Maritime & Coastguard Agency

SS Richard Montgomery: Survey report 2023

April 2023

Contents

Abbreviations

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

1 Executive summary

1.1 Background

1.1.1 The SS Richard Montgomery (SSRM) is 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. This report details the results of the 2023 full survey.

1.2 Survey overview

1.2.1 This report primarily compared the data from the most recent survey (October 2023) with that gathered during the previous full survey conducted in October 2022.

1.2.2 The survey was conducted between 16 October 2023 and 19 October 2023.

1.3 Key results

1.3.1 The whole forward section of the wreck appears to have an increase in lean, approximately 10-15cm, eastward. This might be due to sediment undercutting SSRM on the east side.

1.3.2 The deck space near hold 3 appears to have started to collapse on the port side. This appears to be recent and is clearly visible thanks to good ensonification.

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

1.3.4 More objects are visible on the seafloor between the two portions of wreck. This might be due to objects slipping off the unsupported bridge section or increased data quality.

1.3.5 The seabed updates include that the banks to the west of the wreck are the most active with westward accretion. There was a vertical displacement of at least 2m on some banks with an average site accretion in the range 0.3-0.6m. On the east side of SSRM there is a slight reduction of sediments in the range 0-0.6m.

1.3.6 85 new targets have been added to the contact list for the seabed area surrounding SSRM.

2 Introduction

2.1 Background

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

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

2.1.3 On 23 August, stevedores from Gravesend were engaged to discharge the cargo. However, on the afternoon of the following day, the ship's hull cracked even further, and the bow holds flooded. By 8 September, the ship broke its back completely. Divers reported that the crack extended down both sides of the hull, with the vessel clearly open on the starboard side, but the cargo discharge continued. Royal Navy personnel were brought in to finish the cargo removal, but they were hampered by deteriorating weather and safety

fears as the vessel gradually sank. The salvage operation was abandoned with approximately 1,400 tons net explosive quantity (NEQ) of munitions remaining within the forward section of the vessel in holds 1, 2 and 3.

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

Figure 1. Photograph of M/V Lode and the SSRM's three masts above the water.

2.2 Management

2.2.1 The SSRM is designated as a dangerous wreck under section 2 of the Protection of Wrecks Act 1973. There is a prohibited area around the wreck, and it is an offence to enter within this area without the written permission of the Secretary of State for Transport. The wreck is clearly marked on the relevant Admiralty Charts, the prohibited area is marked with four lit cardinal

buoys and twelve red danger buoys, and the wreck is under 24hr surveillance by Medway Vessel Traffic Monitoring Service (VTS).

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

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

2.3 This report

2.3.1 This report is a summary of the October 2023 SSRM survey findings. This is a full survey and compares the result against the last full survey in 2022. 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 which have been used in successive surveys as markers for measuring levels of change. Of these, there are six areas which have repeatedly demonstrated levels of accelerated deterioration and are therefore a specific focus of each survey.

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

seabed within the survey area, including debris that may have originated from the wreck and debris from other sources.

