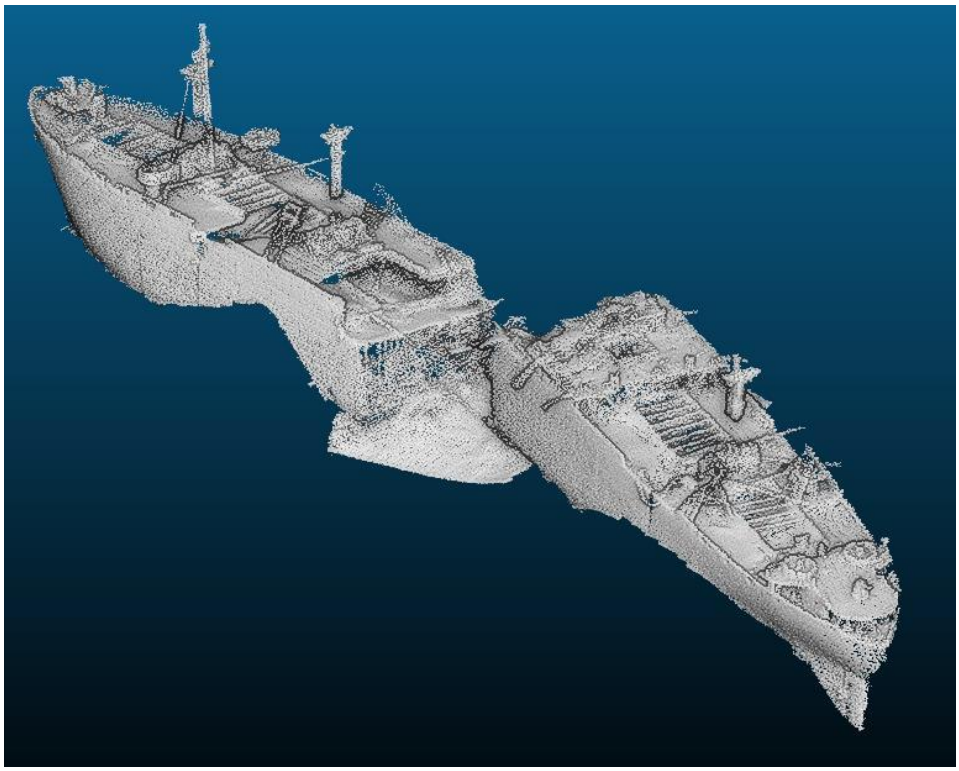

*Figure 5 SSRM overview of the Port side combining MBES and Laser data.*

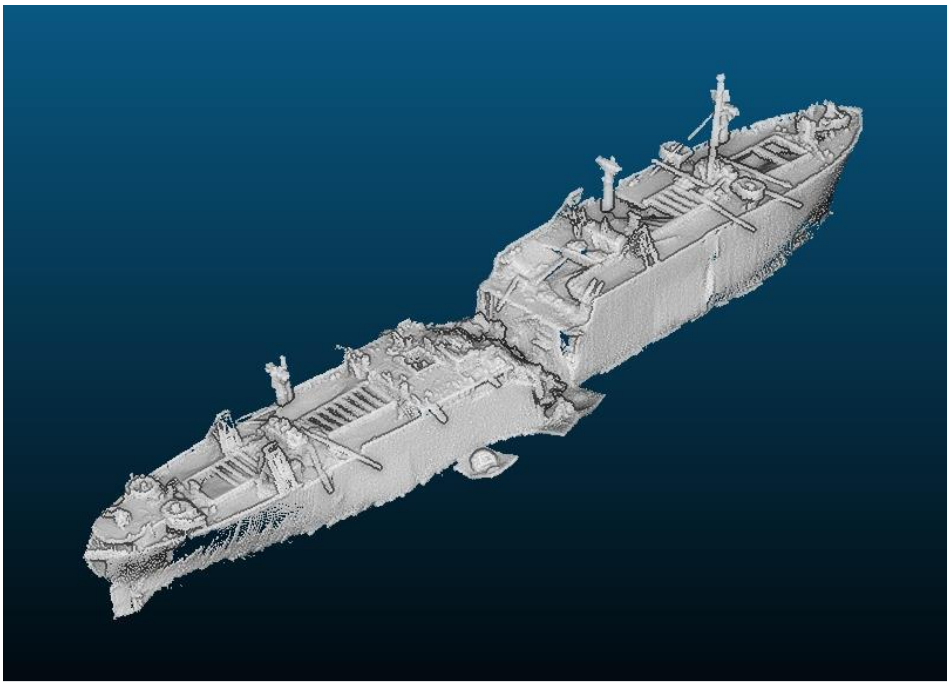

*Figure 6 SSRM overview of the Starboard side combining MBES and Laser data.*

# 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.

## 4.2 Wreck Profiles

4.2.1 Profiles of the hull were reviewed to monitor for any wreck movements or listing which may have occurred since the previous surveys. The locations of these profiles are shown in yellow in Figure 7.

4.2.2 The data shows good correlation between previous datasets with no change observed in the various profiles of the wreck. This suggests that the SSRM has remained stable in all planes of attitude and position, and any minor changes are attributed to small scale feature changes only.

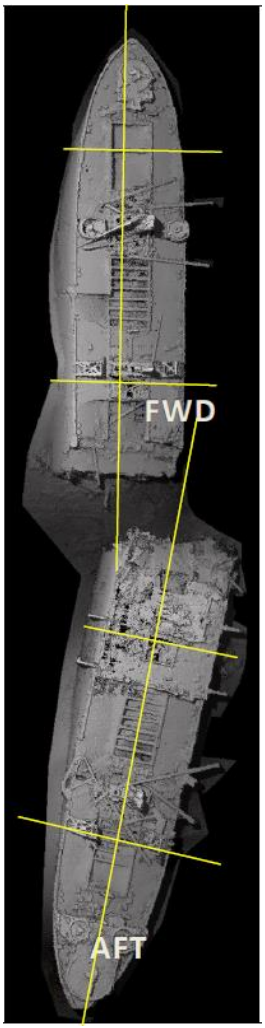


*Figure 7 Location of profiles examined.*

### 4.2.3 Bow Section:

4.2.4 In Figure 8 a cross section through the Richard Montgomery overlaid on a sectional plan shows the extreme bulging outward of the hull plates on the starboard side of the bow section. Although this bulging does seem to have remained stable over the last few surveys, its extent is a cause for possible concern, and it is recommended that this area is included in all future reports as an area for particular study. Note that the starboard side is distorted in as well as out and the port side is also distorted in this area.

4.2.5 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 9).

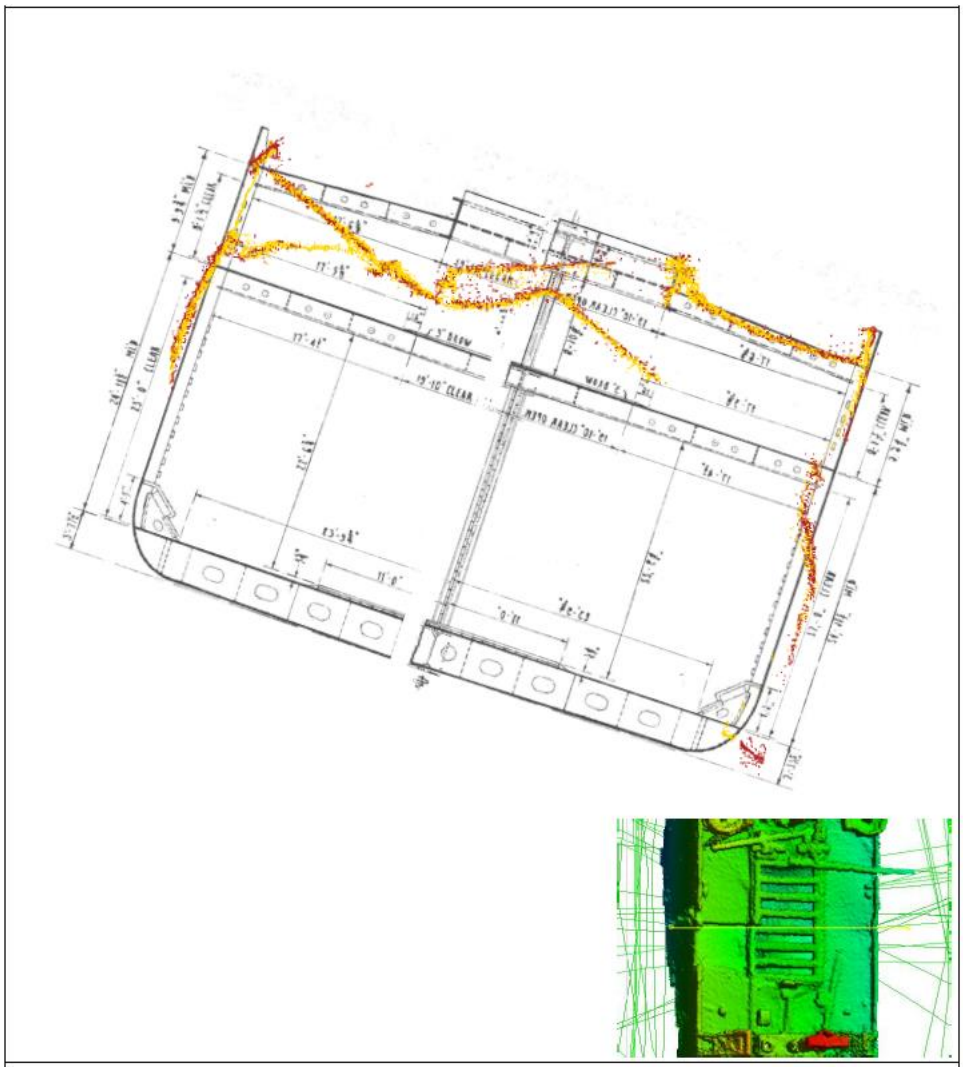

*Figure 8 Area of maximum bulge on hull sides (Yellow August 2019, Red January 2019).*

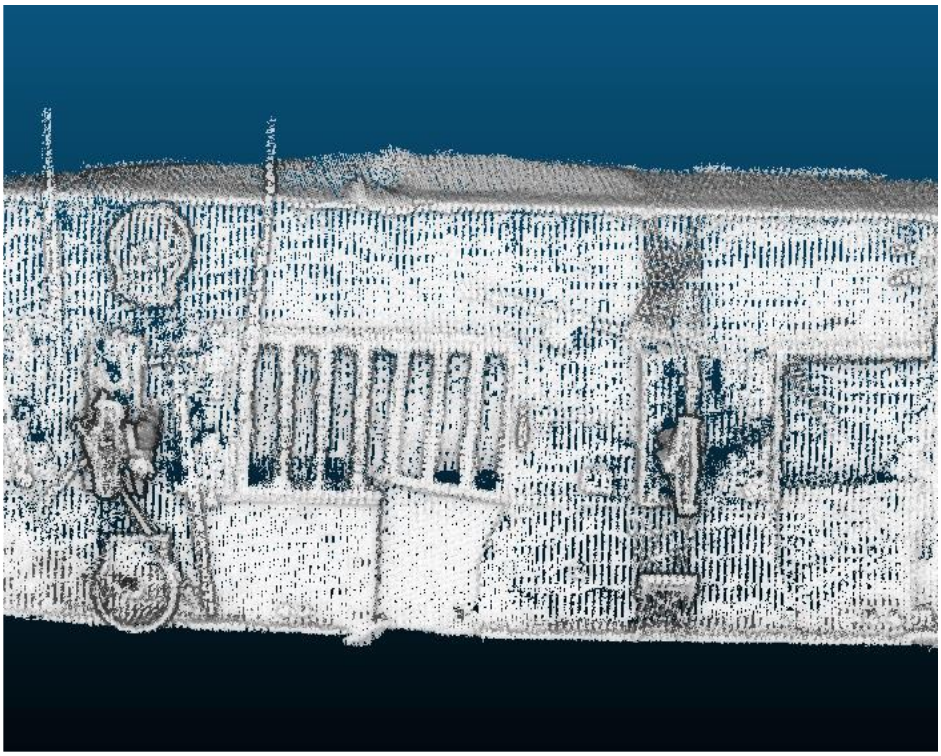

*Figure 9 Overview of bulge in hull plating on starboard side from August 2019 data.*

4.2.6 The forward hull appears to be buckling in two places resulting in there being three different levels to the deck. Firstly, the rear part from the bulkhead at Frame 88 (the rear of Hold 3) to just rear of the main mast (see Figure 10 below). Secondly, the main mast and Hold 2 area up to the fore mast (see Figure 11). This section also contains the large crack at the centre of Hold 2. Finally, at the forward section from the foremast forward (see Figure 12).

4.2.7 The profile chosen for these set of diagrams runs offset from the centre line to pick up the coamings (raised border) of hatches 1, 2 and 3, thereby providing a firm line to which the ship's plan can be matched. Because the profile is offset, the 'bow' in the profile does not reach the actual bow as shown on the plan and the curvature of the 'bow' on the profile has a much more acute angle as the profile cuts through the curvature of the hull to one side of the actual bow.

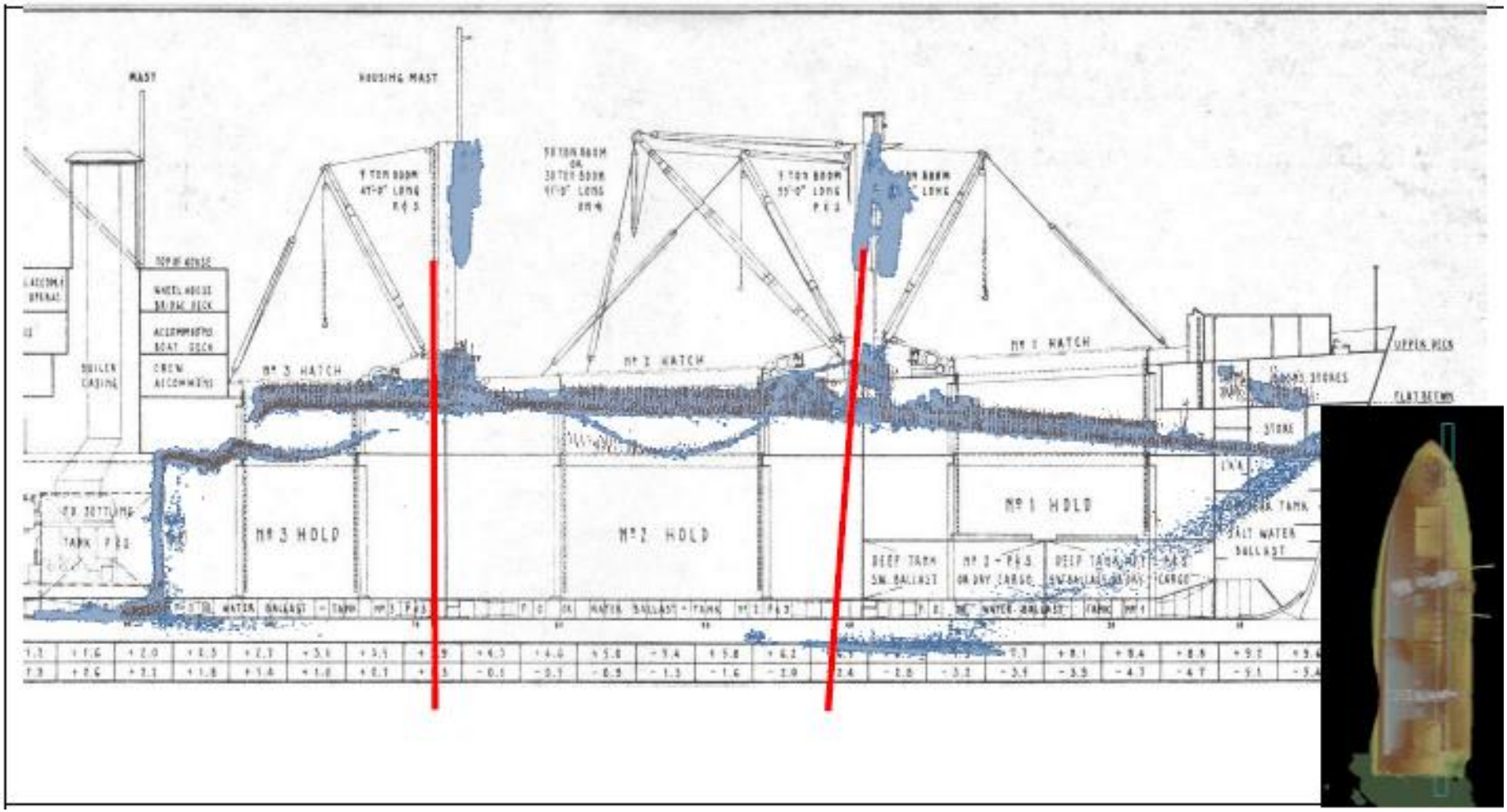


*Figure 10 2010 (brown) and August 2019 (blue) survey data overlain on the ships plan – rear alignment.*

