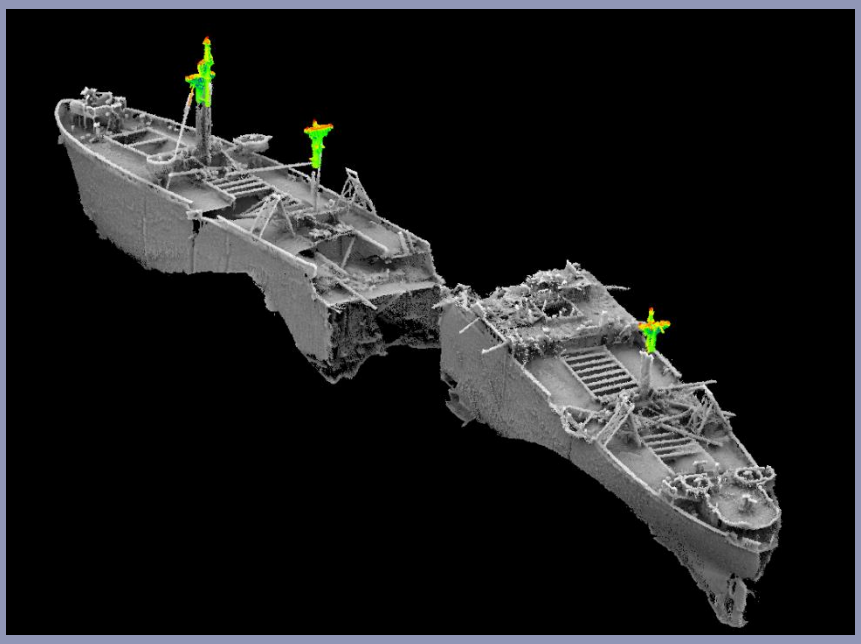
Maritime & Coastguard Agency



SS Richard Montgomery Survey Report 2016

Maritime and Coastguard Agency
January 2019

1. Executive Summary

1.1 The SS Richard Montgomery 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. Approximately 1400 tons of explosives remain on board the wreck and, for this reason, the wreck is designated as a dangerous wreck under section 2 of the Protection of Wrecks Act 1973 and regular surveys are undertaken. 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. All three masts are visible above the waterline at all states of the tide.

1.2 For the 2016 survey of the wreck, the scope of the work included a fully geo-referenced multibeam sonar survey of the wreck and the seabed surrounding it and laser scanning of those areas of the wreck which are visible above the waterline. Both multibeam sonar and laser scanning data have been regular features of the SS Richard Montgomery survey in recent years. As a repeat survey, the multibeam and laser data was acquired in a manner that enabled direct comparison with historical datasets and allows for comparisons with data collected in the future.

1.3 The survey was commissioned in 2016 and, due to weather conditions and availability of survey vessels, the survey work took place in two phases across 2016 and 2017. The initial data was collected on 13th December 2016, this included the multibeam survey of the seabed surrounding the wreck and the laser scanning component of the survey. The over-wreck survey was conducted on 16th February 2017. Other survey work on the wreck had already taken place earlier in 2016, including a magnetometer survey in March 2016 (see the 2015 Survey Report for further details of the magnetometer survey).

1.4 The results of the 2016 survey work showed that, as in previous years, in general terms, continued deterioration was noted in some areas of the wreck, whilst others showed no evidence of change. The following are some of the main points from the 2016 survey results:

- In terms of data density, the 2016 data is a slightly more dense point cloud dataset than the previous survey.

- As in previous years, the 2016 survey covered the entire wreck and surrounding seabed in detail.

- The Key Areas where more accelerated levels of deterioration have been noted in previous years again received close scrutiny.

- The deck plating at Key Area 2 has continued to collapse (by 0.35m) and an adjacent section of gunnel has broken away.

- The crack at Key Area 1 has also shown some change, with a slight increase in the size of adjacent holes in the hull plating (0.2m).

- The superstructure area at Key Area 6 had shown a large area of subsidence in the 2015 survey. Although some subsidence has continued, the magnitude of change is much smaller than previously seen.

- Other areas where changes have occurred include holes in the deck plating at Hold 2 which have increased in size by 0.2m, a height difference of c.1.5m in the gunnery officer's cabin, a general re-working of sediment across the wreck, a mixture of accretion and erosion in the surrounding seabed and the identification of 7 additional contacts in the survey area.

- The orientation of both sections of the wreck has not changed.

- No evidence was found of munitions escaping from the wreck.

- As in previous years, the seabed around the vessel has generally remained stable and, across much of the wreck, no changes were noticeable in the survey data.

2. Introduction

2.1 The SS Richard Montgomery (SSRM) was a US Liberty Ship of the EC2-S-C1 class. It was built 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 bound for the UK and then on to France. After arriving in the Thames Estuary, the vessel dragged its anchor and, on the falling tide, foundered on Sheerness Middle Sand, a sand bank running east from the Isle of Grain and to the north of the Medway Approach Channel. Almost immediately, the vessel hogged and the hull plates forward of the bridge began to split. A salvage operation began and approximately half of the cargo was discharged. However, the ship broke its back, the forward section became completely flooded and, eventually, in September 1944, the salvage operation was abandoned.

2.2 Although the stern section of the wreck was cleared during the salvage operation, approximately 1400 tons (Net Explosive Quantity) of munitions remain in the forward section in holds 1, 2 and 3. The wreck lies in two sections across the tide and close to the Medway Approach Channel. The wreck has settled into the sandbank, gradually scouring away the sediment leaving it lying in two sections in approximately 18m of water. All three masts are visible above the waterline at all states of the tide.

2.3 The wreck is designated under section 2 of the Protection of Wrecks Act 1973[1]. 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. The wreck is clearly marked on the relevant Admiralty charts, the prohibited area around the wreck is ringed with four lit cardinal buoys and twelve red danger buoys and the wreck is under 24-hour surveillance by Medway Port Authority.

2.4 Although the wreck is considered to be stable if left undisturbed and the risk of explosion is considered to be low, the wreck is regularly monitored. Surveys of the wreck are undertaken in order to provide information on its condition, to identify any changes or deterioration and to help inform future management strategy. The SSRM has been the subject of regular surveys since its grounding, with a variety of methods used to monitor the site. Since 2002, multibeam sonar technology has been employed for these monitoring surveys.

2.5 Although diving surveys have been carried out on the wreck, for general surveying multibeam sonar is currently preferred because it is faster, more cost-effective and provides a greater level of detail, accuracy, repeatability and reliability than could be achieved through a diving survey. This is in part due to the very poor visibility and high tidal range in the Thames Estuary which makes diving operations very challenging. However, divers are sometimes employed on the wreck, most recently in 2013 when a hull thickness assessment was undertaken (see the 2013 survey report for further details). Since 2008, laser scanning has also been a key feature of the SSRM survey. The laser survey covers those parts of the wreck which are visible above the waterline and as such are not covered by the multibeam survey.

[1] Text of the Protection of Wrecks Act 1973 Protection of Wrecks Act 1973

2.6 As in previous years, the 2016 survey required both multibeam sonar and laser scanning surveys to provide a clear understanding of the current condition of the wreck, its cargo (as far as is possible) and the seabed topography in the surrounding area in order to identify, visualise and quantify any changes to these.

2.7 This report details the summarised findings of the 2016 SSRM survey work. It compares the results of the 2016 survey to previous data sets in order to quantify and visualise any year-on-year changes. These year-on-year comparisons of survey data are used to help establish the deterioration of the wreck and, in this document, the 2016 survey results are compared with historical datasets from 2015 and 2014 in order to provide a longer view of the condition of the wreck and any changes that have taken place.

2.8 The data analysis covers the entirety of the wreck and in particular 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. These six areas (the Key Areas) are detailed below. 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 and identify any items of debris in the vicinity of the wreck, those that may have originated from the wreck and those that are unrelated (for example a smaller wreck, believed to be a Thames Barge, which is also inside of the survey area).

3. The Survey

3.1 Survey Requirements

3.1.1 For 2016, there were three main requirements of the SSRM survey. These were, a multibeam echo sounder (MBES) survey was to be undertaken of the wreck itself, an MBES survey was to be undertaken of the seabed around the wreck and out to a minimum distance of 400m from the wreck and a laser scanning survey was to be undertaken of the upstanding features of the wreck which are visible above the waterline.

3.1.2 As in previous years, the survey data (MBES and laser) was to be fully georeferenced and the results were to be analysed and compared to previous datasets in order to identify any areas of change or deterioration. Any changes or deterioration were to be quantified and particular attention paid to areas that have previously been identified as having higher levels of deterioration than are noted across the rest of the wreck.

3.1.3 The overall objectives of this survey work are to provide a clear understanding of the current condition of the wreck, its cargo (as far as is possible) and the seabed topography in the surrounding area in order to identify, visualise and quantify any changes to these. This survey report includes comparisons with previous survey findings.

3.1.4 To facilitate ease of comparisons with previous surveys, the format of reporting, the numbering of key areas around the wreck and general nomenclature remains consistent with previous surveys.

3.1.5 The scope of the work can be summarised as:

- Comprehensive MBES survey of the entire wreck
- MBES survey of the prohibited area and the seabed out to at least 400m distant from the wreck, including the edge of the dredged channel in the vicinity of the prohibited area
- Laser scan survey of the masts and other structures which are visible above the waterline
- Process the data and directly compare it to previous survey data in order to identify and highlight any areas of change or deterioration
- Produce a detailed survey report which includes details of any changes noted and comparisons with results from previous surveys

3.1.6 The survey area is located within the Thames Estuary in an area approximately 1.5 miles from the town of Sheerness on the North Kent coast. The survey site covers a section of Sheerness Middle Sand and parts of the Great Nore and Medway Approach Channel (see figure 1 below). The boundary of the survey site is defined as an area

extending a minimum of 400 metres from the centre of the wreck. This has been transformed into a square shaped area that allows for the practical running of survey lines.