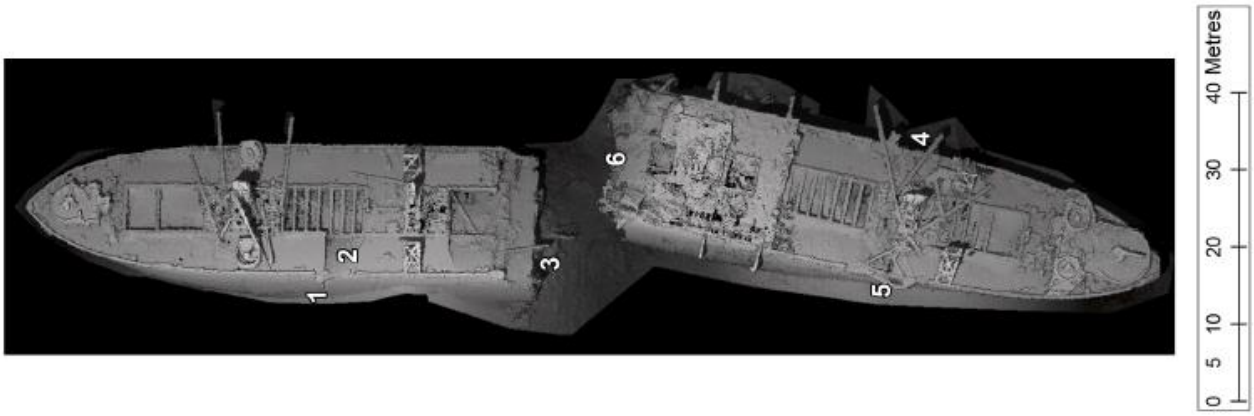

Figure 2. SSRM top-down image showing the 6 key areas.

3 The survey

3.1 Survey requirements

3.1.1 The scope of work as defined by the MCA included the following objectives:

a) Comprehensive multibeam echosounder (MBES) survey of the entire wreck.

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

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

d) Process the data and directly compare it to previous survey data (from October 2022) to identify and highlight any areas of structural change or deterioration.

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

3.2 Survey area

3.2.1 The survey area is shown by the white box (Figure 3).

Figure 3. Location of the SSRM full survey area.

3.3 Survey operations

3.3.1 The MBES survey and laser scanning of SSRM and part of the seabed took place on the 16 October 2023. The complete seabed survey outside the exclusion zone took place the 18-19 October 2023.

3.4 MBES

3.4.1 The MBES data was collected with a Kongsberg EM2040D MBES.

Table 1: M/V Lode equipment specifications used for data collection in 2023 SSRM full survey.

Equipment specifications – M/V Lode	
Primary horizontal & vertical positioning	Kongsberg Seapath 330 with Trimble VRS now RTK corrections
Primary heading sensor	Kongsberg Seapath 330
Acquisition / processing	Eiva Navipac and Kongsberg SIS
Multibeam echosounder (MBES)	Kongsberg EM2040D dual swath
MBES motion reference unit	Kongsberg MRU5
Sound velocity measurement	Valeport mini SVS Valeport swift SVP
Laser scanner system	Ouster os1
Acquisition	Eiva Naviscan

Table 2: M/V Northern Wind equipment specifications used for data collection in 2023 SSRM full survey.

Equipment specifications – M/V Northern Wind	
Primary horizontal & vertical positioning	Kongsberg Seapath 330 with Trimble VRS now RTK corrections
Primary heading sensor	Kongsberg Seapath 330
Acquisition / processing	Eiva Navipac and Kongsberg SIS
Multibeam echosounder (MBES)	Kongsberg EM2040D dual swath
MBES motion reference unit	Kongsberg MRU5
Sound velocity measurement	Valeport mini SVS Valeport swift SVP
Laser scanner system	N/a
Acquisition	N/a

3.4.2 Global Navigation Satellite System (GNSS) data from Kongsberg Seapath was logged using Kongsberg sis software. The recorded GNSS data was post processed using Terrapos resulting in a post-processed kinematic GNSS solution combined with the ordnance survey active networks, with 3 reference stations completely covering the survey area. This improves the real-time positioning to a ±5 cm accuracy by using Rinex data from the reference

stations together with clock and satellite corrections in order to recompute the real time positioning. The post-processed solution then replaces the online navigation and GPS height, after thorough quality control and comparison with the online navigation in EIVA Naviedit.

Reduction to the project vertical datum was performed by using the GNSS height solution and applying a geoid model in EIVA Naviedit. The geoid model is derived from the UKHO VORF model and is used to reduce the bathymetry data to chart datum (ETRS89, UTM31N).

The vertical uncertainty values for the Applanix pos mv system are less than ±0.05m, when post processed.