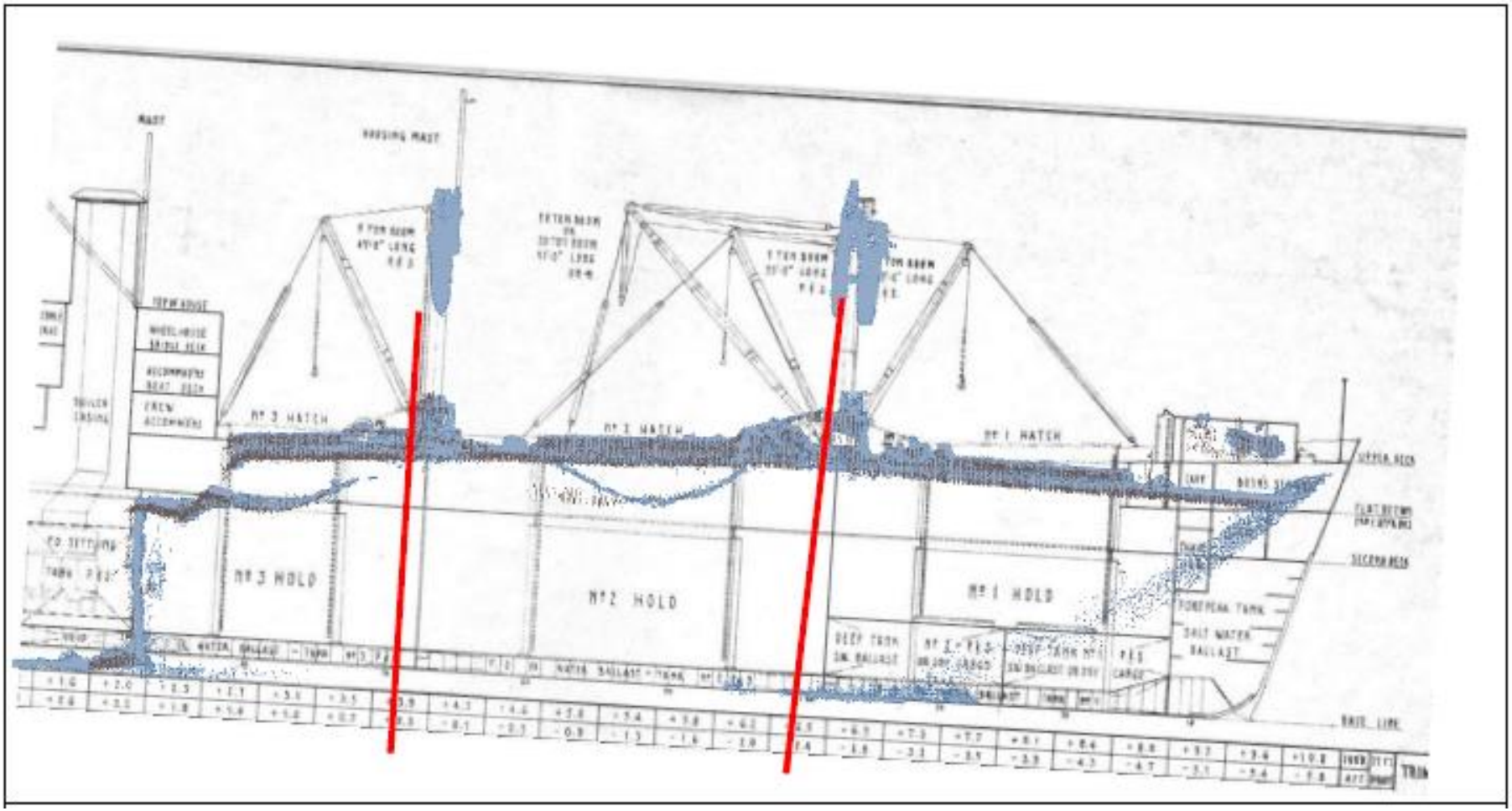


*Figure 11 2010 (brown) and August 2019 (blue) survey data overlain on the ships plan - centre alignment.*

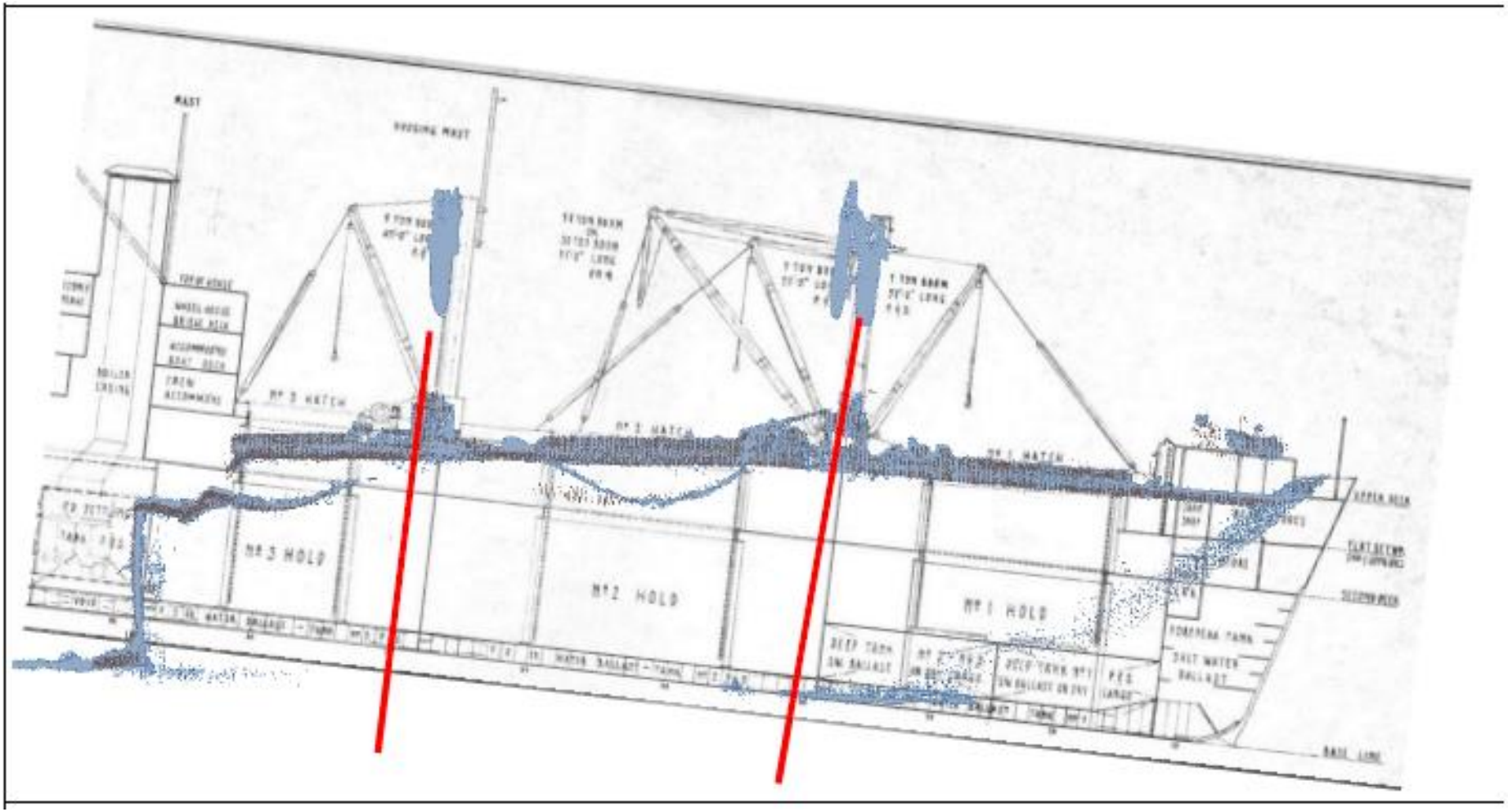


*Figure 12 2010 (brown) and August 2019 (blue) survey data overlain on the ships plan - front alignment.*

### 4.2.8 Stern Section:

4.2.9 Like the forward section, the rear section is hogging (curved-up in the centre and sagging at the ends) 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.

4.2.10 In Figure 13 the 2010 survey has been used for comparison to show the stability of the wreck over the 9 years between surveys. The ship's plan has been positioned and orientated so the stern aligns with the survey data. In Figure 14 below, the same data and ship's plan have been adjusted so this time the forward part of the rear section aligns with the survey data to illustrate the angle of the deformation in the hull at area 4.

4.2.11 The forward end of the stern section was left unsupported when the two halves of the vessel separated soon after it went aground in 1944. This area has steadily subsided although the subsidence seems to have stopped over the last few years – no significant changes have occurred since 2017. It is possible that this has been caused because the collapsing decks are now resting on the ship's boiler which provides a stable base.

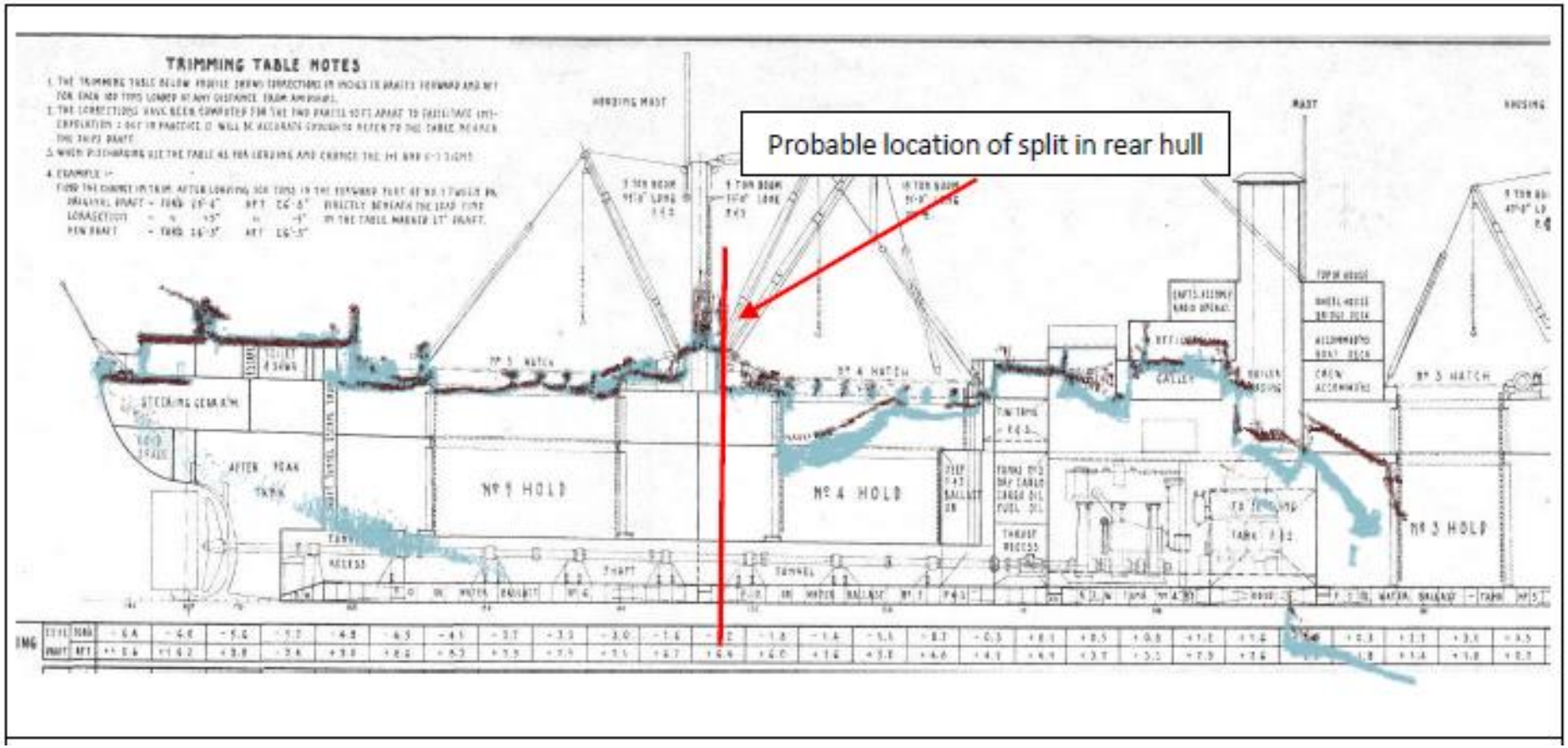


*Figure 13 Longitudinal profile through the stern section showing the slight dip of the stern and the mast.*

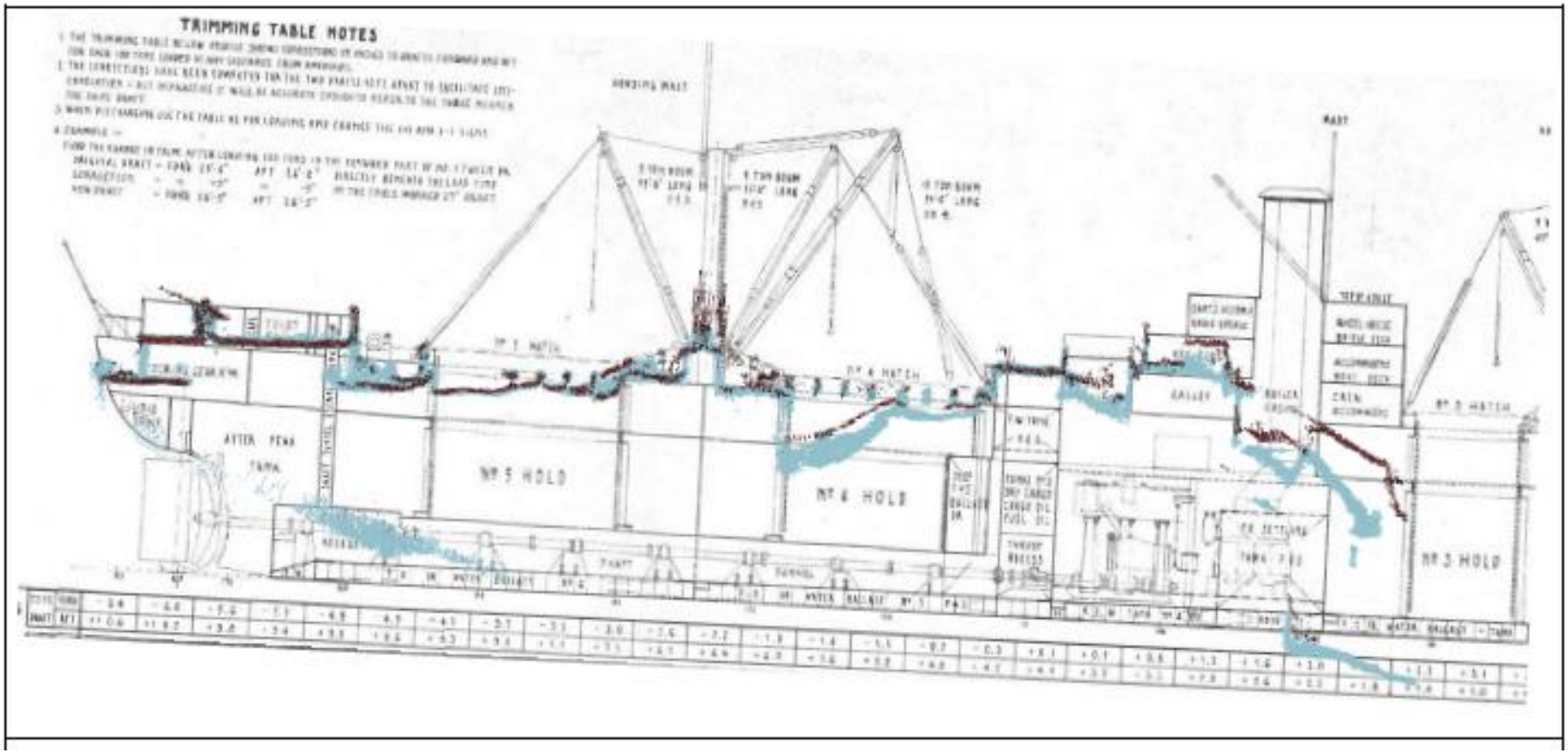


*Figure 14 Longitudinal profile through the stern section oriented so that the wreck's hull aligns with the forward part of the survey data.*

## 4.3 Surface Difference

4.3.1 Surface differencing provides a useful tool in quickly assessing the general deterioration of the wreck. The accuracy of final processed data sets has been considered and the scale is graduated to reflect this by discounting any values less than 0.05m.