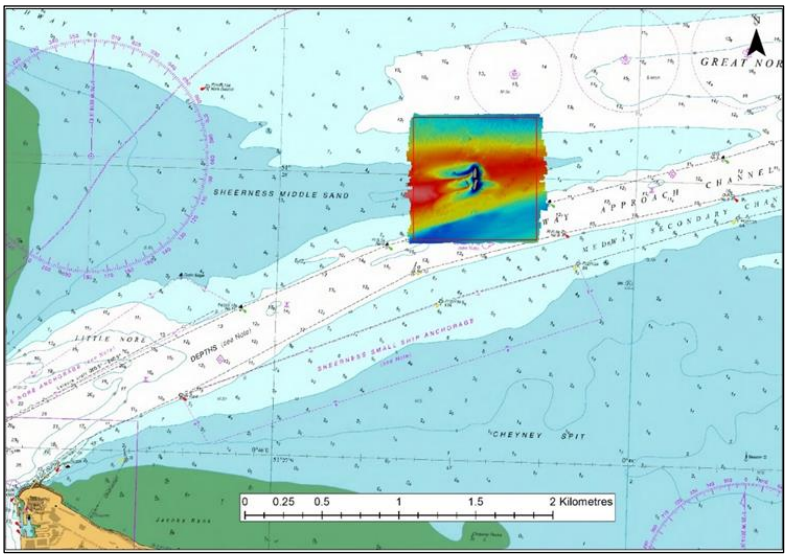


Fig. 1 The survey area identified on a chart

3.2 Survey Operations

3.2.1 Due to a number of factors, mainly a technical problem with one of the MBES units and the combination of coordinating suitable tides, weather conditions, daylight hours and availability of survey vessels and personnel, the 2016 SSRM survey work took place in two main phases. The MBES survey of the seabed surrounding the wreck and the laser scanning component of the survey took place on the 13th December 2016, with the over-wreck survey conducted on 16th February 2017.

3.2.2 All survey operations were carried out using the Port of London Authority (PLA) survey vessels Yantlet and Galloper. Both vessels have been used previously to survey the SSRM. The following tables provide a summary of the equipment utilised during the survey operations:

Table 1. Equipment Specifications – MV Yantlet	
Primary Horizontal & Vertical Positioning	Applanix POS MV 320
Secondary Horizontal & Vertical Positioning	C&C Technologies C-NAV 3050 DGPS
Primary Heading Sensor	Applanix POS MV 320
Acquisition / Processing	QPS QINSy Navigation Software
Multibeam echosounder (MBES)	Reson 8125, hull mounted
MBES Motion reference unit	V5 Applanix POS MV 320
Sound Velocity	Valeport Mini SV Profiler
Acquisition / Processing	Reson Seabat 7k software QINSy acquisition/processing software
Laser Scanning	Optech ILRIS Laser Scanner Applanix POS MV 320

Table 2. Equipment Specifications – MV Galloper	
Primary Horizontal & Vertical Positioning	Applanix POS MV 320
Secondary Horizontal & Vertical Positioning	C&C Technologies C-NAV 3050 DGPS
Primary Heading Sensor	Applanix POS MV 320
Acquisition / Processing	QPS QINSy Navigation Software
Multibeam echosounder (MBES)	Reson 7125, hull mounted (moonpool)
MBES Motion reference unit	Applanix POS MV 320
Sound Velocity	Valeport Mini SV Profiler
Acquisition / Processing	Reson Seabat 7k software QINSy acquisition/processing software

3.3 MBES and Laser Survey Methodology and Data Processing

3.3.1 All horizontal positions are provided as ETRS89 UTM 31N and the vertical survey datum used during processing, interpretation and reporting is Chart Datum.

3.3.2 The Applanix POS MV provided attitude (roll/pitch/heading/heave) and horizontal and vertical positioning on both vessels. A C&C Technologies C-Nav 3050 DGPS was used as the secondary horizontal and vertical positioning system. The differentially corrected position of the C-Nav 3050 antenna was provided to the Applanix POS MV. Applanix POS MV data was post-processed with RINEX-formatted OSNet Active Station data in POSPac Mobile Mapping Suite (MMS) 7.1. Post-processed positioning (horizontal and vertical) and attitude was applied to the bathymetric dataset. The manufacturer's quoted capable horizontal uncertainty for the Applanix POS MV system is better than ±0.05m, when post-processed in Applanix POSPac MMS software.

3.3.3 The Applanix POS MV system was used for primary vertical reduction on both vessels. The raw positioning data were processed using Applanix POSPac MMS 7.1 post-processing software. RINEX data for the Ordnance Survey (OS) Active Station with the closest proximity to the survey site was downloaded from the Ordnance Survey website for each survey day. Each POS MV data file was processed using precise and broadcast ephemeris data. The data was processed using the Applanix Single Base IN-Fusion GNSS module.

3.3.4 The processed navigation data were exported as Smoothed Best Estimate Trajectory (SBET) files, relative to ETRS89. The SBET files were imported into QPS QINSy, where they were combined with the UKHO CD (VORF) model to tidally reduce the dataset to Chart Datum. The data was then fully cleaned, eliminating spurious data. Once cleaned, the data was exported as Generic Sensor Format (GSF) files and imported into CARIS HIPS and SIPS 9.1 where the bathymetry data could be merged with the laser data and compared to previous datasets.

4. Survey Results – Hull Structure

4.1 The SSRM wreck survey was conducted on the 16th February 2017 from the PLA survey vessel Galloper. Multiple passes were run across the wreck in all practicable directions in order to ensure complete coverage. The Reson 7125 transducer was tilted at 39° for optimum data acquisition. The dataset is of good quality, allowing a thorough comparison with previous survey datasets. Throughout this report, all point cloud images have been generated in Cloud Compare. Surface difference plots were generated in QINSy and all historical profile comparisons have been made in Caris HIPS & SIPS.

4.2 The survey of the SSRM draws together both the multibeam and laser scan data to produce a combined dataset which has been used to analyse the structure of the wreck and the surrounding seabed in fine detail to build up a comprehensive understanding of the current state of the wreck.

4.3 Previous surveys have used 96 identification points across both the forward and aft sections of the wreck as markers to help identify and quantify changes and deterioration. These numbered points on the wreck have been used as part of the survey reporting for approximately ten years. Within these 96 ID areas, six Key Areas have been identified over successive surveys as areas of the wreck which have shown more accelerated deterioration than other parts of the wreck. For this reason, they receive particular attention.

4.4 The following summary of the survey results begins with the six Key Areas, then moves on to the other ID features which have shown some level of change since the last survey and then the features of the wreck which have shown no change.

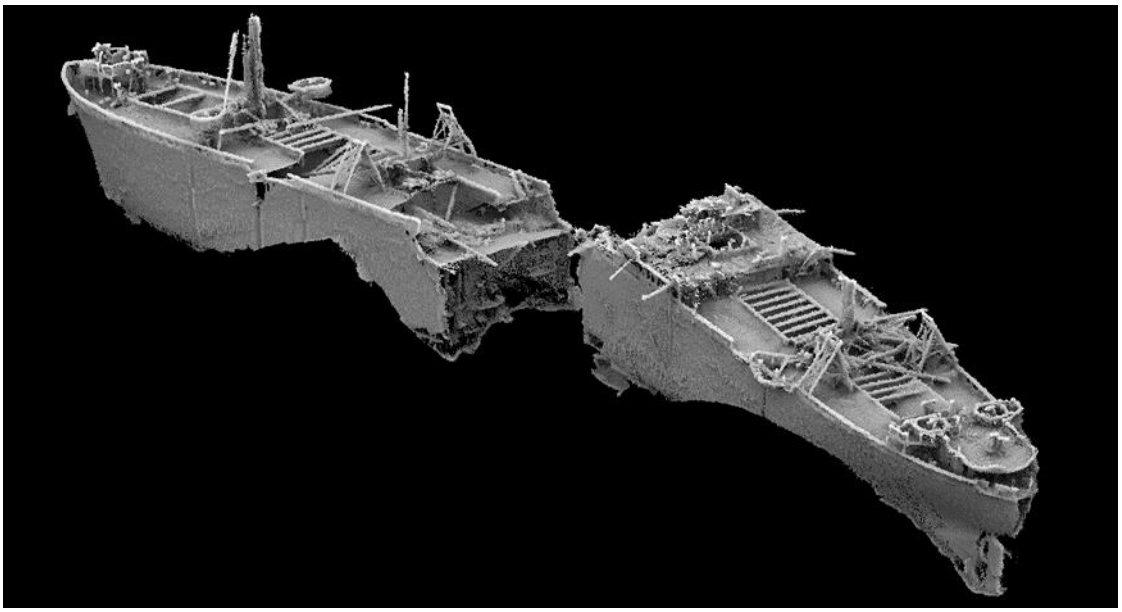


Fig. 2 Overview of the port side of the SSRM – 2016 data

4.5 Key Area 1 – crack in the hull on the port side of Hold 2 (ID04)

4.5.1 Key Area 1 (Feature ID04) is a crack in the hull located on the port side of the forward section of the wreck adjacent to hold 2. This crack has been known in the survey data since at least the 1970s and may have occurred at the time the vessel sank. Comparison with point cloud datasets from 2014 and 2015 suggests that changes have occurred in this location. The ship's gunnel, which originally bridged across the top of the crack, has fractured and slumped. The gunnel section now appears to be attached only to the section aft of the crack and hangs over the side below deck level. There is also evidence of an increase in the size of the crack in both the horizontal and vertical directions by up to 0.5m.