This survey has maximised the data density to ensure full and complete ensonification of the SSRM and the surrounding seabed. The seabed was consistently covered by 70 or more valid soundings per 1m bin. The wreck itself had between 2000-12000 soundings per 1m bin. The masts were covered by 7000-30000 soundings per 1m bin.

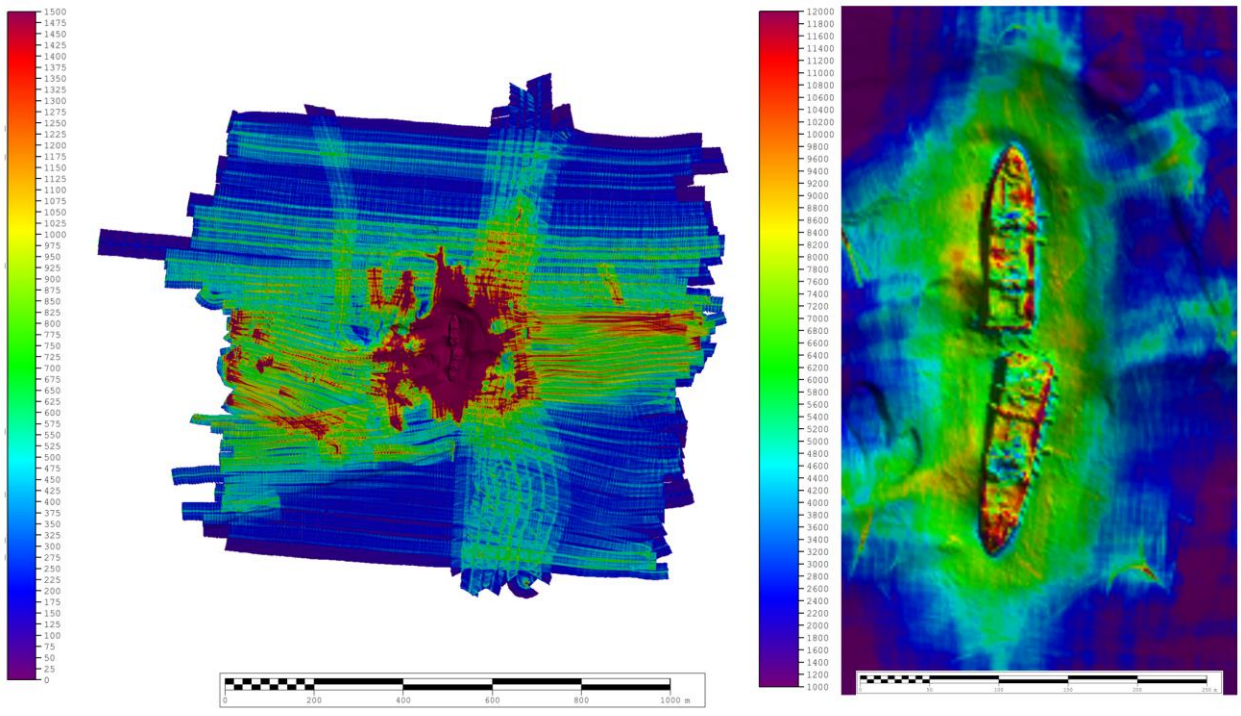

Figure 4. Density plot of SSRM and the surrounding seabed. Masts are omitted from the SSRM for clarity in the density values.

3.5 Laser scanning

3.5.1 The laser data indicates no structural changes between the 2022 full survey and the 2023 full survey.

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

3.5.3 The laser data from the 2022 full survey was overlaid on the data gathered on the 2023 full survey and this shows the three masts are well defined within the laser data and show good correlation with the 2022 data. The cross-section analysis shows no structural differences but a slight change in position on the forward section (not restricted to only the masts, see sections 4.2.2 and 4.2.3).

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 (Figure 5). 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.