4.3.2 Surface differencing between the January and August 2019 datasets has not highlighted any area that has changed.

4.3.3 The red areas over the masts are because the August 2019 survey used in this comparison has the lidar data on the masts included while the data from the January 2019 survey did not. Also, the small area of apparent deepening just forward and to the right of the main mast is assessed as resulting from noise left in the earlier survey but removed in the cleaning of the current data set.

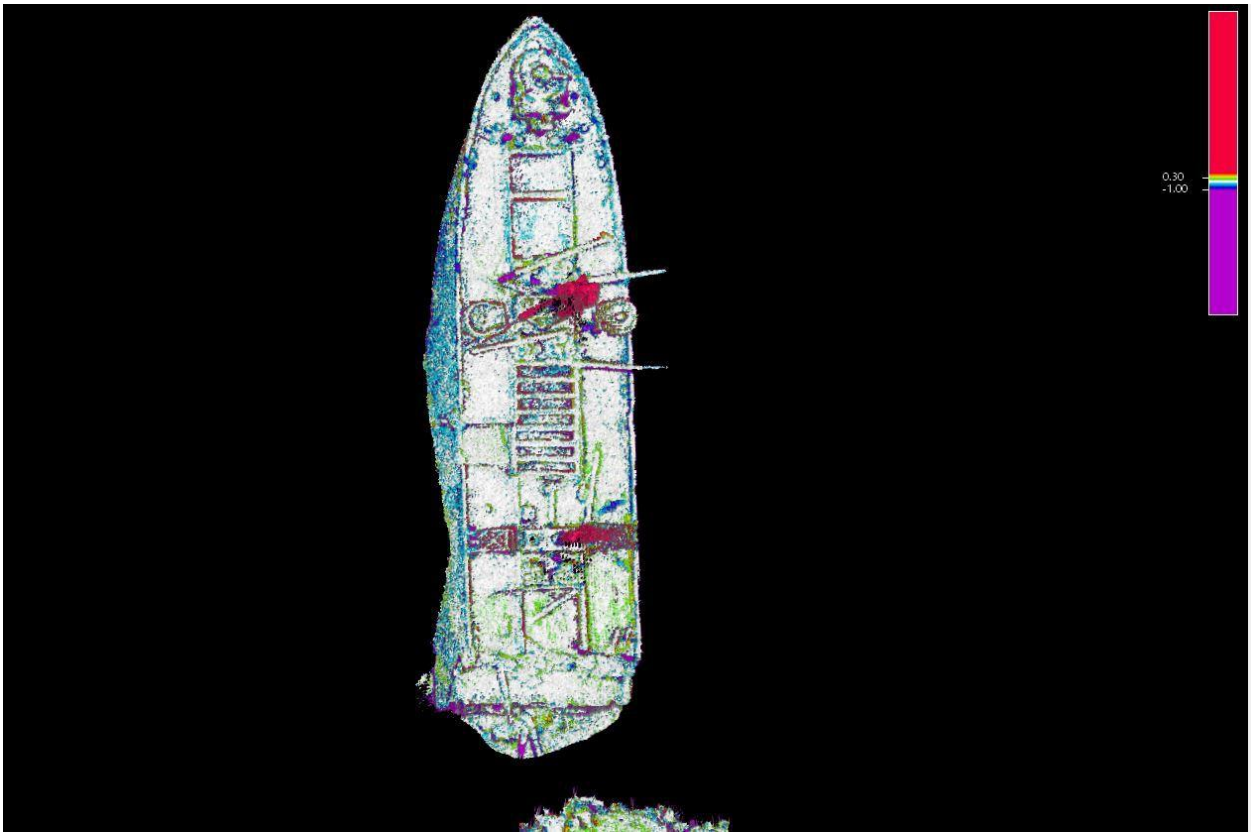


*Figure 15 Forward section surface difference results August 2019-January 2019 MBES survey.*

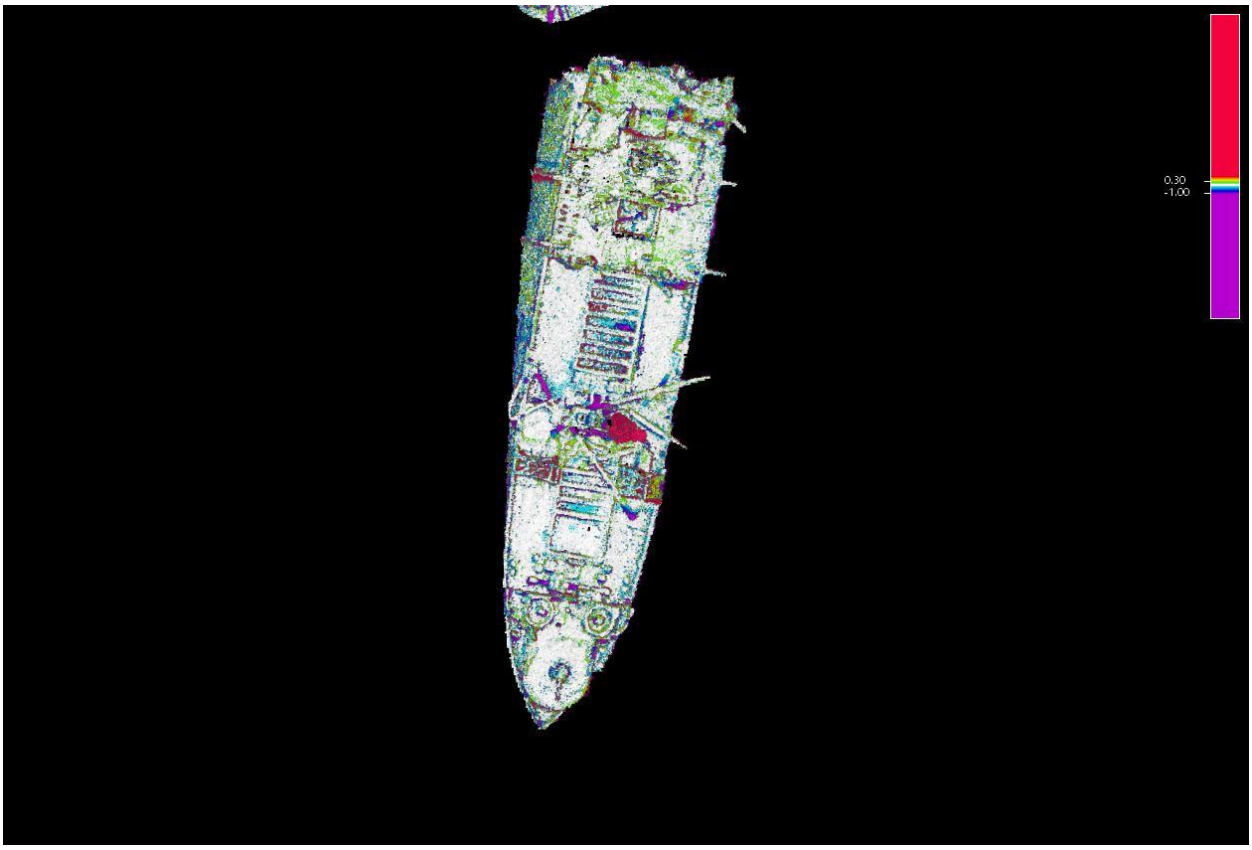


*Figure 16 Aft section surface difference results August 2019 - January 2019 MBES.*

## 4.4 List of Features

4.4.1 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 17 and Figure 18.

4.4.2 All feature IDs detailed in this report are consistent with those from previous survey. No changes have been identified at any of these IDs between the August survey and the preceding survey completed in January.

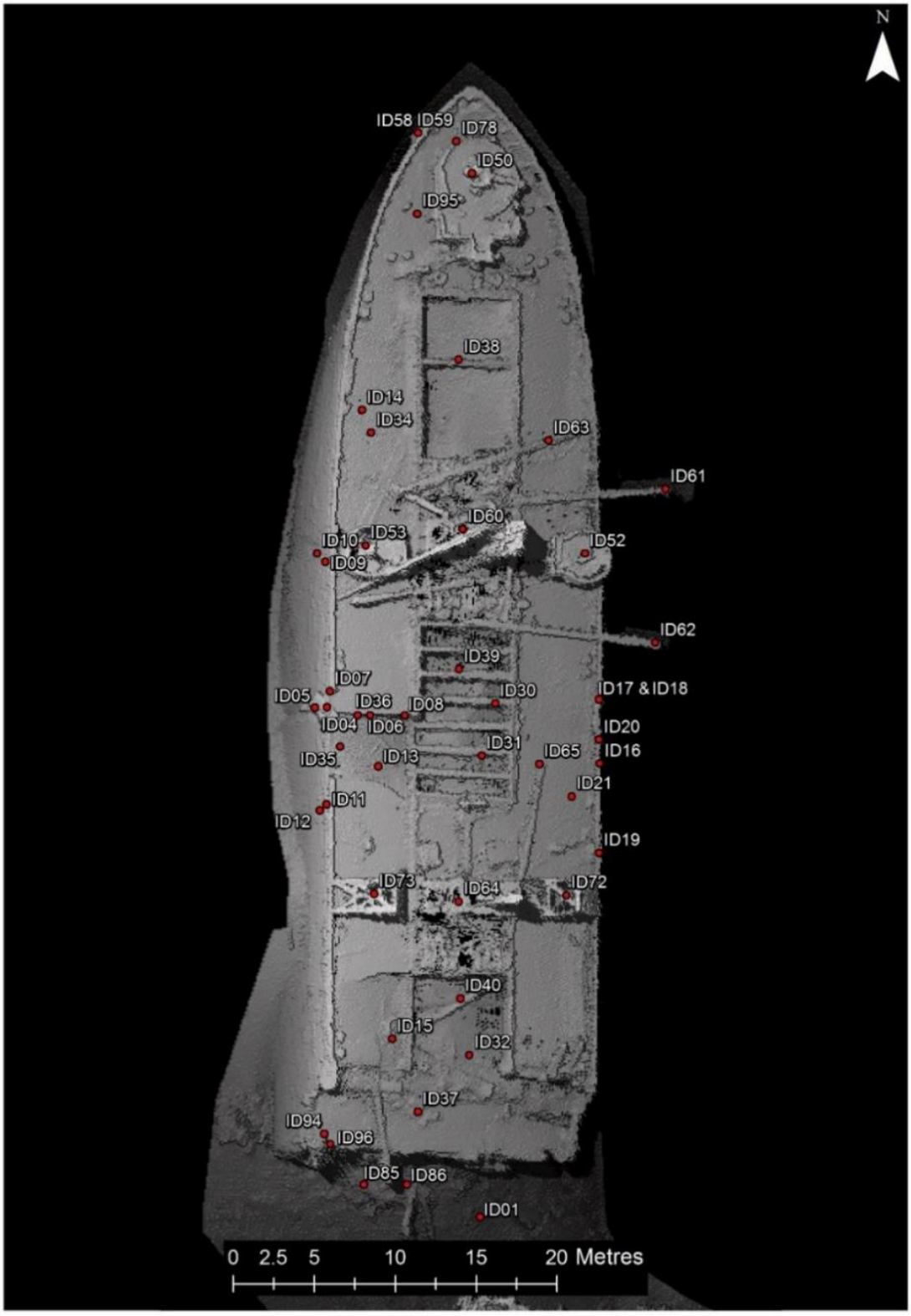


*Figure 17 ID features on forward section.*

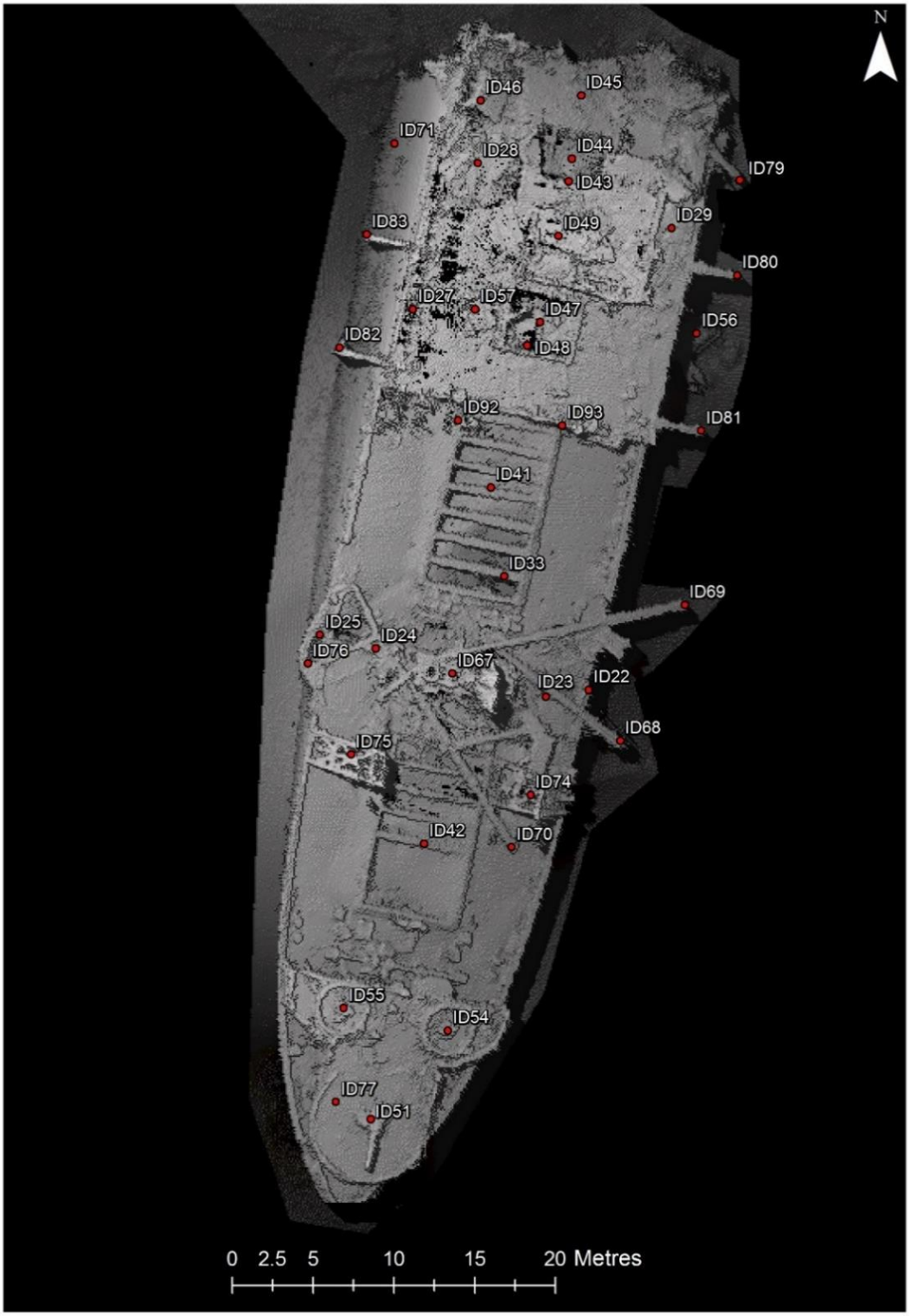


*Figure 18 ID features on aft section.*

*Table 2 List of ID features.*

| Number | Feature | Location | 2019 Status |
|---|---|---|---|
| ID01<br>ID02<br>ID03 | Separation of the hull in two sections forward section aft Section | Wreck site | No change observed |
| ID04 | Crack in hull (Key Area 1) | Port side, forward section | No change observed |
| ID05 | Severe buckling of hull plating | Forward end, port side near Hold 2 | No change observed |
| ID06 | Split in deck | Forward end, port side near Hold 2 | No change observed |
| ID07 | Break in gunnel | Portside Hold 2 | No change observed |
| ID08 | Collapse of Hold 2 deck (Key Area 2) | Port side, forward section | No change observed |
| ID09<br>ID10 | Severe buckling of hull plating<br>Buckling of hull Plating | Port side Hold 2 | No change observed |
| ID11 | Hole in hull plating | Forward section, port side | No change observed |
| ID12 | Buckling of hull plating | Port side Hold 2 | No change observed |
| ID13 | Holes in deck plating | Portside Hold 2 | No change observed |
| ID14 | Holes in deck plating | Port side Hold 1 | No change observed |
| ID15 | Collapse of deck and hatch coaming | Portside Hold 3 | No change observed |
| ID16 | Horizontal crease in hull plating | Stbd side Hold 2 | No change observed |
| ID17 | Hole in hull plating | Fwd side, by Hold 2 | No change observed |
| ID18 | Severe vertical discontinuity of hull plating | Fwd side, by Hold 2 | No change observed |
| ID19 | Severely horizontal buckling of Hull | Stbd side Hold 2 | No change observed |
| ID20 | Large hole in hull plating | Fwd side, by Hold 2 | No change observed |
| ID21 | Bends in deck plating | Stbd side Hold 2 | No change observed |