4.5.2 Comparisons of the datasets also suggests that there has been an increase in the size of the small holes on the aft side of the crack, measuring 0.1 to 0.2m across (these holes were considered to be part of the crack feature in the 2015 survey). The deck plating above has also cracked close to where the hull crack meets the deck level. The crack also appears to be spreading down below the broken gunnel as there is a strip devoid of soundings. However, the area that is devoid of soundings may be due to acoustic shadowing caused by an outward protruding flap of hull.

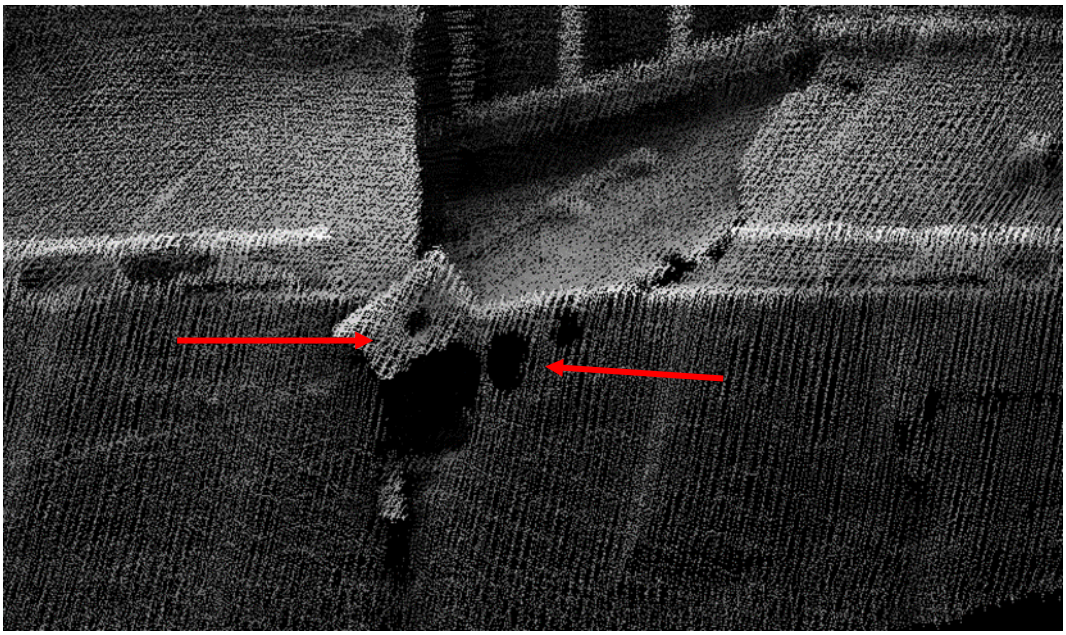


Fig. 3 Broken gunnel and holes in hull, port side, Hold 2

Table 3. Dimensions of crack in hull (ID04)

Dataset	Height (m)	Width (m)
2014	3.3	2.2
2015	3.4	2.1
2016	3.9	2.4

4.6 Key Area 2 – collapsed deck plating on the port side of Hold 2 (ID08)

4.6.1 The collapsed deck plating on the port side of hold 2 consists of an area of deck that has shown gradual subsidence over a long period of time. The results of the 2016 survey also indicate that further subsidence has taken place.

4.6.2 Comparison of the 2015 data against the 2016 data shows that further changes have occurred in this area. A new fracture is present on the aft side of the previously collapsed hold decking. Surface difference analysis confirms that the deck has collapsed further on the forward end by 0.35m, whilst the aft end has risen by 0.30m where the fracture is located. The forward end of the collapsed deck appears to be resting on the material within the hold.

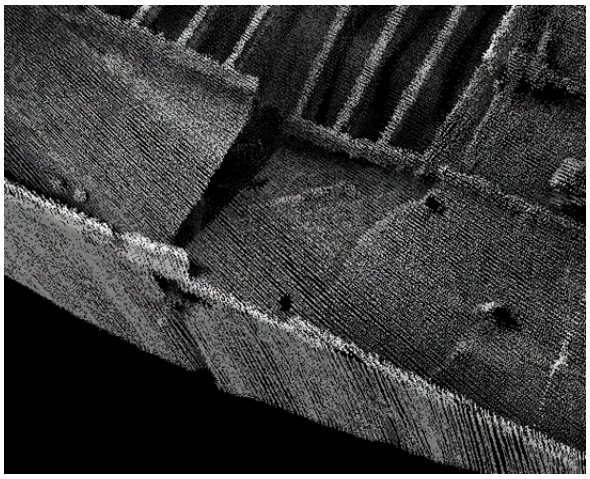


Fig. 4 2015 data showing the collapsed deck plating at Hold 2.

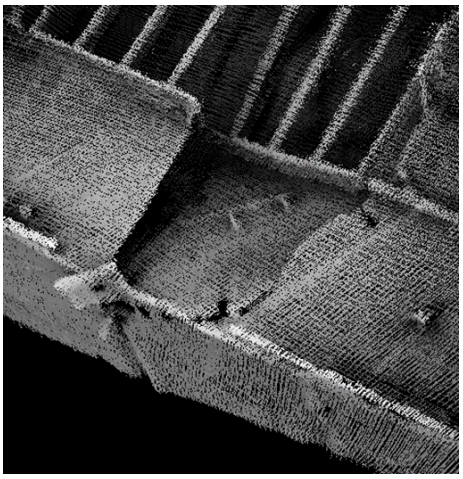


Fig. 5 2016 data showing the collapsed deck plating at Hold 2

Table 4. Comparison of Collapsed Deck Depths

Dataset	Depth	Magnitude of Collapse (m) from original deck level*	Collapse since last survey (m)
2014	5.8	1.7	
2015	6.0	1.9	0.2
2016	6.35	2.25	0.35

4.7 Key Area 3 – Aperture and hold contents, bulkhead aft of Hold 3 (ID96 & 94)

4.7.1 At the aft end of the forward section, the bulkhead between Hold 3 and the engine room is still in place and is providing containment for the contents of Hold 3. Although the bulkhead remains intact, apertures can be seen in successive survey data, in particular, an aperture on the port side. This aperture is clearly visible in the 2016 dataset. A CARIS profile shows very good correlation between the data sets. The dimensions of the aperture have remained consistent across the datasets from the previous three years, no changes have been noted.

4.7.2 Whilst the hold cargo can be seen through the aperture, the exact oblique sonar angle required for good internal ensonification was not achieved. This may be because of the state of tide or beam sector angle during that pass. The shoalest depth recorded of the internal cargo was 8m below CD compared to 7.04m in 2015. It is not possible to ascertain whether this represents a decrease in the amount of cargo visible or whether the area was not fully ensonified. No change was noted in the debris field at the foot of Hold 3, which suggests that this change is related to data collection rather than an actual change in the wreck.

4.7.3 For future surveys, it is recommended that flex mode on the Reson 7125 should be used. This compresses all the beams into a very narrow sector and, by varying the distance from the hold 3 aperture to the sonar head, this should allow for better angles of acoustic signal propagation.

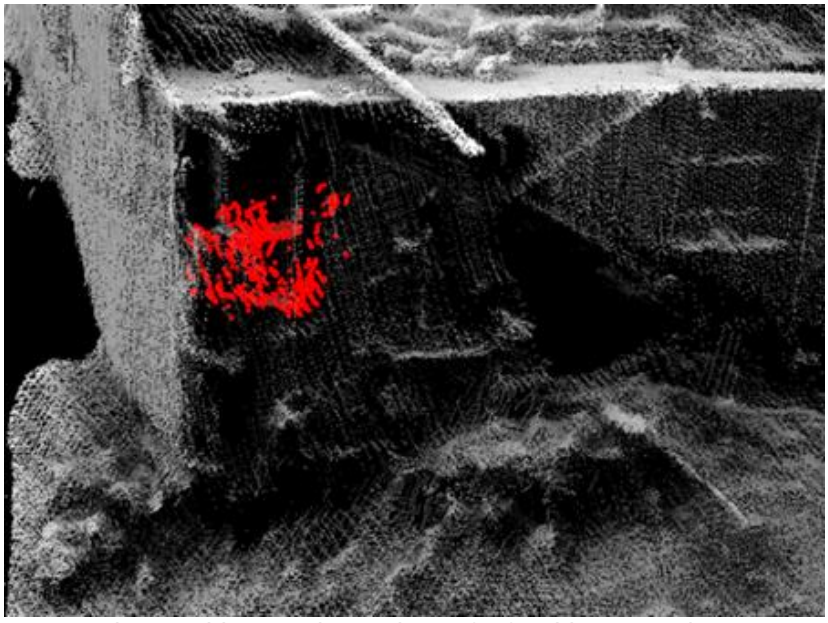


Fig. 6 Hold cargo data points, aft of Hold 3, 2016 data

4.8 Key Area 4 – Split in hull, starboard side, aft section (ID22)

4.8.1 The split in the hull is located on the starboard side of the aft section of the wreck, adjacent to the mizzen mast. An initial visual inspection of the point cloud data shows little change in the split in the hull over the last three years of survey, although the feature is difficult to visualise due to the slightly differing beam pattern affecting the visual characteristics. Using a surface difference plot and CARIS profiles, it is clear that no significant change has occurred. The split in the hull appears to be the same with data points inside the hull visible in the survey data.

4.8.2 Cross profiles show part of the hull plate protruding at lower depth, which has remained the same throughout the last three surveys. A slightly better match between the 2016 and 2014 data rather than the 2016 and 2015 data is identified as a positional discrepancy in the dataset. Surface difference analysis shows a slightly raised deck level in the 2016 data when compared to the 2015 survey. This difference has been attributed to varying densities of data over the complex deck structures. The 2016 point-cloud data

indicates that there is a gap below the protruding hull plate. This is believed to be acoustic blanking caused by the protruding plate.