| Number | Feature | Location | 2019 Status |
|---|---|---|---|
| ID22 | Split in hull (Key Area 4) | Starboard side, aft section (near aft mast house) | No change observed |
| ID23 | Split in deck plating | Aft section, starboard side | No change observed |
| ID24<br>ID25 | Split in deck<br>Split in hull (Key Area 5) | Aft section, port side. | No change observed |
| ID26 | Holes in bulwarks | | No change observed |
| ID27 | Holes in boat deck | Port side aft section | No change observed |
| ID28 | Collapsed boat deck | Starboard side aft mast | No change observed |
| ID29 | Boat deck missing above walkway | Starboard side, aft section, (forward end) | No change observed |
| ID30<br>ID31 | Hole in lower hold cover<br>Collapse of lower hold cover | Hold 2 | No change observed |
| ID32 | Collapse of lower hold cover | Hold 3 | No change observed |
| ID33 | Collapse of lower hold cover | Hold 4 | No change observed |
| ID34 | Indications of tween deck cargo | Starboard side, Hold 1 | No change observed |
| ID35<br>ID36 | Indications of tween deck cargo | Port side, Hold 2 | No change observed |
| ID37 | Indications of tween deck cargo | Hold 3 | No change observed |
| ID38 | Hold 1 catch supports | Hold 1 | No change observed |
| ID39 | Hold 2 catch supports | Hold 2 | No change observed |
| ID40 | Hold 3 catch supports | Hold 3 | No change observed |
| ID41 | Hold 4 catch supports | Hold 4 | No change observed |
| ID42 | Hold 5 catch supports | Hold 5 | No change observed |
| ID43<br>ID45<br>ID46 | Boiler room casing<br>Collapsing bridge deck (Key Area 6)<br>Collapsing boat deck | Forward end, aft section | No change observed |

| Number | Feature | Location | 2019 Status |
|---|---|---|---|
| ID47<br>ID48 | Engine room skylight & casing | Central superstructure | No change observed |
| ID49 | Gunnery officer's cabin | Aft section, central bridge block | No change observed |
| ID50 | Forward gun & gun tub | Bow | No change observed |
| ID51 | Stern gun & gun tub | Stern superstructure | No change observed |
| ID52<br>ID53 | 20mm gun tubs | Adjacent to fore mast | No change observed |
| ID54<br>ID55 | 20mm gun tubs-stern superstructure | Stern superstructure | No change observed |
| ID56 | 20mm gun tubs – laying on seabed | Starboard side aft section | No change observed |
| ID57 | 20mm gun tubs-upturned on boat deck | Central superstructure | No change observed |
| ID58 | 20mm gun tubs | Aft | No change observed |
| ID59 | Port anchor | Port side, bow | No change observed |
| ID60 | Foremast and mast house | Forward section | No change observed |
| ID61<br>ID62<br>ID63 | Foremast cargo and handling booms | Forward section | No change observed |
| ID64<br>ID65<br>ID66 | Main mast and mast house | Forward section | No change observed |
| ID67<br>ID68<br>ID69<br>ID70 | Mizzen mast & mast house | Aft section | No change observed |
| ID71 | Bilge keel | Port side, forward and aft sections | No change observed |
| ID72<br>ID73<br>ID74 | Life raft racks | Adjacent to main mast<br>Adjacent to Hold 5 | No change observed |
| ID76 | Anti-torpedo net cage | Port side, mizzen mast | No change observed |
| ID77 | Propeller and rudder | Stern | No change observed |
| ID78 | Forefoot | Bow | No change observed |

| Number | Feature | Location | 2019 Status |
|---|---|---|---|
| ID79 | Lifeboat davit | Starboard side, aft section (forward end) | No change observed |
| ID80<br>ID81 | Lifeboat davits | Starboard side, aft section | No change observed |
| ID82<br>ID83 | Lifeboat davits | Portside aft section | No change observed |
| ID84 | Lifeboat davit | | No change observed |
| ID85<br>ID86 | Debris on seabed | Gap between forward and aft | No change observed |
| ID87 | Debris on seabed | | No change observed |
| ID88 | Debris on seabed | | No change observed |
| ID89 | Debris on seabed | | No change observed |
| ID90 | Small targets to west | | No change observed |
| ID91 | Scour pattern to west | | |
| ID92 | Port and starboard lighting towers | Central superstructure | No change observed |
| ID93 | Starboard side lighting tower | Aft rail of boat deck on accommodation block | No change observed |
| ID94 | Aperture in Hold 3 exposing cargo of bombs | At the aft end of the forward section | No change observed |
| ID95 | Bow section | Bow | No change observed |
| ID96 | Aperture (Key Area 3) | Aft end, forward section | No change observed |

## 4.5 Key Areas

4.5.1 In addition to the 96 features, six Key Areas that have been highlighted in previous surveys as areas of significant structural change are monitored in each survey (Figure 19). These are further described below.

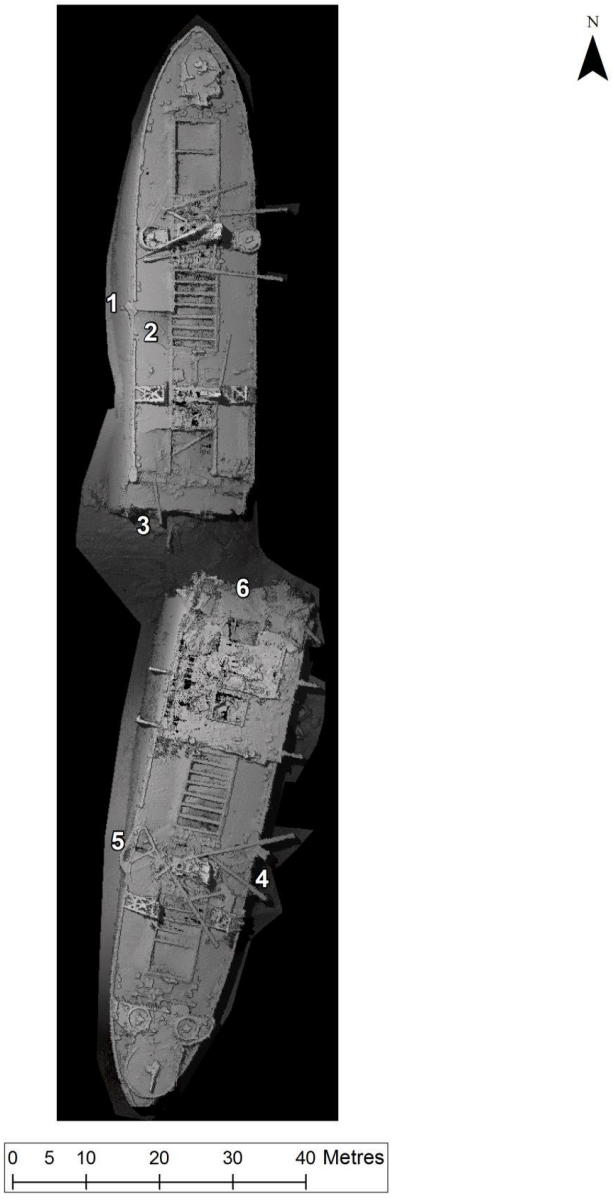


*Figure 19 Location of the 6 Key Areas described in this section.*

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

4.5.3 The forward section of the Richard Montgomery is 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 on both the port and starboard sides as well as significant deformation of the hull sides, particularly on the starboard side. 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 20)

4.5.4 Overlaying the 2019 survey data on a section through a Liberty Ship at Frame 60 (looking aft at the aft end of No. 2 Hold Hatch) shows the extent of the upper deck collapse - Figure 21. The collapsed upper deck and coaming to No. 2 Hold Hatch have not fallen to the level of the second deck. Whether this is the result of the collapsing deck supporting itself or whether it is resting on sediment is not known.

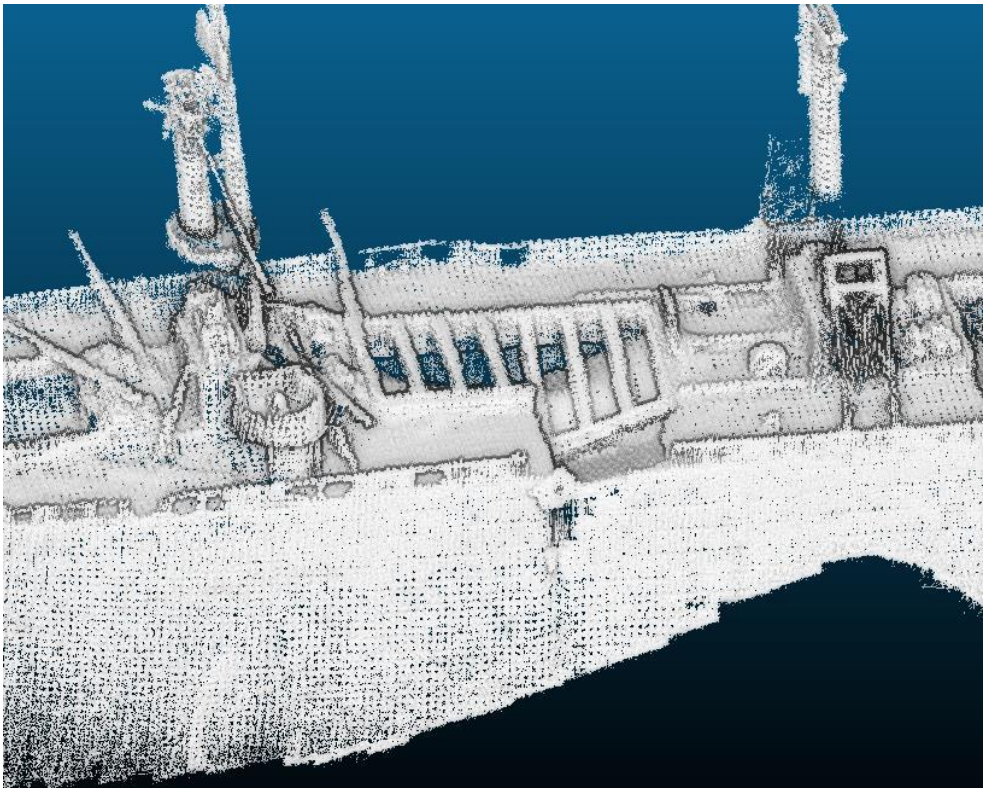

*Figure 20 Crack in hull (ID04) and collapsed upper deck (ID08) from the August 2019 dataset.*

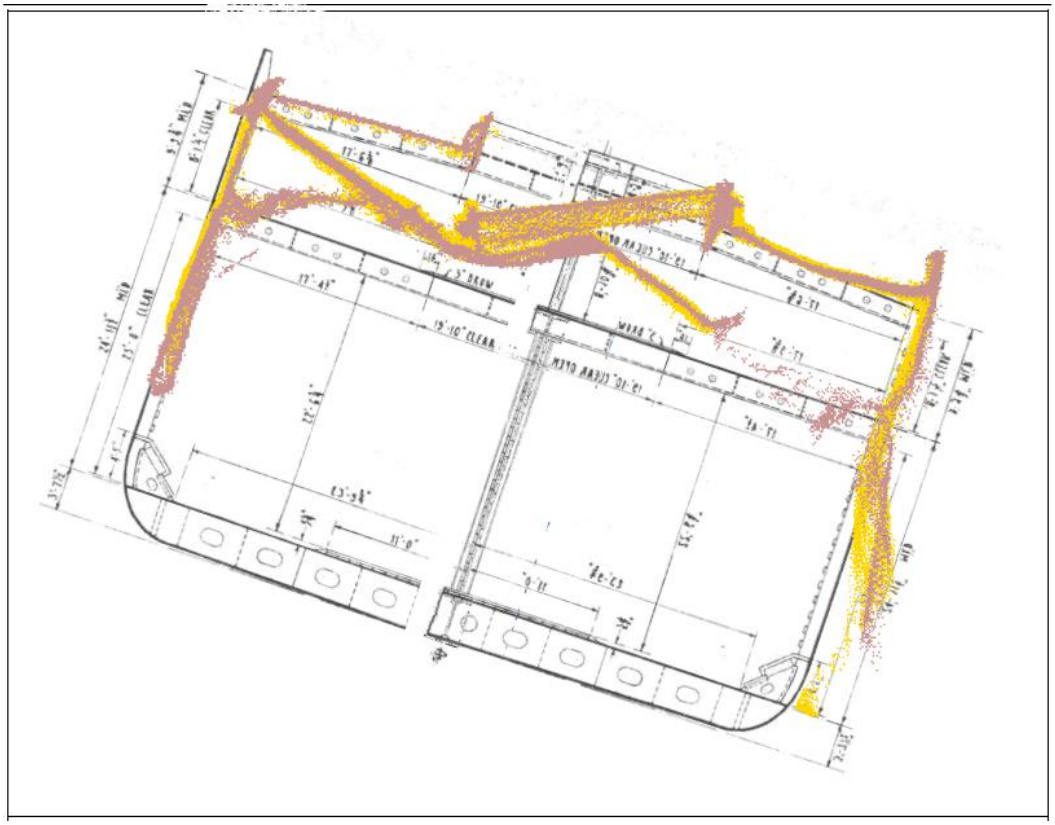

*Figure 21 August 2019 (Yellow) and 2017 (Red) data overlaid on a section plan.*

### 4.5.5 Key Area 3 (ID96)– Port side aperture

4.5.6 The apertures on the bulkhead at frame 88 at the aft end of the forward section are clearly visible in the 2019 dataset although there are no appreciable differences between the August full survey and either the January 2019 or the 2017 full survey (Figure 22).

4.5.7 A CARIS profile, illustrated in Figure 23, shows the August 2019 data (as shown in Figure 22) overlaid on a plan of the oil and watertight bulkhead at frame 88 (the rear of Hold 3). The apertures in the bulkhead occur where the plates have corroded away but frequently leaving the stringers in place (the dashed vertical lines in the plan). Note that the second stringer from the left and the second stringer from the right have also fallen away. Also note the absence of the upper part of the bulkhead that would have formed the rear end of the No. 3 Hold ‘tween deck storage area. This was carried away with the stern section of the wreck when the two halves separated.

4.5.8 Whilst returns were obtained off objects through the aperture the quality of the returns is poor. As a result, it is not possible to identify what the objects are. The

data collected during August shows very similar dimensions to what was gathered during January and in 2017 (Figure 24). However, whether the returns are from cargo in the hold or sediment surrounding them cannot be ascertained.