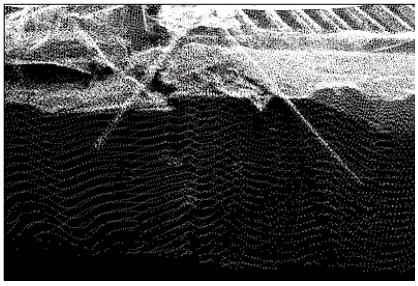


Fig. 7 Key Area 4 2014

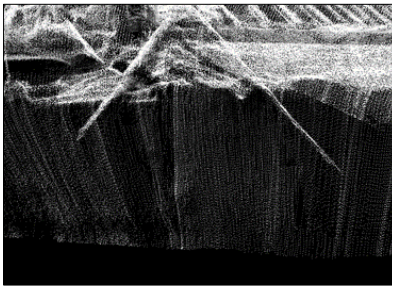


Fig. 8 Key Area 4 2015

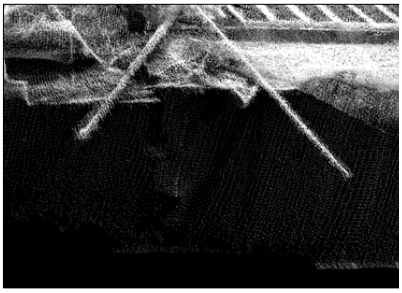


Fig. 9 Key Area 4 2016

4.9 Key Area 5 – Split in deck and hull, aft section (ID24 & 25)

4.9.1 Area 5 is a split in deck and hull on the port side of the aft section of the wreck. It is associated with the split on the starboard side at the same area (Key Area 4). This split appears to have remained stable throughout the past three years of survey. Cross profiles along the deck show that the collapsed deck plate is in the same position with good positional correlation between the three surveys. Cross profiles through the hull show the assumed sediment within the hold, which has been ensonified through the crack in the deck above. This material has not been highlighted in previous surveys, but the sediment appears be in a similar position to preceding surveys, arranged in an even manner with several peaks.

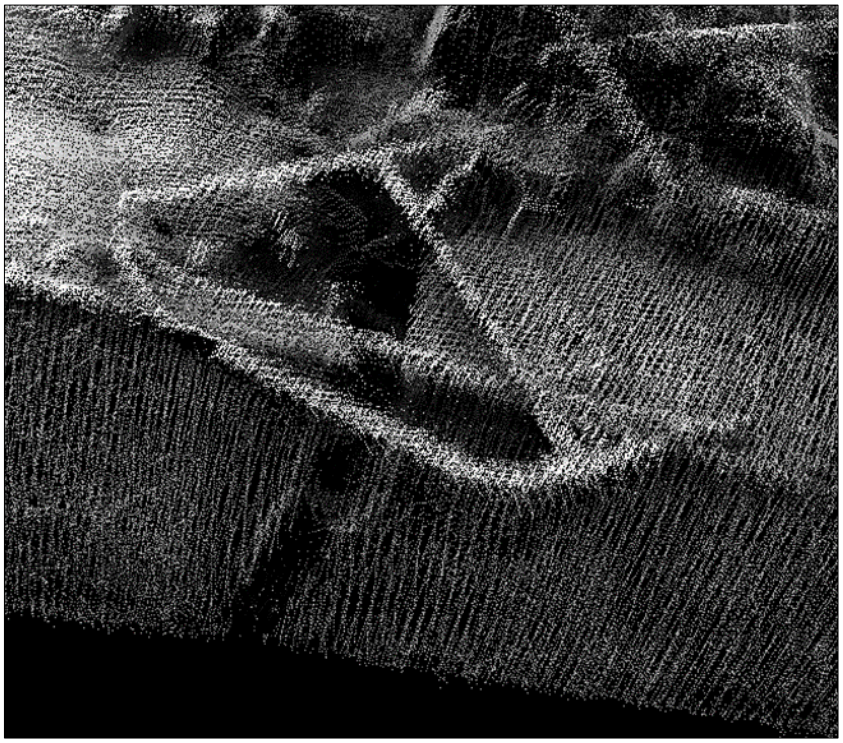


Fig. 10 Key Area 5 showing no change

4.10 Key Area 6 – Collapsing bridge deck area (ID43, 45 & 46)

4.10.1 Key Area 6 encompasses the collapsing bridge deck/superstructure at the forward end of the aft section. This superstructure overhangs the main hull structure of the aft section of the wreck and was unsupported. This area of the wreck showed significant degradation in the previous surveys between 2014 and 2015. The 2016 survey data indicates that, whilst there has been some change, it is not of the same magnitude seen in the previous survey results. There is only one area of change, on the aft section starboard side upper deck level. Changes of less than 1m are noted to some of the previously protruding deck plates.

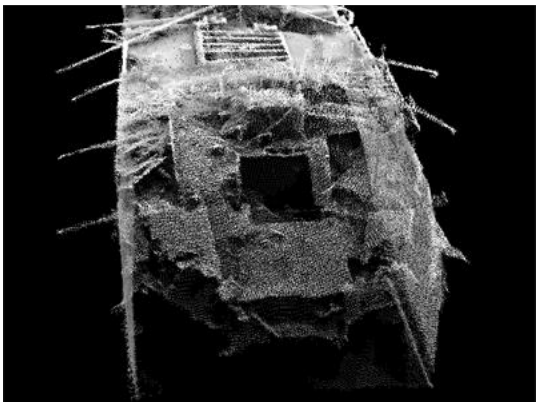


Fig. 11 Area 6, bridge deck, 2014

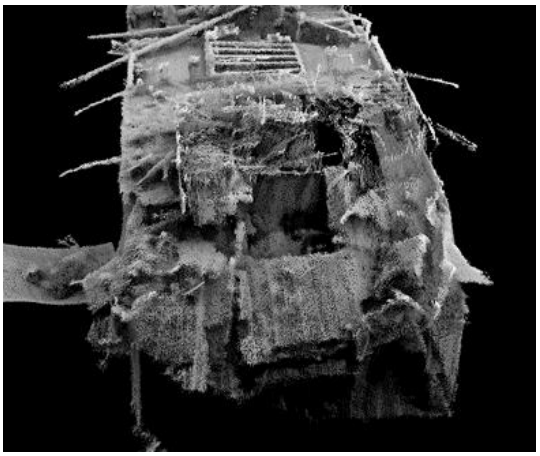


Fig. 12 Area 6, bridge deck, 2015

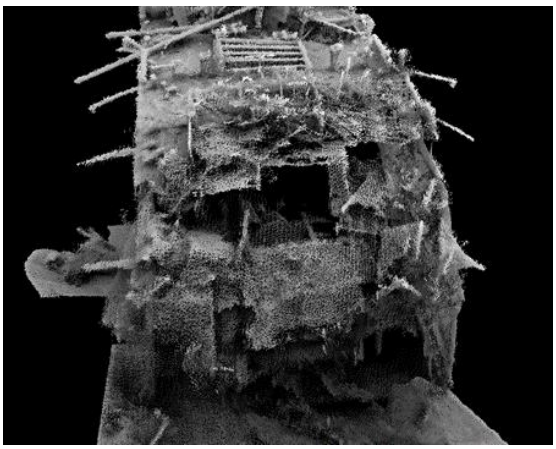


Fig. 13 Area 6, bridge deck, 2016

4.11 Other ID features showing change in the 2016 survey data

4.11.1 Aside from the Key Areas listed above, of the 96 ID features across the wreck, 17 others showed some level of change since the 2015 survey.

4.11.2 ID07 – Break in Gunnel. The break in the gunnel is located adjacent to Hold 2 on the port side of the forward section. This section of the gunnel has now almost broken off completely. This feature is closely linked to the collapsing deck plate at hold 2 (ID08) which has also shown movement (see above). The collapsing deck plate is thought to have caused the gunnel to break away and it is now only attached by the aft section, slumping over the side of the vessel.

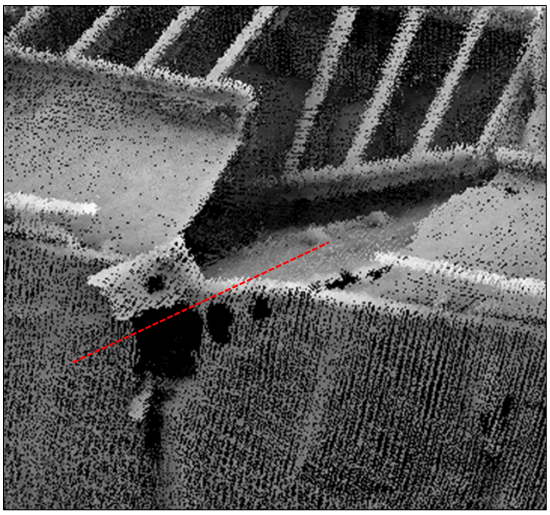


Fig. 14 break in gunnel at Hold 2

4.11.3 ID13 – Holes in Deck Plating – The holes in the deck plating are located adjacent to hold 2 on the forward section of the wreck. The holes were seen in the 2016 survey, with change noted to the larger of the holes. The deck has fractured at the site of the previous holes and the entire deck plating has moved. This progression has occurred gradually, as seen throughout the yearly surveys and these holes have served as good indicators of the ongoing degradation of this area.

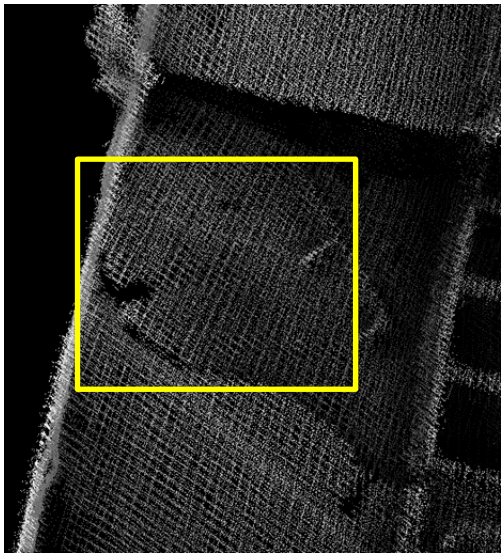


Fig. 15 Holes in deck plating at Hold 2

4.11.4 ID15 – Collapse of Deck and Hatch Coaming - The deck hatch and coaming features are located on the aft end of the forward section of the SSRM and form part of the hatch opening of Hold 3 which was damaged at the time of the sinking as the ship broke in two. The deck and hatch coaming has remained in the same condition since the 2015 survey. Surface difference shows little or no change along the main deck area, with a slight rise of 0.15m in level towards the hatch coaming. This change is attributed to a denser dataset in 2016 which has delineated the hatch coaming with more definition.

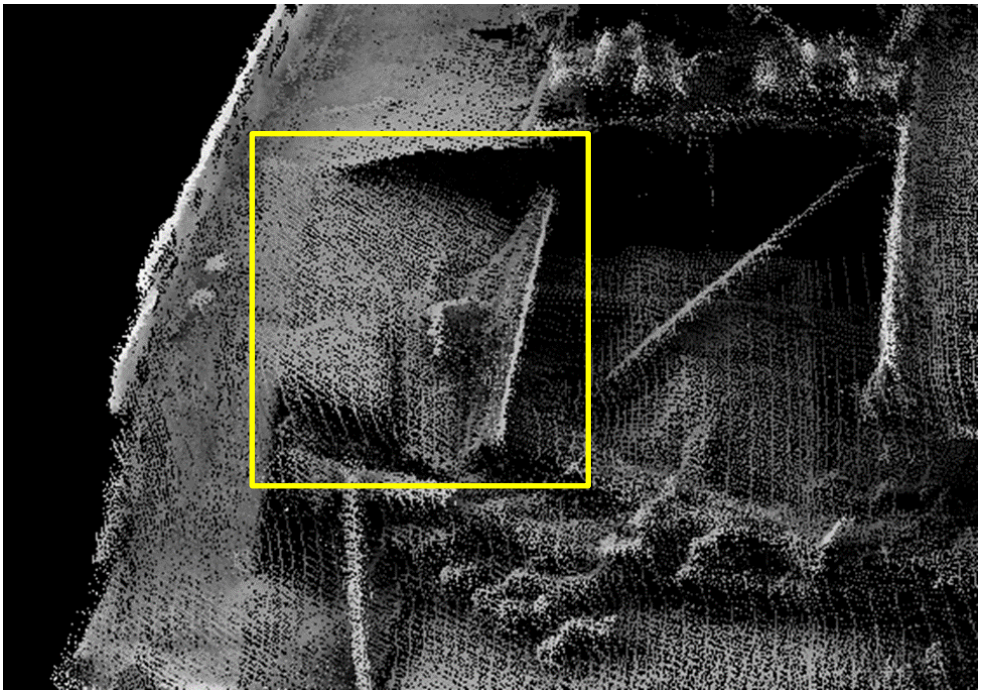


Fig. 16 Hold 3

4.11.5 ID17, 18 & 20 – Holes in Hull Plating and Vertical Discontinuity - This area of change is located on the starboard side of the forward section of the wreck adjacent to Hold 2 and consists of a discontinuity or buckling of the hull with 2 holes in the deck plating which have been identified in previous surveys. It is difficult to quantify an exact measurement due to some acoustic blanking, but it appears that more data is visible inside the hull which would indicate that the hole has increased in size. The discontinuity of the hull at location ID18 has been compared with previous datasets and the deflection remains of a similar magnitude. Cross profiles in CARIS show a tight alignment between the datasets which indicates that the area has remained stable. Due to the complex nature of the discontinuity, this area will induce acoustic blanking which makes definitive measurements difficult and is dependent on sonar head position during the survey pass.

4.11.6 ID23 – Split in Deck Plating – This split in the deck plating is located on the starboard side of the mizzen mast house on the stern section of the wreck. It consists of a split in the deck plating with the vessel superstructure strewn on top. Cross profile analysis within CARIS shows good correlation between the 2014, 2015 and 2016 surveys with no apparent further separation of the deck plates.

4.11.7 ID28 – Collapsing Boat Deck – This is part of the same overall structure as Key Area 6 and is a complex area of collapsing superstructure at the forward end of the aft

section of the wreck. Since around 2014, this has been a dynamic region in terms of subsidence and degradation. However, a difference plot over the collapsing port boat deck shows that this area has remained relatively stable between 2015 and 2016 with only minor point source changes in height to the finer superstructure, possibly due to varying densities of data on vertical structures. A longitudinal profile through the area shows little or no change when compared to the 2015 survey, although some change can be seen when compared to the 2014 survey.

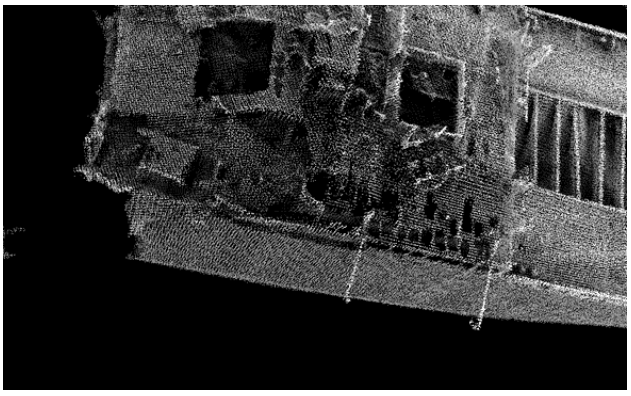


Fig. 17 Superstructure, aft section of the wreck, 2014 data

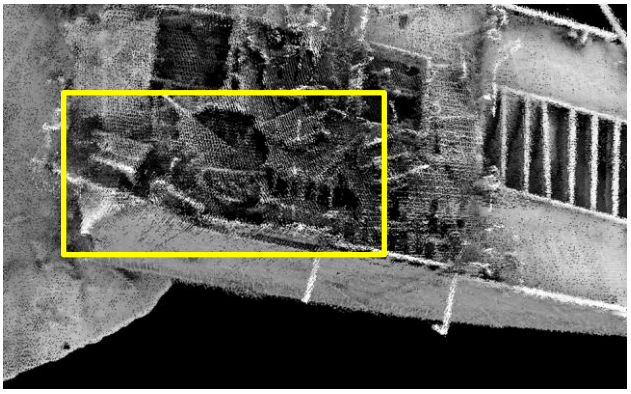


Fig. 18 Superstructure, aft section of the wreck, 2016 data

4.11.8 ID29 – Boat Deck Missing Above Walkway – This ID feature is on the starboard side of the collapsing superstructure, on the aft section of the wreck and, along with ID28 above, it is located in a dynamic region of the wreck in terms of subsidence and degradation. The boat deck was last listed as present in the 2012 survey and between the 2014 and 2015 surveys the area subsided and dropped towards the seabed. In the 2016 survey data, there is evidence of further subsidence. The magnitude of this subsidence is smaller than was previously seen, with changes of approximately 1m noted. These changes are predominantly to the sheets of overhanging deck plating which are gradually collapsing towards the seabed.

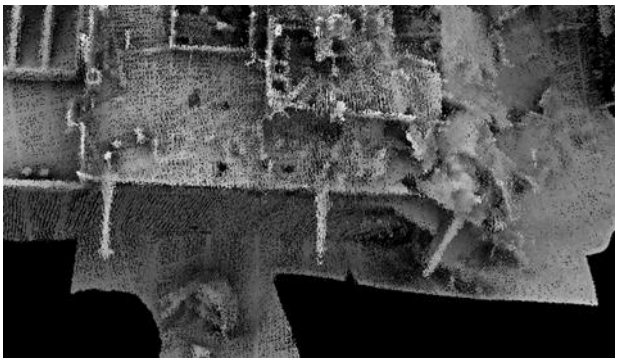


Fig. 19 ID29, missing section of boat deck, 2016 data

4.11.9 ID30 & 31 – Lower Hold Cover, Hold 2 – These ID features relate to holes in, and the collapse of the lower hold cover at Hold 2. The lower hold cover was noted in survey data prior to 2010 but, since then, yearly sediment build-up has obscured this hatch. Due to the large aperture in the upper hold, MBES data is obtainable through the hatch which allows a comparison of sediment build up between surveys. Between the 2015 and 2016 surveys there has been a general accumulation of sediments with up to 0.35m deposited within the hatch with a higher ridge of sediment orientated through the centre of the hatch to the northeast.

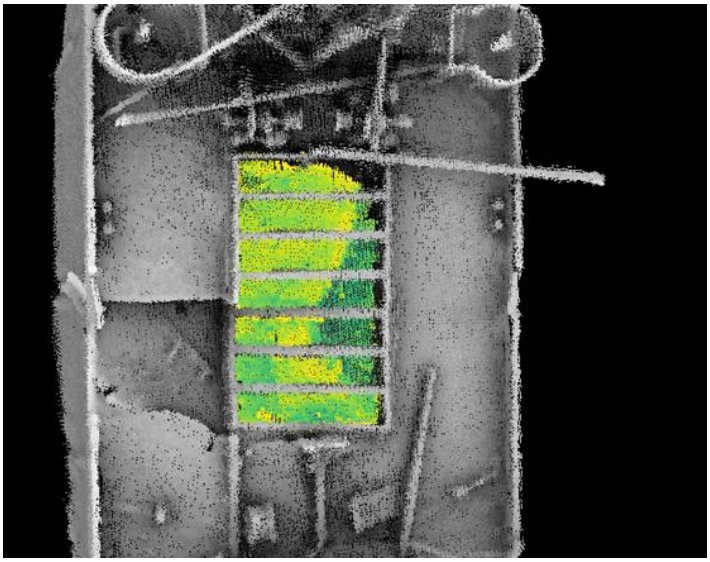


Fig. 20 Sediment accretion in Hold 2

4.11.10 ID32 & 33 – Lower Hold Covers, Holds 3 & 4 – The smooth internal surfaces over the lower hold hatch at Hold 3 show year-on-year changes which suggest a dynamic sediment regime. Accretion and deposition of up to 0.5m have been seen from surface differencing within the hatch. A hole in the deck plate was identified in the 2016 survey data which had not been noted in previous surveys. This measures approximately 0.8m by 0.5m. ID33 at Hold 4 also shows a build-up of sediment since the 2015 survey. This build-up is in the order of approximately 0.35m and, similar to Hold 3, this year-on-year change suggests a dynamic sediment regime.