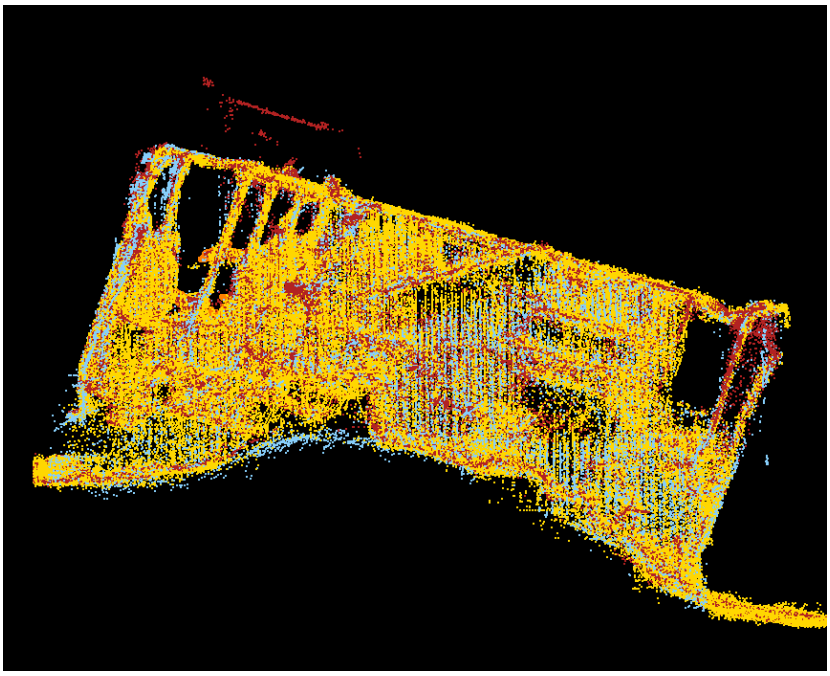

*Figure 22 Aperture in the bulkhead to the rear of Hold 3. Yellow August 2019, blue January 2019, red 2017.*


*Figure 23 August 2019 data overlaid on sectional plan of the bulkhead at frame 88 (rear of Hold 3).*

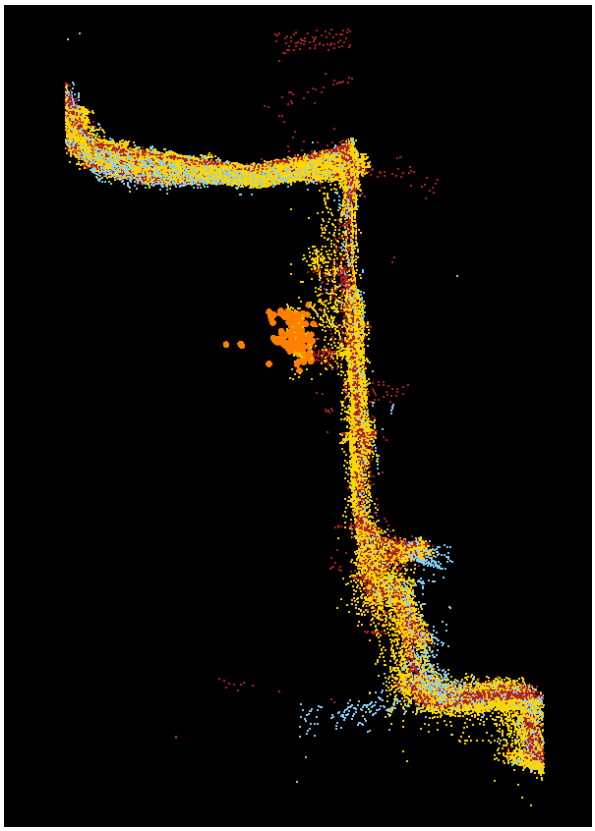

*Figure 24 Section showing returns from contents of hold through aperture. Yellow August 2019, blue January 2019, red 2017. Orange dots highlighted in the 2017 survey as potential cargo.*

### 4.5.9 Key Areas 4 & 5 (ID22 and ID24 & ID25)– Splitting of hull and split in deck and hull.

4.5.10 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.

4.5.11 Figure 25 below shows the August 2019 survey data and the 2017 survey data and clearly shows that no changes have occurred in the angle of the hull and that no changes have occurred to the sediment levels within the hull.

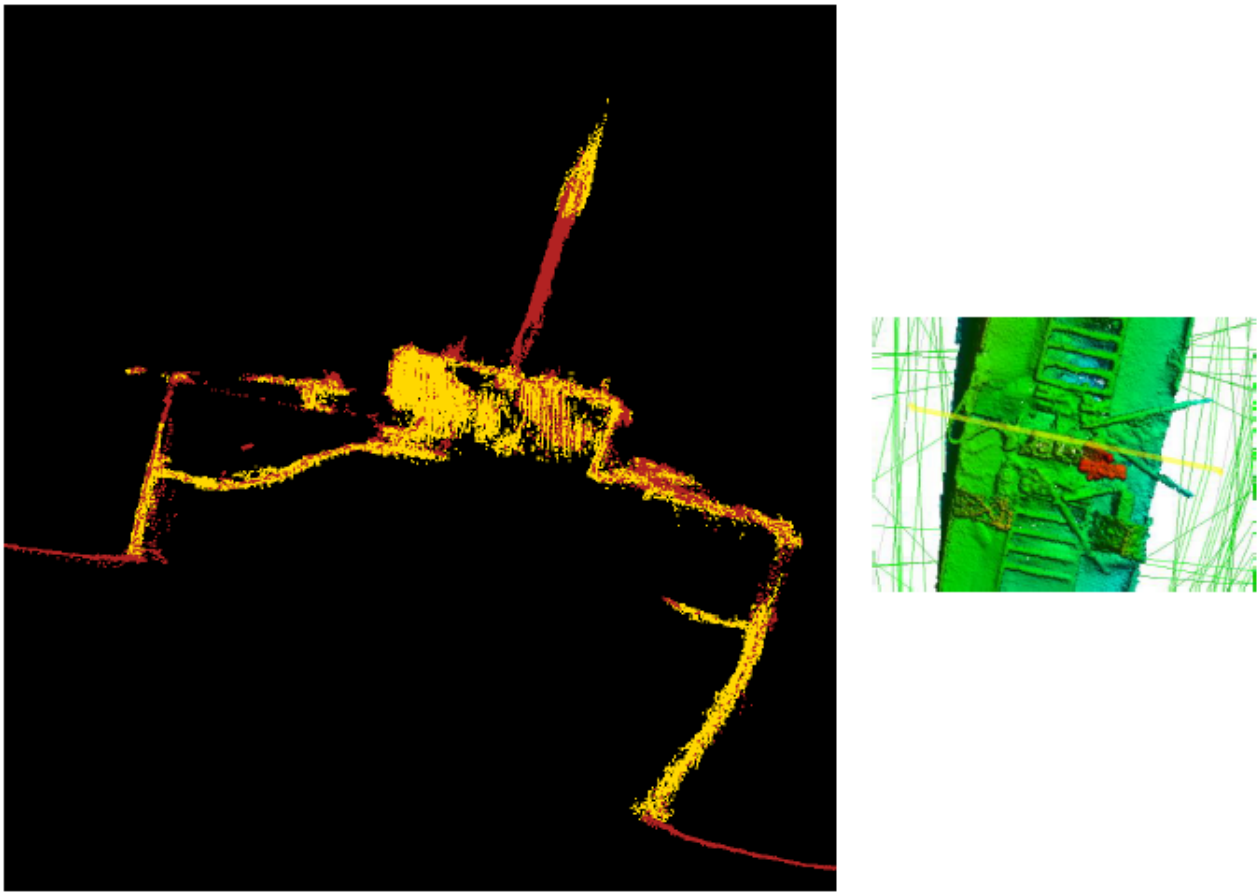

*Figure 25 Cross section through the crack in the rear section of the hull. Yellow August 2019, red 2017.*

### 4.5.12 Key Area 6 (ID43, ID45, ID46)– Collapsing bridge deck.

4.5.13 This area was left unsupported when the ship broke in two back 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 no noticeable change between the August 2019 survey and the 2017 survey.

4.5.14 Key Area 6 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 lack of change in this region.

4.5.15 In Figure 26 the lack of change on the wreck is evident from the good agreement of the 2019 and 2017 surveys. One change that is apparent is the slight raise in the seafloor to the east (port side) of the wreck.

4.5.16 The long unsupported section of deck is part of the upper deck that formed the top of Hold 3's 'tween deck space. The lump at its end is probably the rear coaming of No. 3 Hatch. This portion of the upper deck and section of coaming were carried away with the stern when the two halves separated.

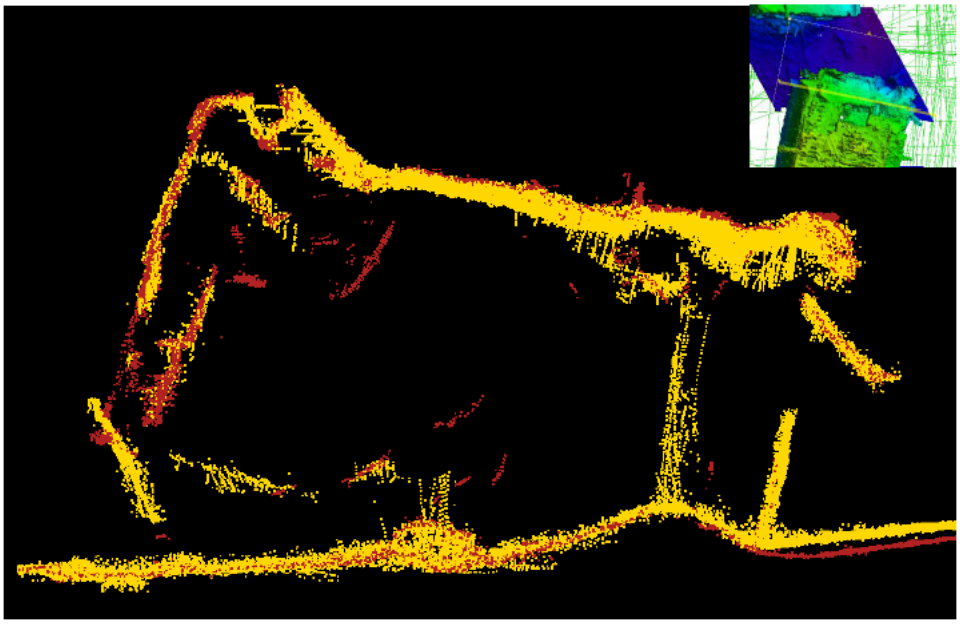

*Figure 26 CARIS subset profile through bridge deck area. Yellow 2019, red 2017.*

## 4.6 Debris Between the Hull Sections

4.6.1 There has been no appreciable difference in the debris between the bow and stern section since 2017. In Figure 27 below the difference between the 2017 and August 2019 surveys is shown. This has been limited to changes of +/- 0.2m and any change greater than this is white.

4.6.2 The horizontal white 'bar' towards the top of the image is the vertical face of the bulkhead at the rear of the forward section (see inset location diagram) where any slight horizontal displacement between survey points will result in a large vertical difference. Similarly, the largely white area to the bottom of the image is the subsiding bridge/superstructure to the front of the rear part of the wreck. Although this has not subsided much between the January and August 2019 surveys it has moved more than 0.2m since 2017 and hence the difference here is outside the limit of this image.

4.6.3 The area within the dotted black line is the seafloor between the front and rear sections of the wreck and predominantly shows changes of less than +/- 0.2m depending on the direction of change. The larger portion of white near top centre is again caused by overhanging debris giving large height differences for small lateral movements.

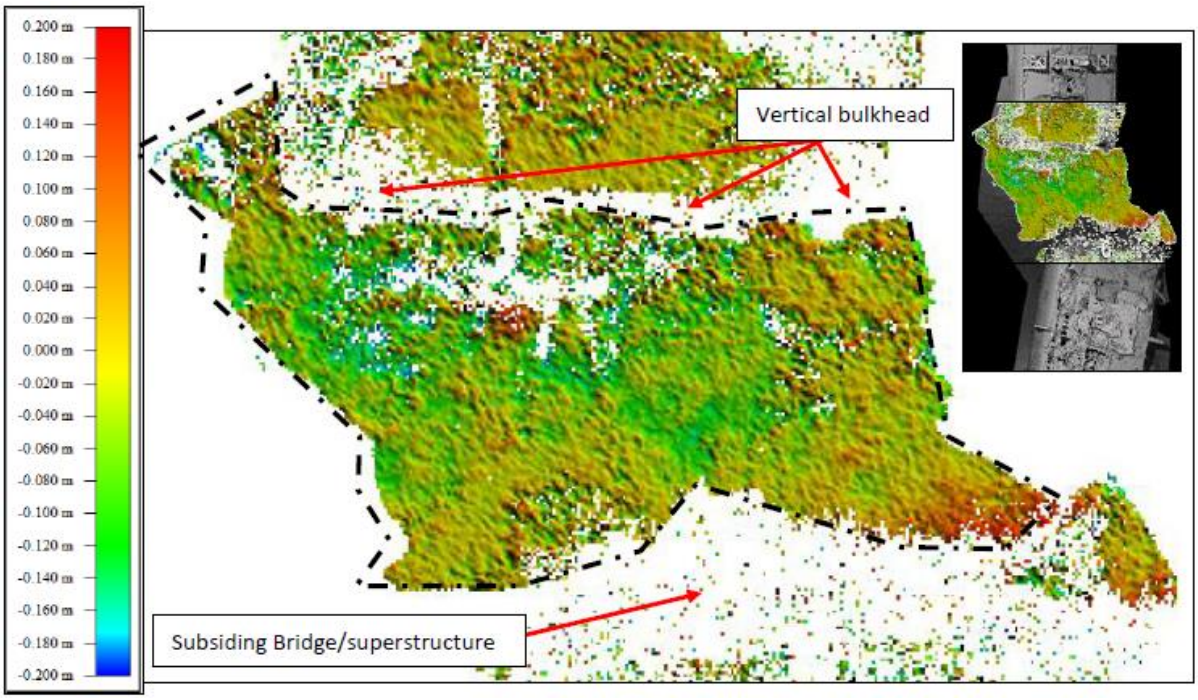


*Figure 27 Difference surface of 2017 survey - August 2019 data.*

## 4.7 Cargo

4.7.1 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).

4.7.2 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.

4.7.3 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.

4.7.4 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:**

4.7.5 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. (Figure 28 & Figure 29).

4.7.6 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.

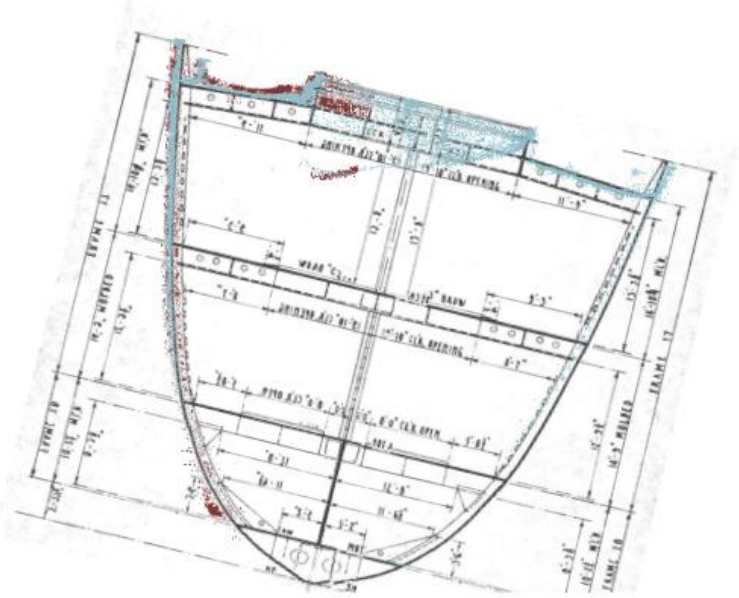

*Figure 28 Cross-section at frame 17-18, forward of No 1. Hatch (red August 2019, blue 2017 survey).*

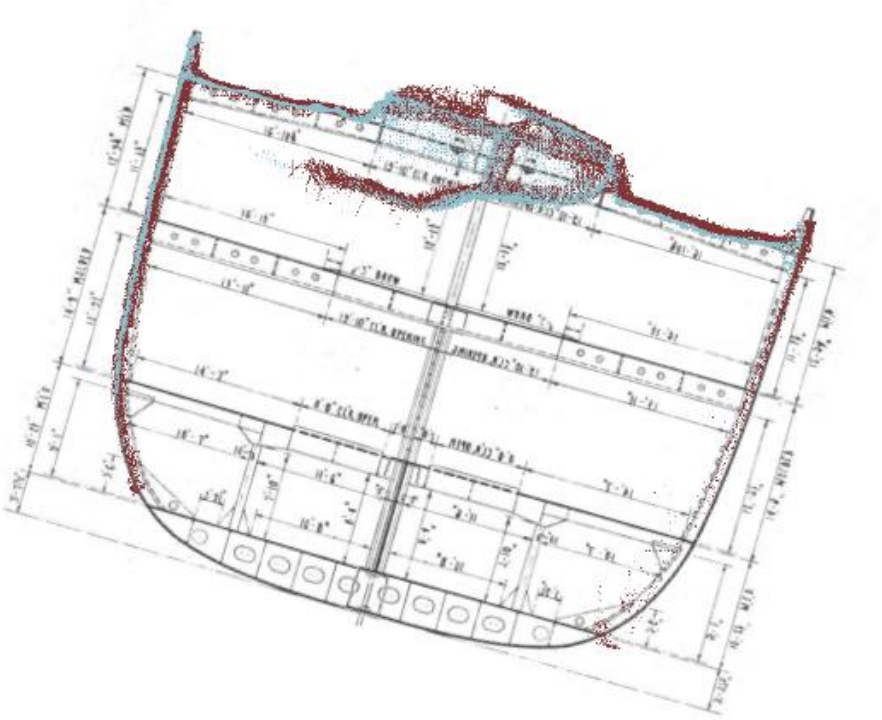

*Figure 29 Cross-section through frame 32, aft end of No. 1 Hatch (red August 2019, blue 2017 survey).*

**Hold 2:**

4.7.7 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. (Figure 30 & Figure 31).