4.11.11 ID79 – Lifeboat Davit – This lifeboat davit is situated in the highly dynamic region of the starboard forward side of the aft section. A sheet of decking that was resting on the davit has now broken off and the davit arm has changed orientation and is now pointing further aft.

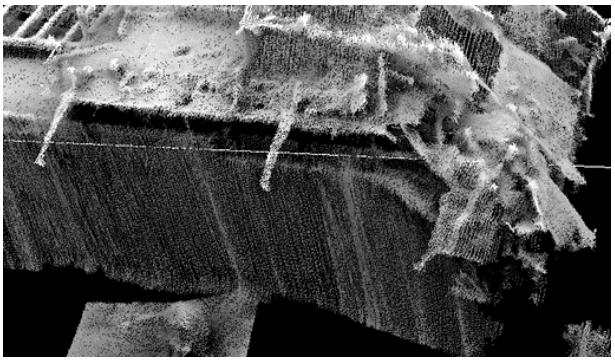


Fig. 21 ID79 covered by deck plating in 2015

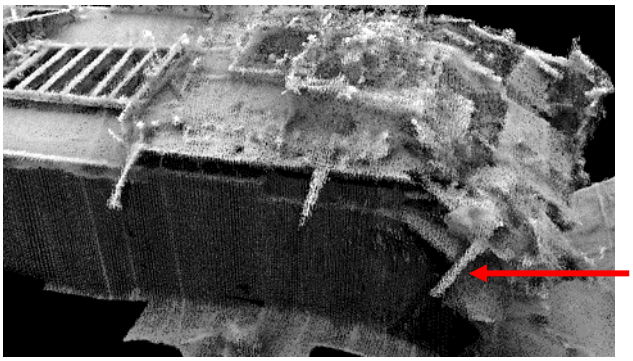


Fig. 22 ID79 uncovered in 2016

4.11.12 ID11 – Hole in Hull Plating – This hole in the hull plating is situated adjacent to hold 2 on the forward section of the wreck. In analysing three years of point cloud data it is evident that a change has occurred in this area and now a larger hole exists in this buckled section of the hull. Although difficult to measure precisely due to the point cloud data distribution, it appears to have opened by 0.2-0.3m. This section is in close proximity to the aft of hold 2, which has also experienced hull buckling and associated holes.

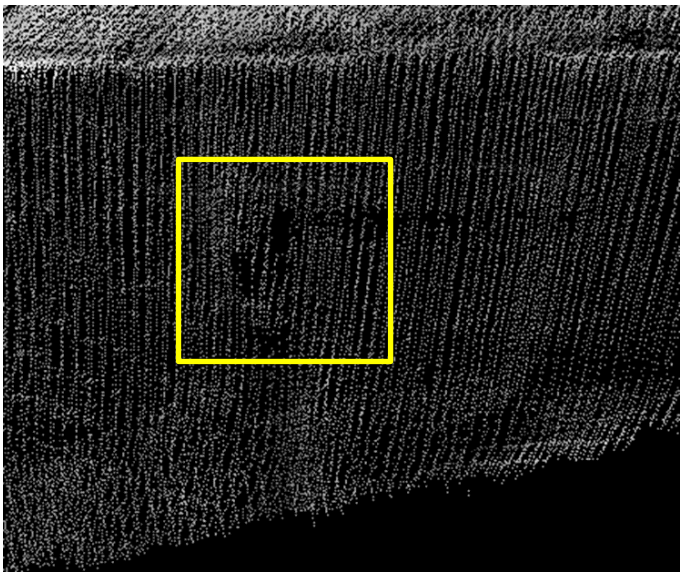


Fig. 23 Holes in hull plating, Hold 2

4.11.13 ID49 – Gunnery Officer's Cabin – The gunnery officer's cabin is located on the aft section of the wreck along the centreline towards the forward end. It consists of an open box type structure, which has undergone considerable degradation. Comparison of the datasets is difficult due to the varying amounts of data acquired each year, with data gaps present in all datasets. A direct comparison was achieved at the forward end of the gunnery cabin, with data from all three surveys present. The CARIS profile shows that, since the 2015 survey, the height of the cabin structure has decreased by up to 1.5m.

Fig. 24 Looking down on the area of the gunnery officer's cabin

4.12 ID features showing no change

4.12.1 Across much of the wreck, no specific changes were noted between the 2015 and 2016 survey results. The table below outlines those remaining ID features where no change has been noted.

Table 5. ID Features Showing No Change		
Feature ID	Feature	Location
ID01 ID02 ID03	Separation of the hull in two sections Forward section Aft Section	Wreck site
ID09 ID10	Severe buckling of hull plating Buckling of hull Plating	Port side hold 2
ID12	Buckling of hull plating	Port side hold 2
ID14	Holes in deck plating	Port side hold 1
ID16	Horizontal crease in hull plating	Stbd side hold 2
ID19	Severely horizontal buckling of Hull	Stbd side hold 2
ID21	Bends in deck plating	Stbd side hold 2
ID27	Holes in boat deck	Port side aft section
ID35 ID36	Indications of tween deck cargo	Port side, hold 2
ID37	Indications of tween deck cargo	Hold 3
ID38	Hold 1 catch supports	Hold 1
ID39	Hold 2 catch supports	Hold 2
ID40	Hold 3 catch supports	Hold 3
ID41	Hold 4 catch supports	Hold 4
ID42	Hold 5 catch supports	Hold 5
ID47 ID48	Engine room skylight & casing	Central superstructure
ID50	Forward gun & gun tub	Bow
ID51	Stern gun & gun tub	Stern superstructure
ID52 ID53	20mm gun Tubs	Adjacent to fore mast
ID54 ID55	20mm gun tubs- stern superstructure	Stern superstructure
ID56	20mm gun tubs – laying on seabed	Starboard side aft section
ID57	20mm gun tubs- upturned on boat deck	Central superstructure
ID59	Port anchor	Port side, bow
ID60	Foremast and mast house	Forward section
ID61 ID62 ID63	Foremast cargo and handling booms	Forward section
ID64 ID65 ID66	Main mast and mast house	Forward Section
ID67 ID68 ID69 ID70	Mizzen mast & mast house	Aft section

Table 5. ID Features Showing No Change		
Feature ID	Feature	Location
ID71	Bilge keel	Port side, forward and aft sections
ID72	Life raft racks	Adjacent to main mast
ID74		
ID75		Adjacent to hold 5
ID76	Anti-torpedo net cage	Port side, mizzen mast
ID77	Propeller and rudder	Stern
ID78	Forefoot	Bow
ID95	Bow section	
ID80	Lifeboat davits	Starboard side, aft section
ID81		
ID82	Lifeboat davits	Portside aft section
ID83		
ID85	Debris on seabed	Gap between forward and aft
ID86		
ID92	Port and starboard lighting towers	Central superstructure
ID93		

4.13 Indications of Cargo

4.13.1 Although the regular monitoring surveys are focussed on the condition of the hull rather than the cargo contained within, there are some areas on the wreck where the cargo can visualised in the multibeam data. In particular, these include the various cracks and holes in the hull structure, the debris between the two sections of the wreck and the remains of the ‘tween deck area at Hold 3.

4.13.2 Holes in the deck plating at Hold 1 have facilitated the acquisition of MBES data points from the ‘tween deck below. The surface here appears to be undulating, which suggests that there is sediment build-up over the cargo. Similarly, MBES data was acquired through the crack in the hull at Hold 2. The data points show good agreement with previous surveys, suggesting that no changes have occurred. In the debris pile at the foot of Hold 3 and the remains of the Hold 3 ‘tween deck area, no changes were noted in the cargo that is visible in the multibeam data.

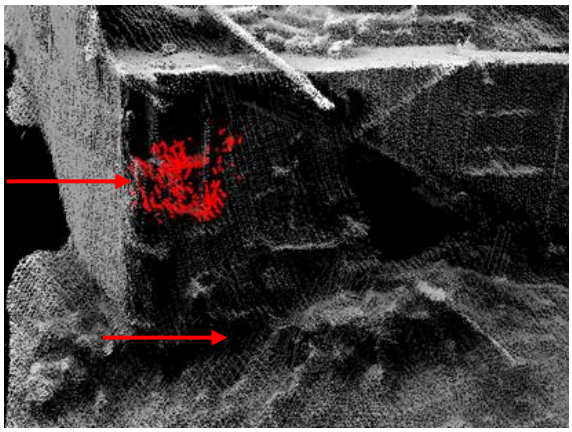


Fig. 25 Bulkhead at Hold 3 showing data inside of the hold and debris pile

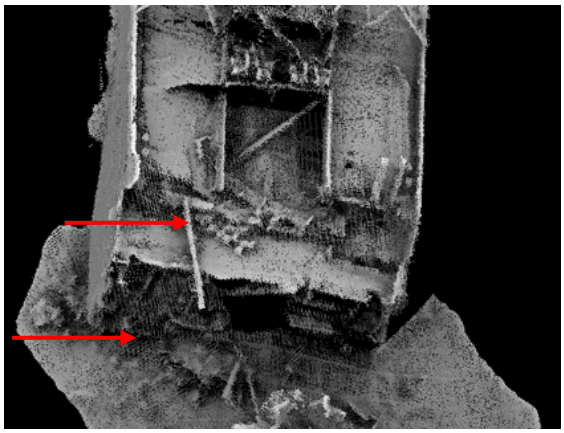


Fig. 26 Aft end of bow section showing the remains of Hold 3 ‘tween deck and debris

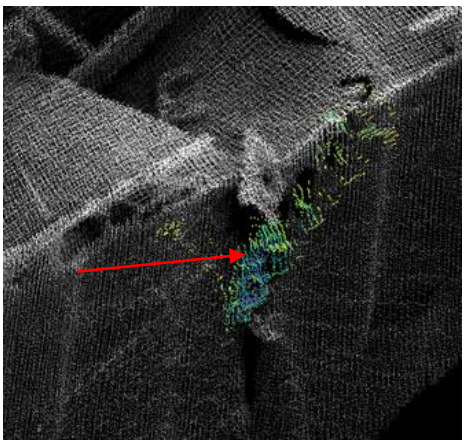


Fig. 27 MBES data inside of Hold 2

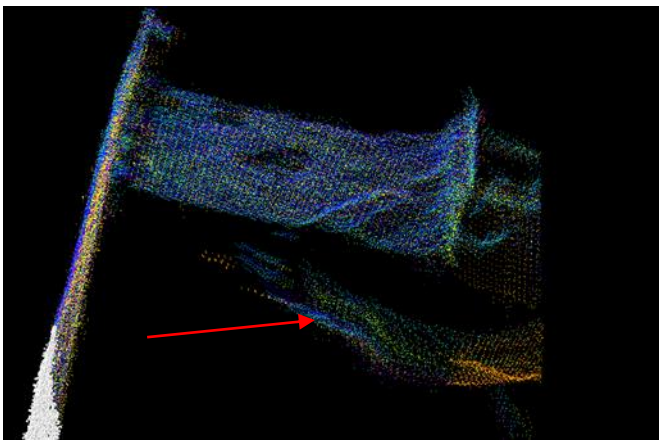


Fig. 28 Showing data inside the hull

4.14 Laser Scanning

4.14.1 Laser scanning is used to survey those parts of the wreck which are visible above the waterline. This includes all three masts and other upstanding features. Laser scan lines were acquired by the MV Yantlet. Multiple lines were run in various directions within the vicinity of the wreck to achieve full coverage and data density around the masts.

4.14.2 Full coverage was achieved in the foremast area with overlap between the MBES and laser surveys. The foremast has remained in the same condition since the previous survey. Good agreement between the laser and MBES survey can be seen in the overlap

4.14.3 The main mast and cargo handling boom was well covered although slightly less coverage was achieved than in 2015 due to low spring tides coinciding with fading light. The data indications that the condition of the masts has not changed noticeably since 2015.

4.14.4 Data coverage of the mizzen mast was good in the 2016 survey although with small gap between the MBES and laser data. As with the fore and main masts, the mizzen mast has remained stable with no noticeable deterioration.

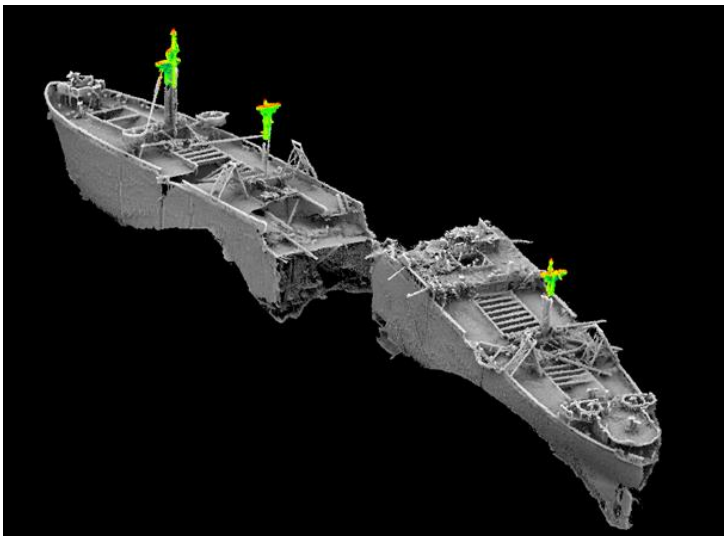


Fig. 29 Multibeam (grey) and laser data (green) combined

4.15 Orientation of the Wreck

4.15.1 Profiles along and across the hull were reviewed in CARIS to monitor for any wreck movements or listing which may have occurred since the previous surveys. The profiles show that the SSRM has remained stable in all planes of attitude and position and any minor changes are within the achievable survey accuracies or attributed to small-scale feature change only.

5. Seabed Survey

5.1 Seabed Survey

5.1.1 The survey of the seabed surrounding the wreck was carried out on 14th December 2016 by the survey vessel Yantlet. Full coverage was achieved within the area, although post-processing of the data highlighted five lines that required density infill. These lines we re-run when the survey vessel Galloper returned to site to complete the survey work. The data collected is of high quality and adheres to IHO special order as per the survey requirement.

5.1.2 There are known to be a number of other objects within the survey area, these include at least one other wreck and various chains and sinkers related to the marking of the SSRM. The survey required that all previously identified seabed targets be relocated and assessed for any change, and any new targets surveyed and reported on.

5.1.3 Across the site, water depths vary between 20.6m below LAT in the scour pit surrounding the wreck of the SSRM (off the starboard- bow quarter), and 2.2m below LAT on the top of the sandbank at the very west of the survey area. The scour pit is present on both sides of the wreck, though it extends further to the west, up to 330m from the structure. The edge of the dredged channel is clearly visible in the south of the survey area. Depths in this area are in the region of 16m CD.

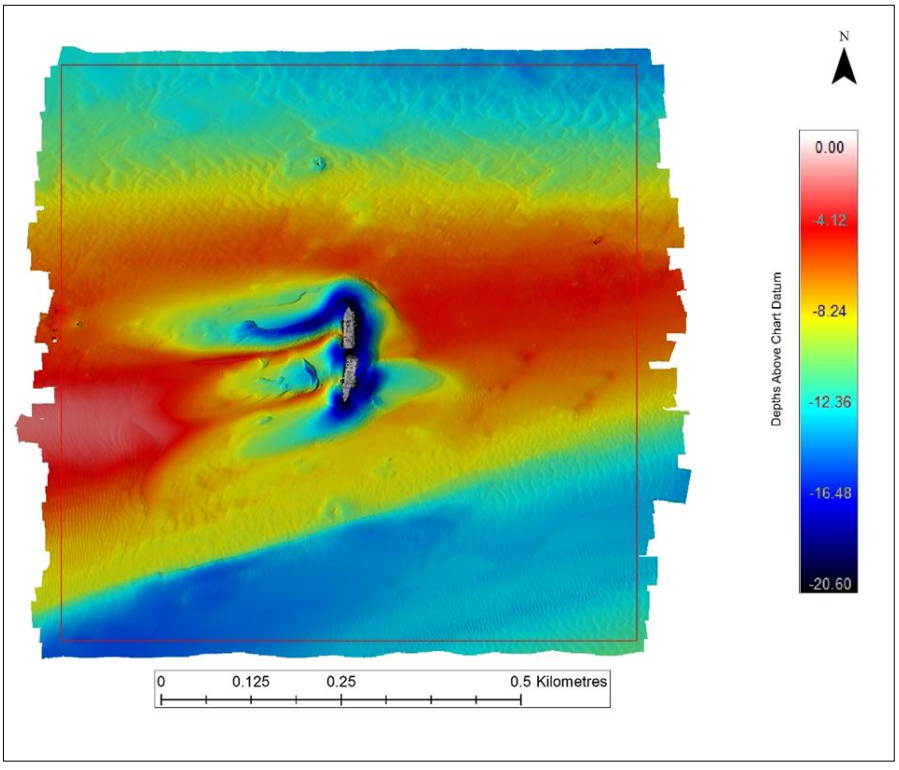


Fig. 30 Bathymetry from the survey area, 2016

5.1.4 In order to assess the seabed topography, a 1metre surface difference grid was generated in QINSy software. Examination of the surface difference plot between the 2015 and 2016 surveys shows that, for the most part, the site has remained stable. Around the wreck area scouring has occurred to the east and northeast of the wreck by

up to 0.65m. Deposition has occurred at the bow and port side of the wreck and at the port forward side of the aft wreck section. This has caused a seabed shoaling of up to 0.65m.

5.1.5 Scouring has occurred at the port side of the aft end of the forward wreck section by up to 0.9m. Towards the stern of the wreck on the port side further scouring of up to 0.8m is noted. An area of deposition is located between these two scouring areas on the port side, with deposition of up to 0.65m.

5.1.6 Scouring has also occurred in an area approximately 200m southwest of the wreck site, with up to 1.5m eroded from an area of larger sand waves. Small changes in the order of 0.2m to 0.3m have also occurred in the Medway approach channel, with a general migration of sand waves seen in the southeast of the site.

5.1.7 The image below highlights the prominent scouring around the SSRM area. The scour extends out from all sides of the wreck but is more prominent in an east to west direction extending out up to 200m from the wreck structure. The difference plots show that the prominent scour has increased further to the northeast of the forward section of the wreck where up to 0.7m difference is experienced.

5.1.8 Comparison of the contours from the 2015 and 2016 surveys shows that the general contour trend has remained consistent with no new major erosional or depositional regimes occurring.