4.7.8 In Figure 32 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 32, although this could also be the result of data inaccuracies caused by poor acoustic properties of the sound passing through the narrow gap.

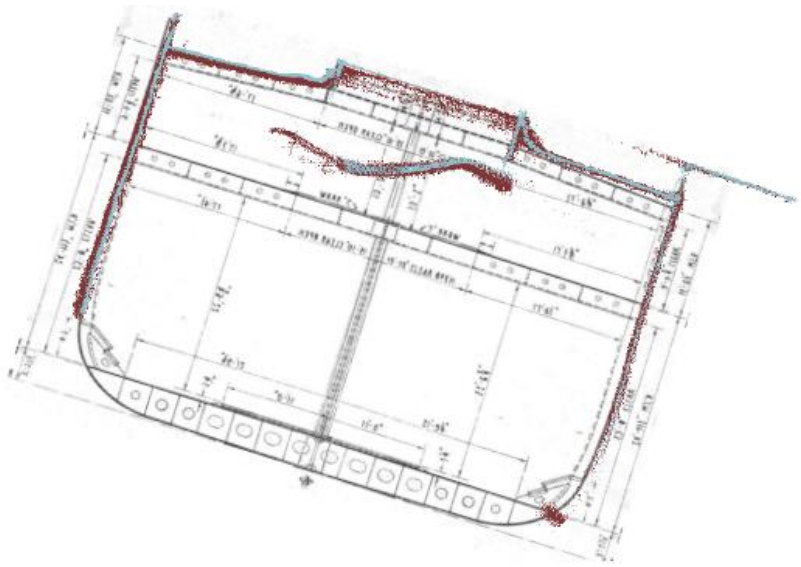

*Figure 30 Cross-section of hull at frame 46, forward end of No. 2 Hatch (Red August 2019, Blue 2017).*

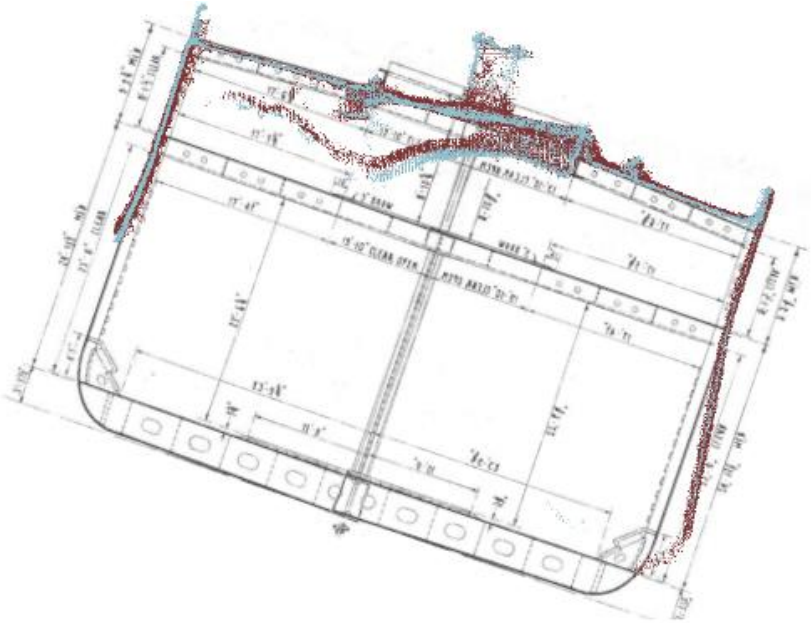

*Figure 31 Cross-section of hull at frame 60, aft end of No. 2 Hatch (red August 2019, blue 2017).*

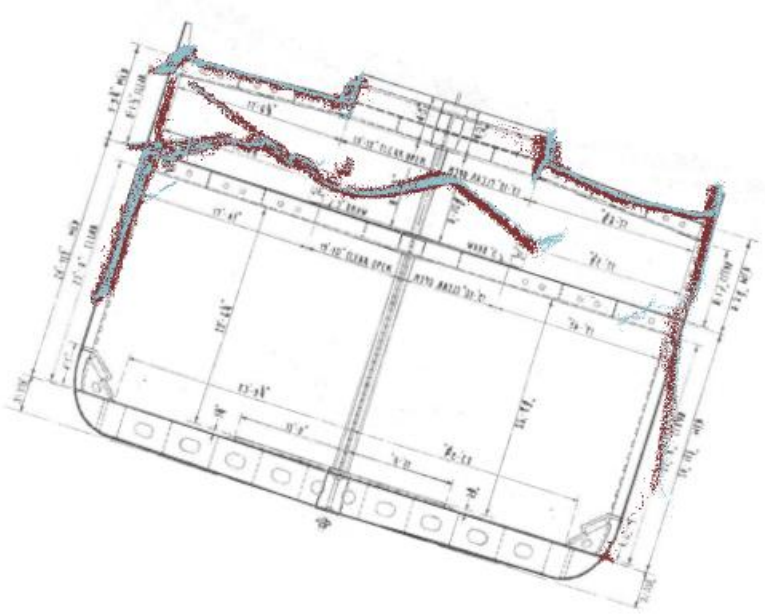

*Figure 32 Cross-section of hull at frame 54 where forward section of hull is breaking in two (red August 2019, blue 2017).*

**Hold 3:**

4.7.9 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 (Figure 33 & Figure 34).

4.7.10 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.

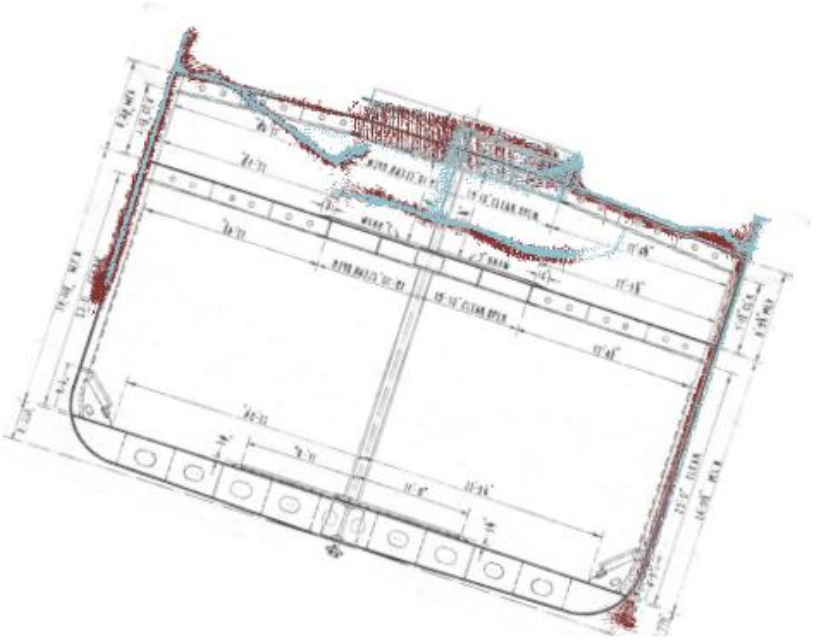

*Figure 33 Cross-section of hull at frame 73, forward edge of No. 3 Hatch (red August 2019, blue 2017).*

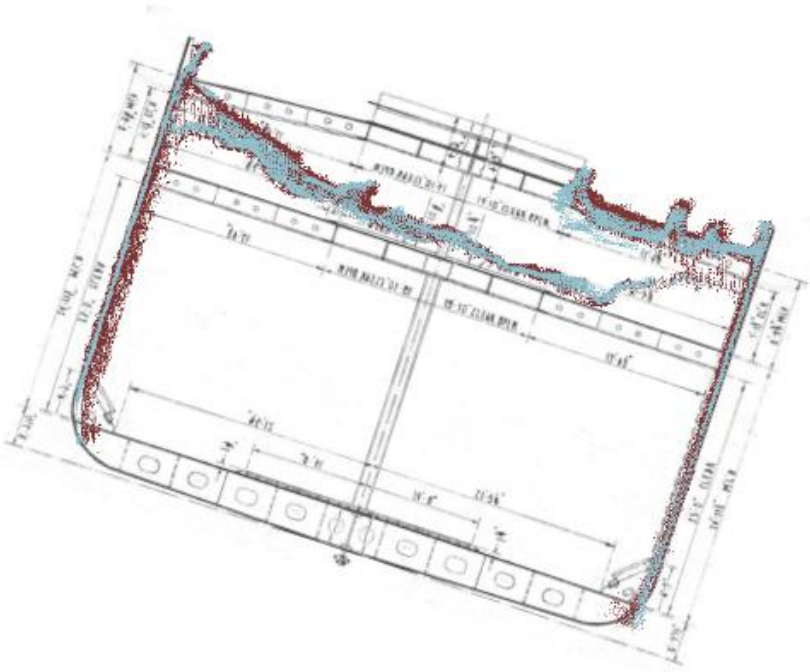

*Figure 34 Cross-section of hull at frame 82, aft of No. 3 Hatch (red August 2019, blue 2017).*

**Hold 4:**

4.7.11 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 35, 36 and 37).

4.7.12 The sediment in the forward part of No. 4 Hatch shows distinct similarities with that in Nos 1 and 2 hatches 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 (Figure 35). 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 (Figure 36) 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 is just below the second deck – see Figure 37 below. The sediment has deepened slightly between 2017 and the August 2019 survey.

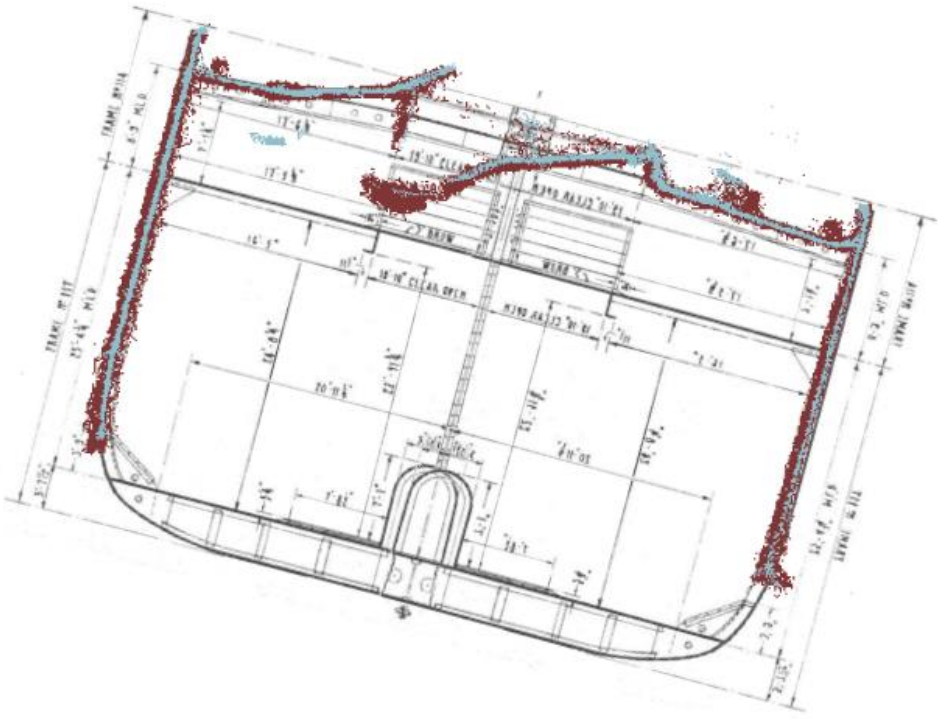

*Figure 35 Cross-section through frame 114 at the forward edge of No. 4 Hatch (red August 2019, blue 2017).*


*Figure 36 Cross-section through frame 114 at the forward edge of No. 4 Hatch (red August 2019, blue 2017).*

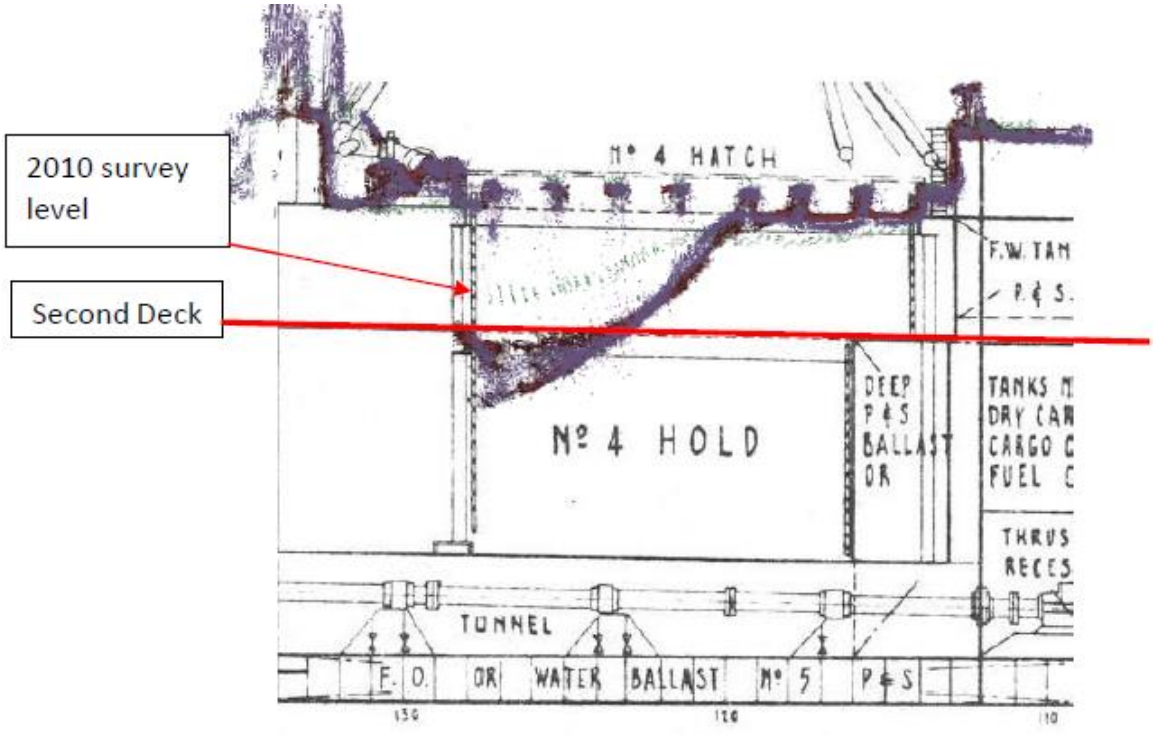


*Figure 37 Longitudinal section through No. 4 Hold (red August 2019, blue 2017).*

**Hold 5:**

4.7.13 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.