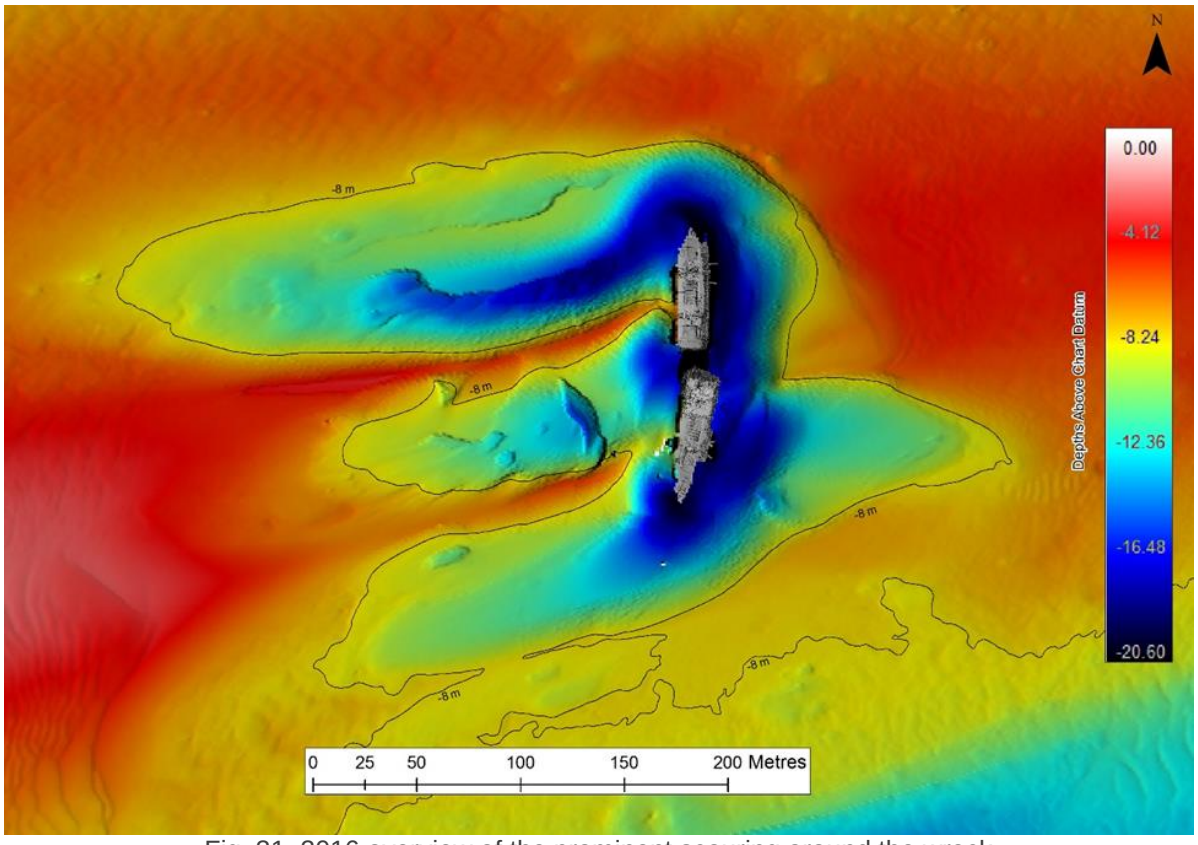


Fig. 31 2016 overview of the prominent scouring around the wreck

5.2 Seabed Contacts

5.2.1 As outlined above, within the wider survey area a variety of other objects are known on the seabed. These are located and assessed in each survey. The seabed contact list from 2015, with a total of 59 contacts, was compared against the 2016 bathymetry and backscatter datasets. This careful analysis has added a further 7 targets to the contact list, while 3 items from the 2015 contact list are not apparent on the 2016 data. The image below shows the location of each of these objects.

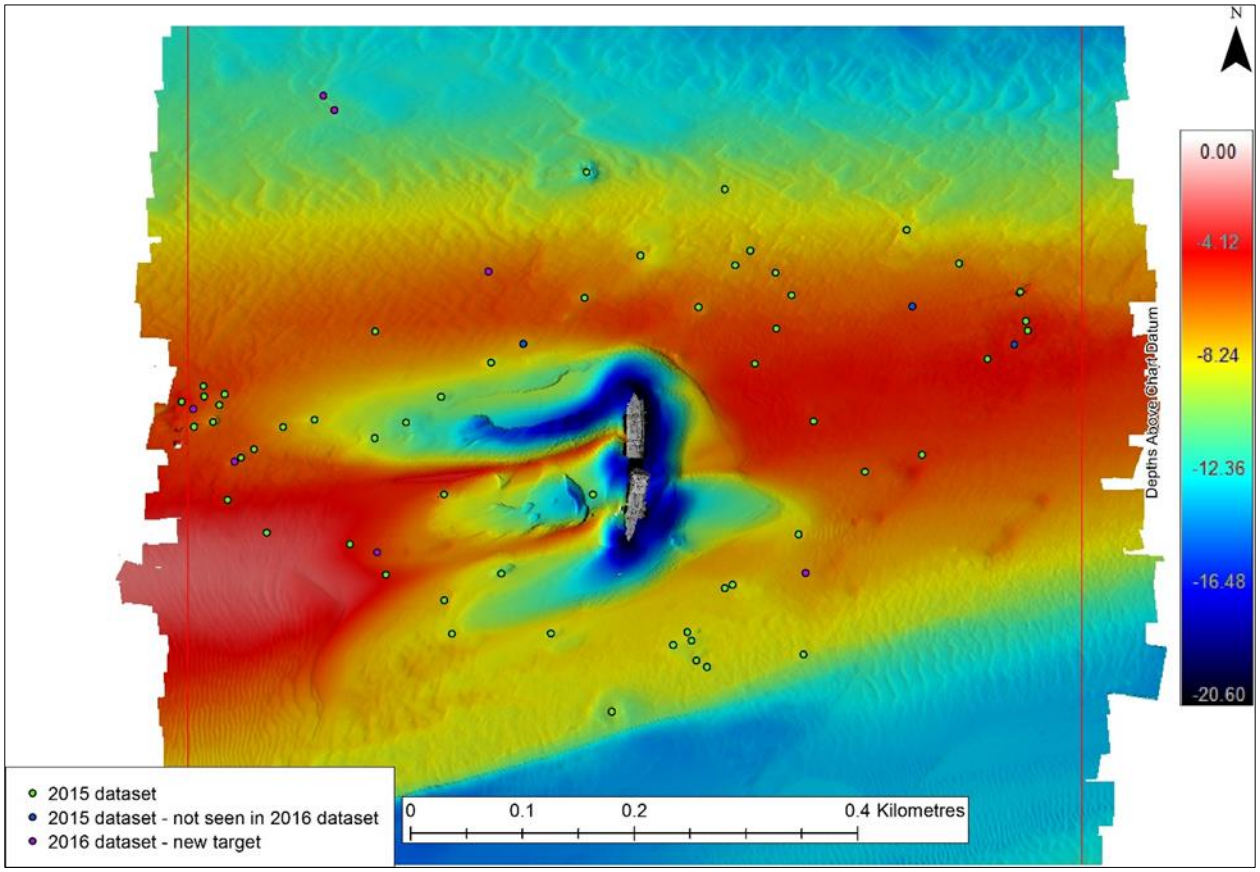


Fig. 32 Seabed contacts, 2016

6. Conclusion

6.1 The results of the 2016 SSRM survey have been assessed by a thorough comparison of point cloud and sliced historical HDCS CARIS data. This has been compared in a systematic way, providing the most successful way of measuring the degradation of the wreck.

6.2 To provide consistency in reporting the current state of wreck, nomenclature and vessel structural ID features and Key Areas have remained the same so that a true comparison could be made.

6.3 The datasets from 2014-2015 and 2016 were compared in order to provide a good indication of the current condition of the wreck and the evolution of the degradation.

6.4 In terms of density and quality, the 2016 data is a slightly more dense point cloud dataset than the previous survey, which has enabled some features to be delineated with greater clarity than before.

6.5 As with the previous methodologies for the processing and visualisation of the wreck, the data has been displayed in Cloud compare for all 3D point cloud images. Cloud compare contains specialised shading tools which facilitate the visualisation of extremely high-quality cloud images. Any comparative measurements have been made in CARIS Hips and SIPS where the data sets can be sliced and spatially compared with greater accuracy.

6.6 The key finding in the analysis of the 2016 data set was the continued fracturing of the deck plate at Key Area 2. The deck plating has continued to collapse (by 0.35m), the deck plate has fractured and some holes noted in the hull plating adjacent to this feature have increased in size by 0.2m. The gunnel has broken off and now slumps over the side below deck level.

6.7 The crack in the hull at Key Area 1 is closely linked with the collapse of the hold 2 deck plating. This has also shown some changes to the size of the holes (0.2m) and the spreading of these holes toward the fractured deck plate.

6.8 The 2015 survey showed deterioration of the large superstructure area on the forward end of the aft section of the wreck which encompasses the boiler room casing, the collapsed boat deck, the remains of the bridge deck and the accommodation block. Following the collapse seen between the 2014 and 2015 surveys, this area has remained reasonably stable with one further area of subsidence noted on the starboard boat deck where several of the previously overhanging sheets of metal have now broken free. Differences of less that 1m are noted on the difference plot and consist of smaller sheets of decking subsiding.

6.9 At Key Area 5, the split in the deck and hull remains in the same state of deterioration but the contents inside the crack have been ensonified in greater detail than in previous surveys. This assumed sediment accumulation is well structured, indicating bedform features.

6.10 At Key Area 4, the splitting of the hull has not shown any evidence of deterioration when compared with previous datasets.

6.11 At Key Area 3, the aperture at the aft of the forward section was surveyed with good clarity and no changes have been noted to the opening. The cargo inside was ensonified but not to the same level as the 2015 survey. This is because of the tidal state and the angle of the MBES beam achieved through the opening.

6.12 Other areas where changes have occurred include holes in the deck plating (ID12) which have increased in size by 0.2m, a height difference of c.1.5m in the gunnery officer's cabin, a general re-working of sediment across the wreck, a mixture of accretion and erosion in the surrounding seabed and the identification of 7 additional contacts in the survey area.

6.13 As in previous years, the seabed around the vessel has generally remained stable and, across much of the wreck, no changes were noticeable in the survey data.