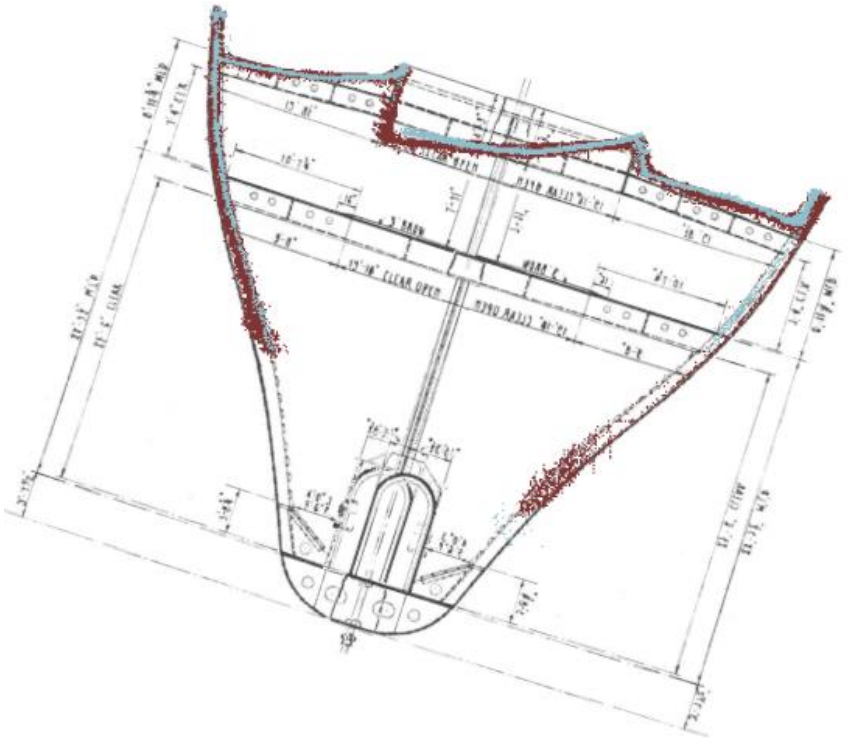

*Figure 38 Cross-section through hull at frame 154 (red August 2019, blue 2017).*

## 4.8 Laser Survey

4.8.1 The laser data from the August 2019 survey was overlain on the 2017 laser data (see Figure 39). The two data sets agree extremely closely indicating that there has been no movement of the masts since 2017.

4.8.2 The three masts are well defined within the laser data and show good correlation with the bathymetry derived points on the foremast stay and on the life raft davit.

4.8.3 Unfortunately, due to the angle of the MBES heads and the height of tide when the MBES data was acquired a vertical data gap of between 1.5m and 2.5m exists between the laser and MBES on the main mast structures.

*Figure 39 Masts, Fore mast to left, Mizzen mast to right.*

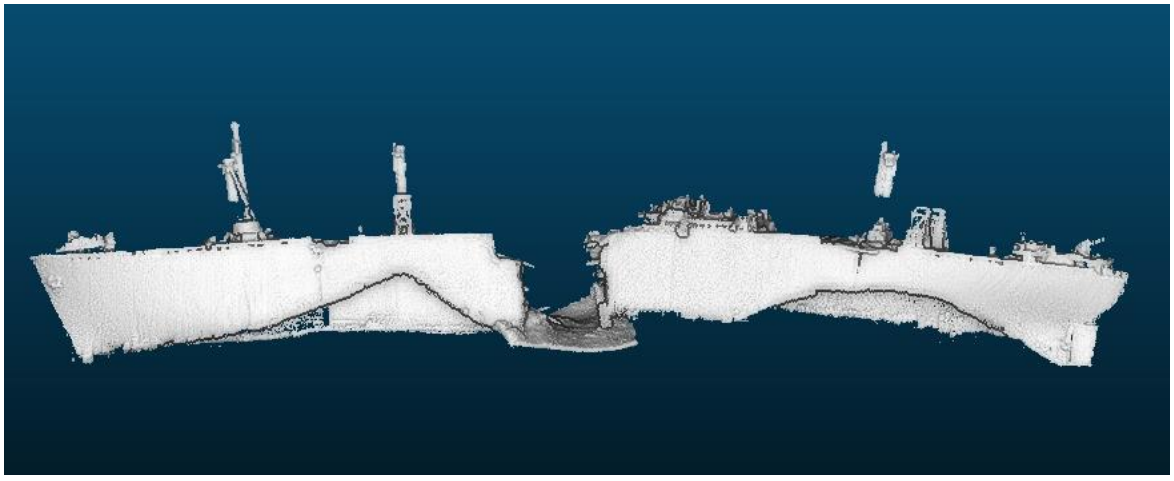

*Figure 40 Laser point cloud combined with 2019 MBES data showing masts.*

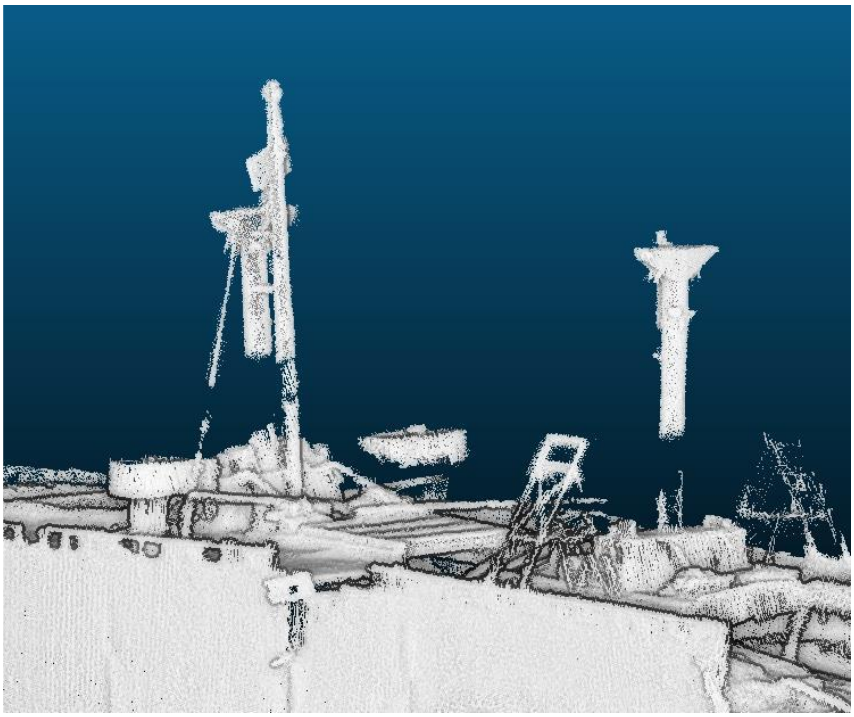

*Figure 41 Fore and main masts - combined laser and MBES data.*

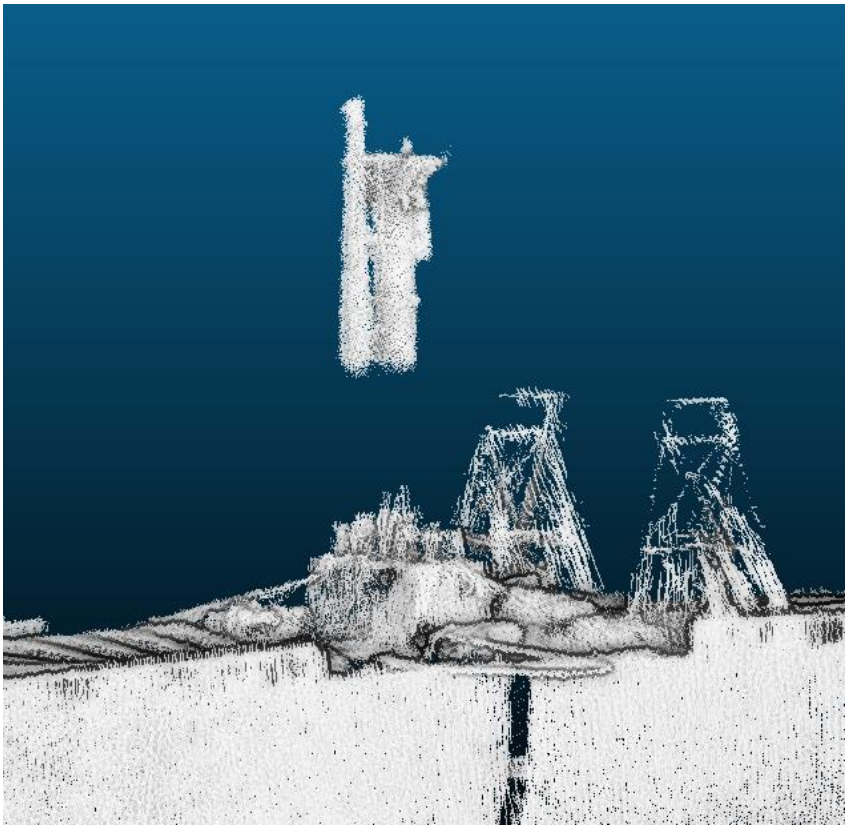

*Figure 42 Mizzen mast - combined laser and MBES data.*

# 5 Seabed Survey

## 5.1 General

5.1.1 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.

5.1.2 The seabed survey fully covered the area of the survey identified below in Figure 43.

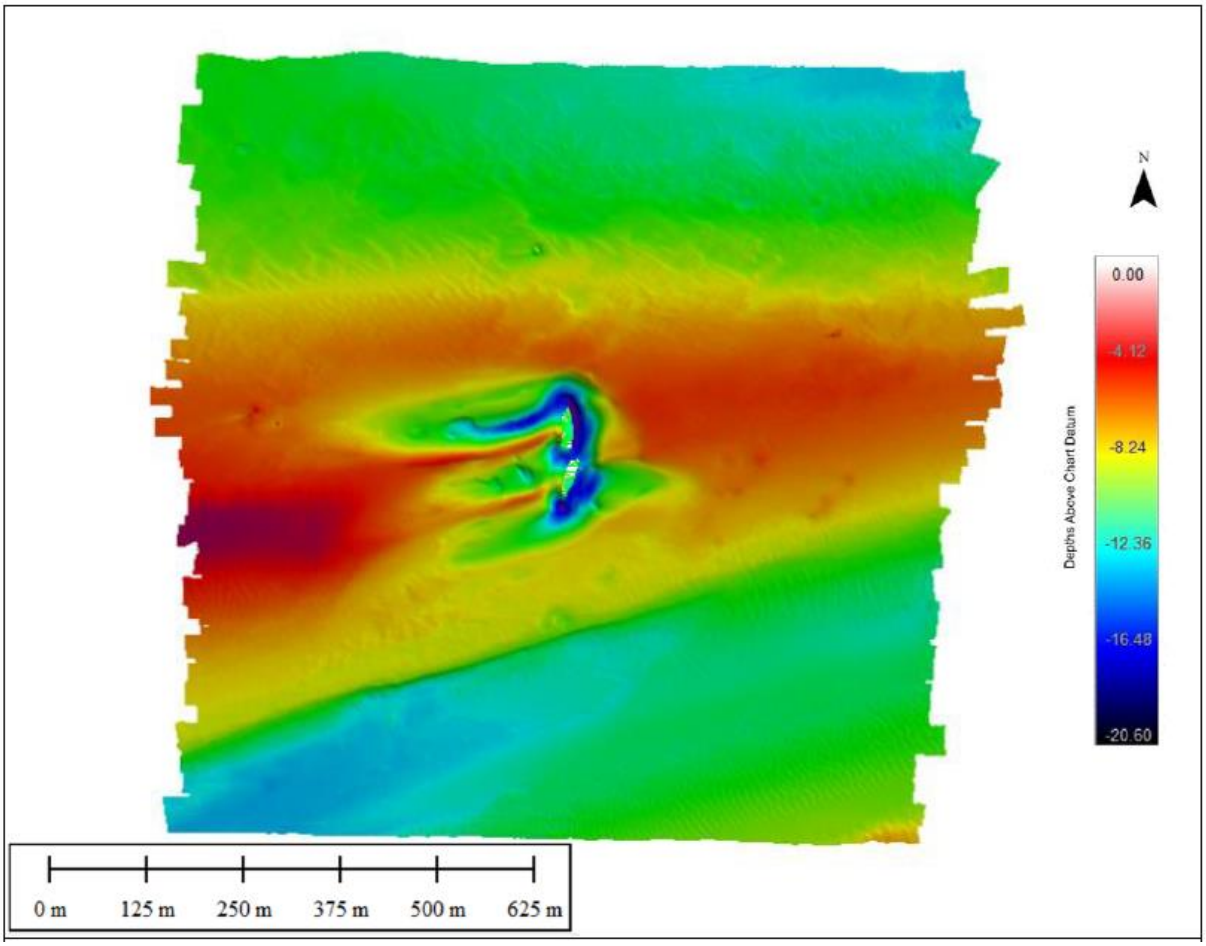


*Figure 43 Shaded relief plan of seabed survey area.*

5.1.3 A difference plot was made between the 2017 and 2019 surveys. Changes to the seafloor are fairly limited with the majority remaining stable (+/- 0.1m) between the 2017 and 2019 surveys (Figure 44).

5.1.4 The sand bank to the west of the SSRM has been scoured away leaving the seabed some 80 – 90cm deeper in this region. This may show the westerly migration of the sand bank but, with the western depositional end not being covered by the survey, this cannot be confirmed. Tt could possibly be the erosion of the sand bank with no accretion at the far end. It is of note that a similar pattern of deepening seabed was noted in the 2017 report where the difference surface was between the 2017 survey and the 2014 survey.

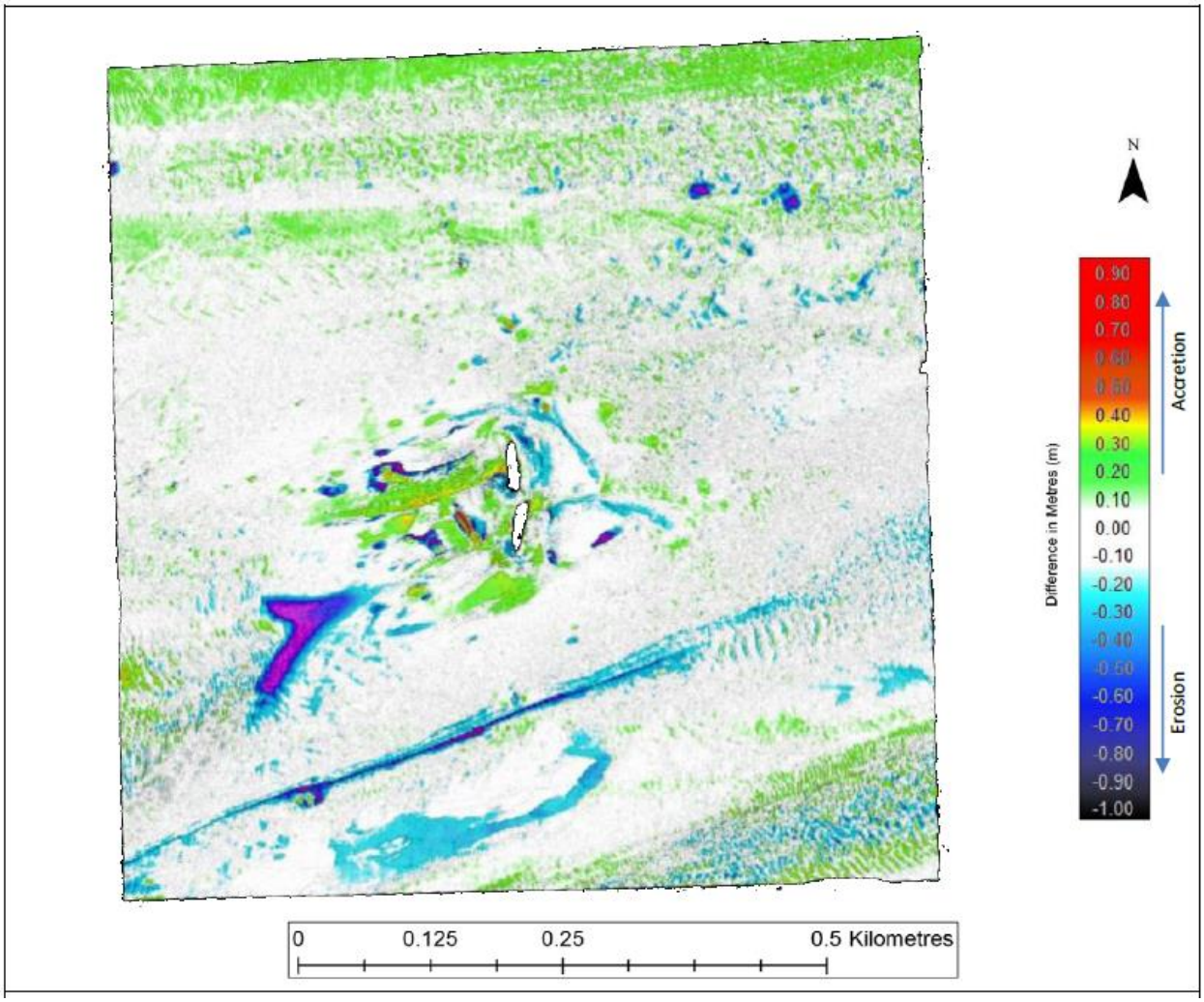


*Figure 44 Comparison of seabed surveys between 2017 and 2019.*

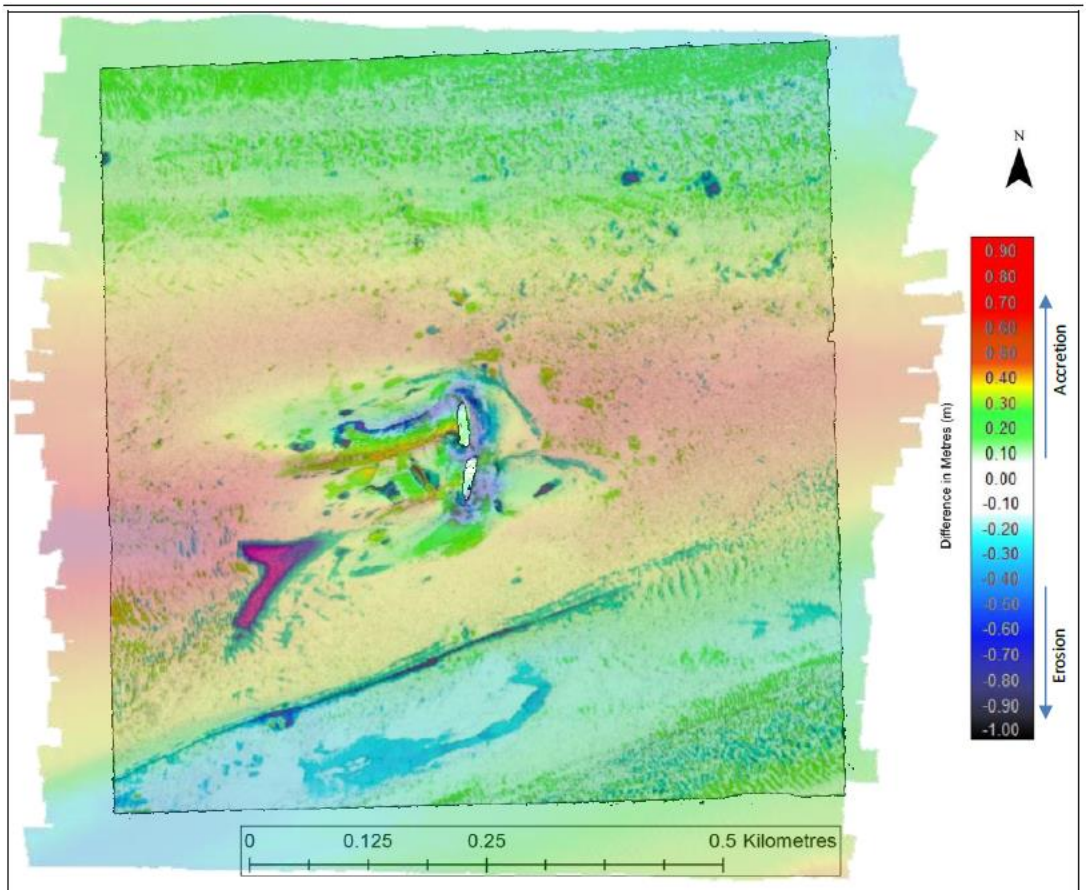


*Figure 45 - Overlay of difference plot on the bathymetry.*

## 5.2 Scour around wreck

5.2.1 The degree to which the bow and stern may be being undercut as the supporting sediment is eroded away is a potential concern.

5.2.2 In Figure 46, the seafloor difference plot around the wreck shows very little change at the bow or stern. The port and starboard sides of the bow show less than 10 cm change over the two-year interval while the actual bow has had 10 – 20cm of deposition.

5.2.3 Figure 47 and Figure 48 show profiles from the August 2019 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 are supported.

5.2.4 The stern shows less than10cm change to the east while the western side has suffered from 20 – 30cm of erosion between the two surveys. However, the rudder is still resting on the sea floor and forward of the propeller the hull is quite deeply embedded in the sediment.

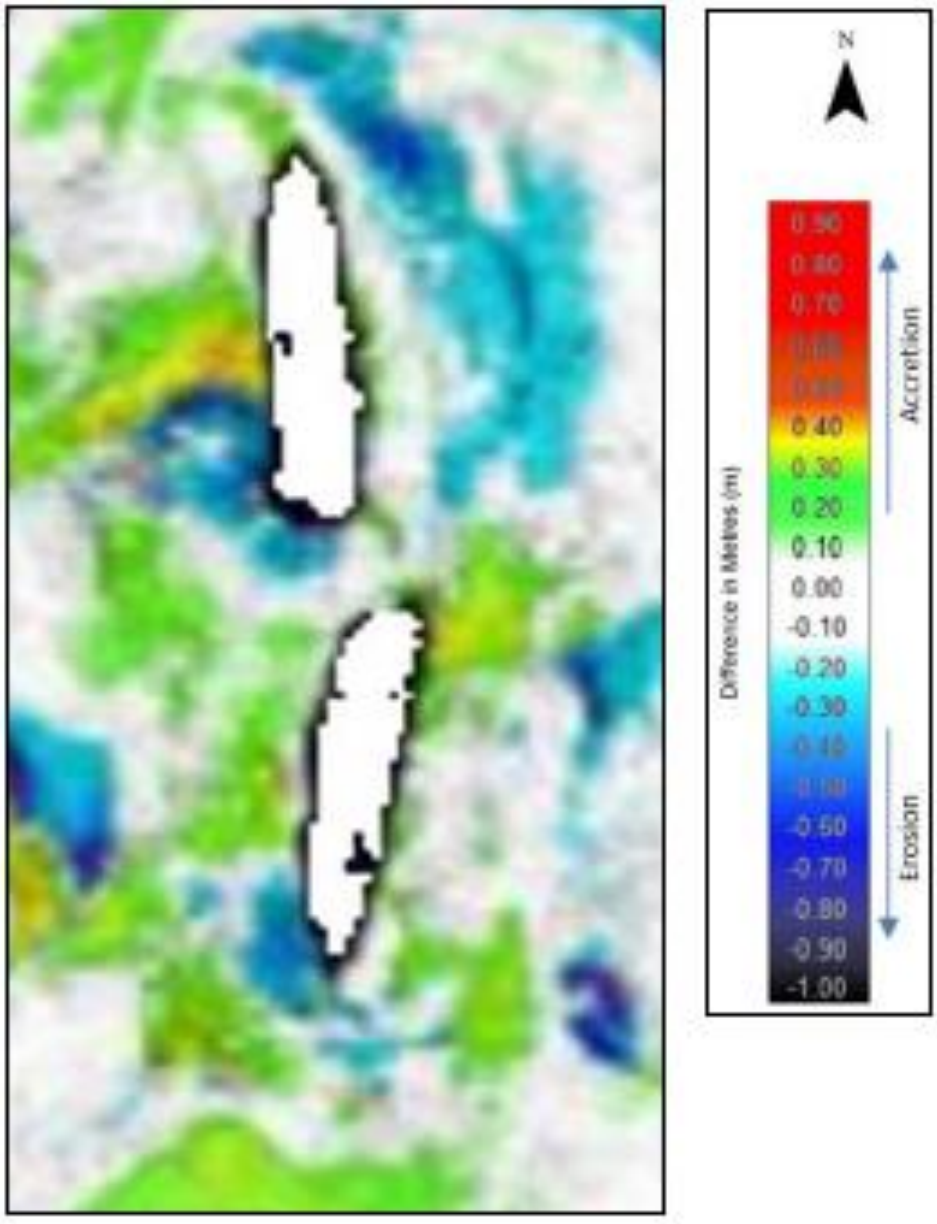


*Figure 46 Seafloor difference plot around the wreck.*

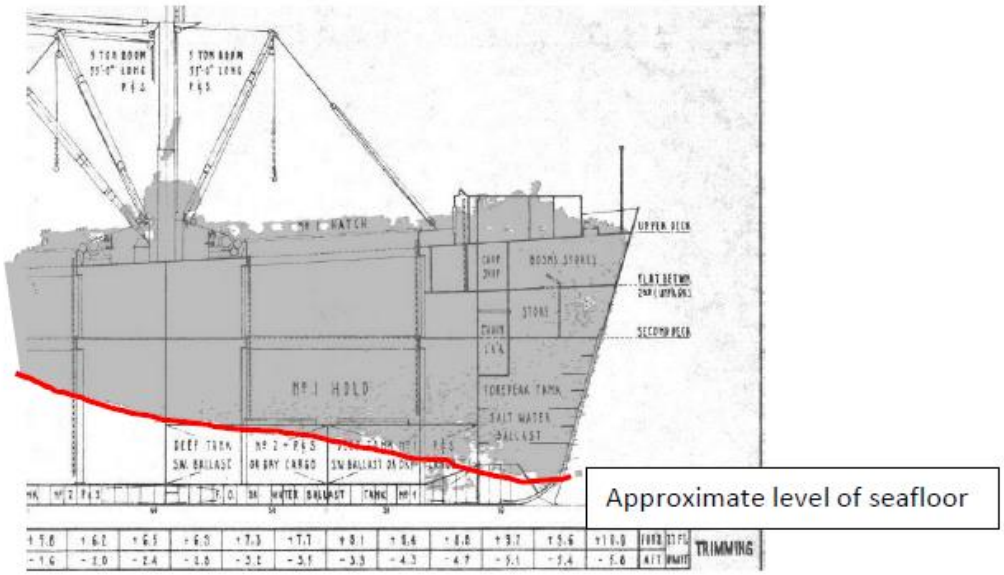


*Figure 47 Profile of the August 2019 data of the bow over laid on the ships plan.*

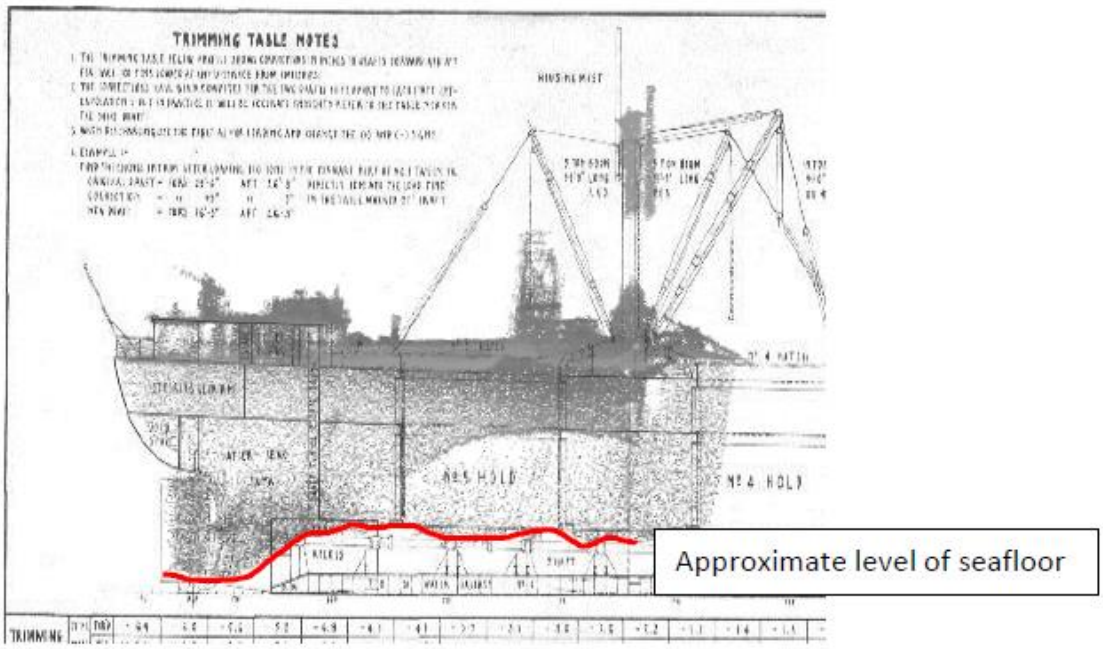


*Figure 48 Profile of the August 2019 survey data of the stern over laid on the ships plan.*

## 5.3 Seabed Contacts

5.3.1 The 66 seabed contacts from 2017 were compared against this year's bathymetry. Analysis of the 2019 dataset has added a further 2 targets to the contact list, while 12 items from the 2017 contact list are not apparent on the 2019 data.

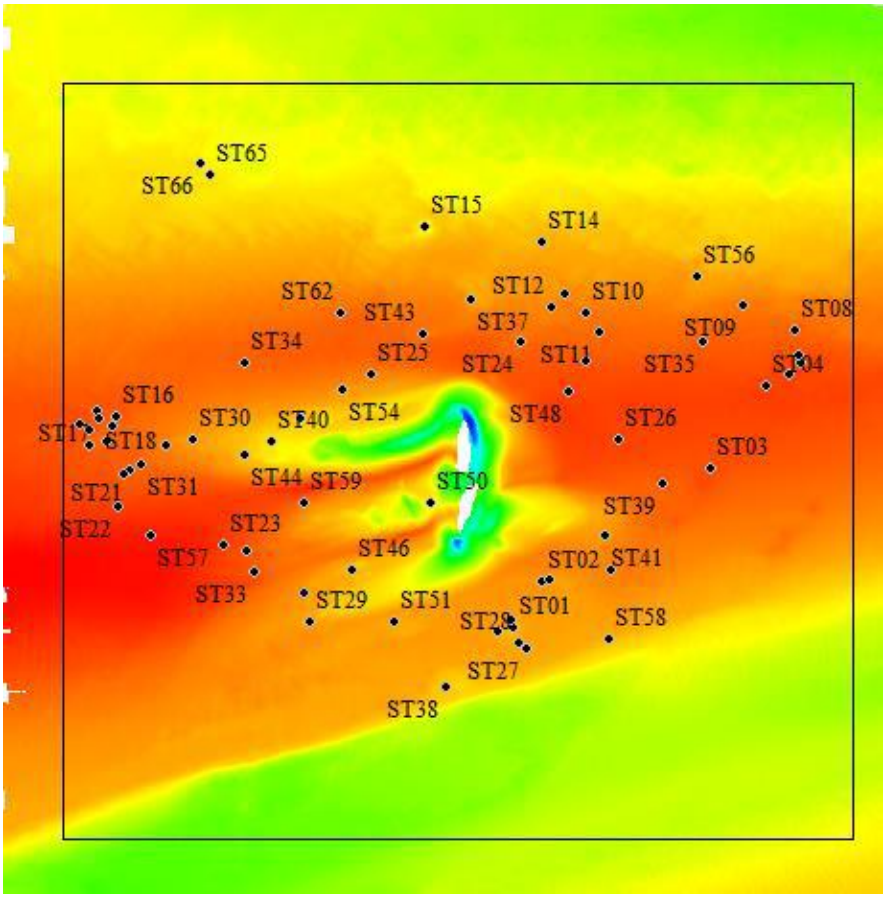


*Figure 49 – Seabed contacts.*

# 6 Conclusions

6.1.1 The 2019 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. However, despite operating across the full range of the tide, it proved to be impossible to close the gap between the laser data and the MBES data on the three masts. The gap varied on each mast but ranged from 1.5m – 2.8m.

6.1.2 The comparisons between this survey's data and the preceding two surveys (January 2019 survey and the 2017 survey) indicated that no changes had occurred between January and August 2019 and only a very few and minor changes existed between the January 2019 and 2017 data sets.

6.1.3 It is recommended that the 6 Key Areas of change identified in previous reports are modified since several of these are parts of the same degradation feature and should be studied together to gain an understanding of how the wreck is deforming as it continues to degrade.

6.1.4 It is recommended that Key Areas 1 and 2 are combined and joined by all IDs across the hull to the gap in the port hull at ID 20 and the bulge on the port side adjacent to this. This collection of IDs will then represent the significant split in the hull at approximately frame 53 which should be monitored as a single entity.

6.1.5 Secondly it is recommended that the split on the rear hull is also monitored as a single entity by combining Key Areas 4 and 5 as well as all IDs between.

6.1.6 Monitoring the bulkhead at the rear of Hold 3 (Key Area 3) and the forward end of the rear section (Key Area 6) remain valid points to consider.

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