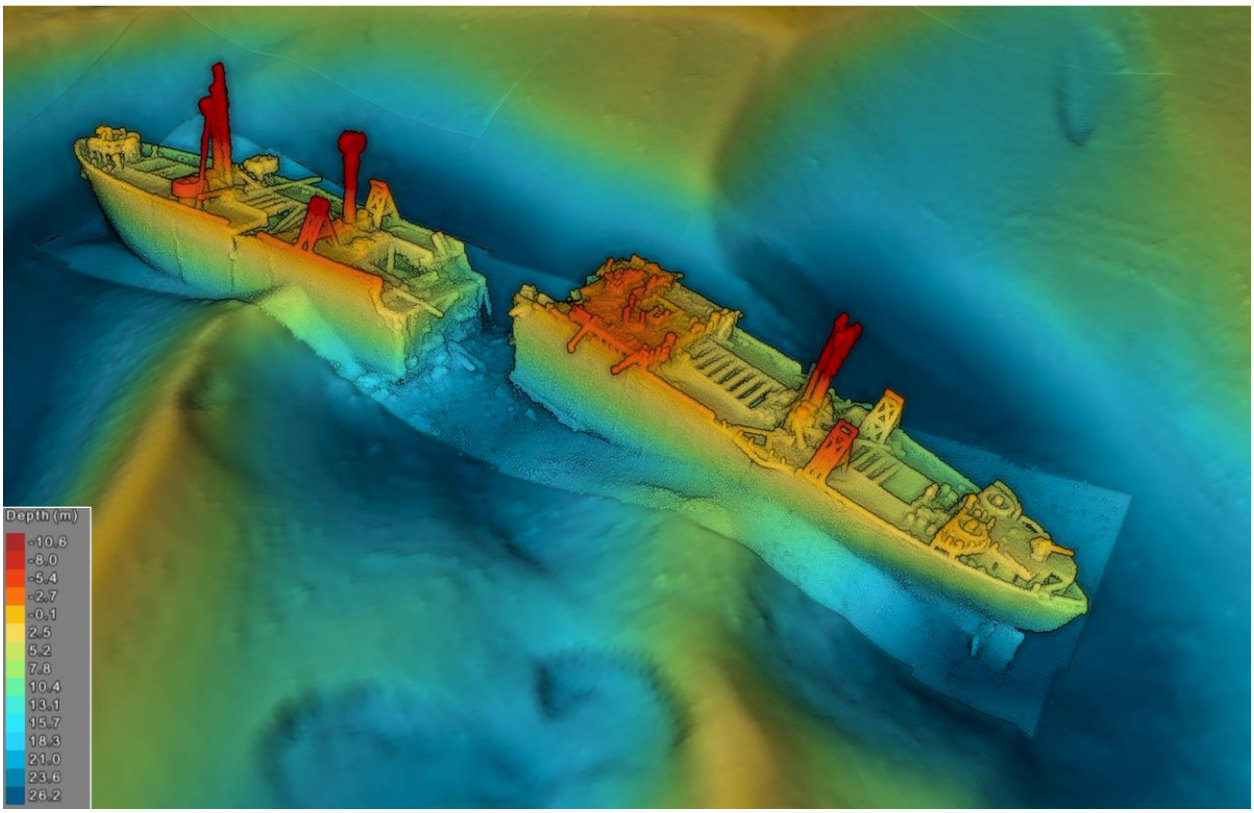

Figure 5. Overview picture of SSRM. Point cloud data, including lidar, overlaid on a digital terrain model of the surrounding seabed.

Several features across the wreck have been highlighted during previous surveys as key areas of significant structural change. Changes were identified in all these locations between the 2022 and 2023 survey. Other changes were also identified at locations that were not key areas.

4.1.2 Key area 1, crack in the hull (port side, forward section) (Figure 6).

4.1.3 Key area 2, collapse of cargo hold 2 deck (port side, forward section) (Figure 6).

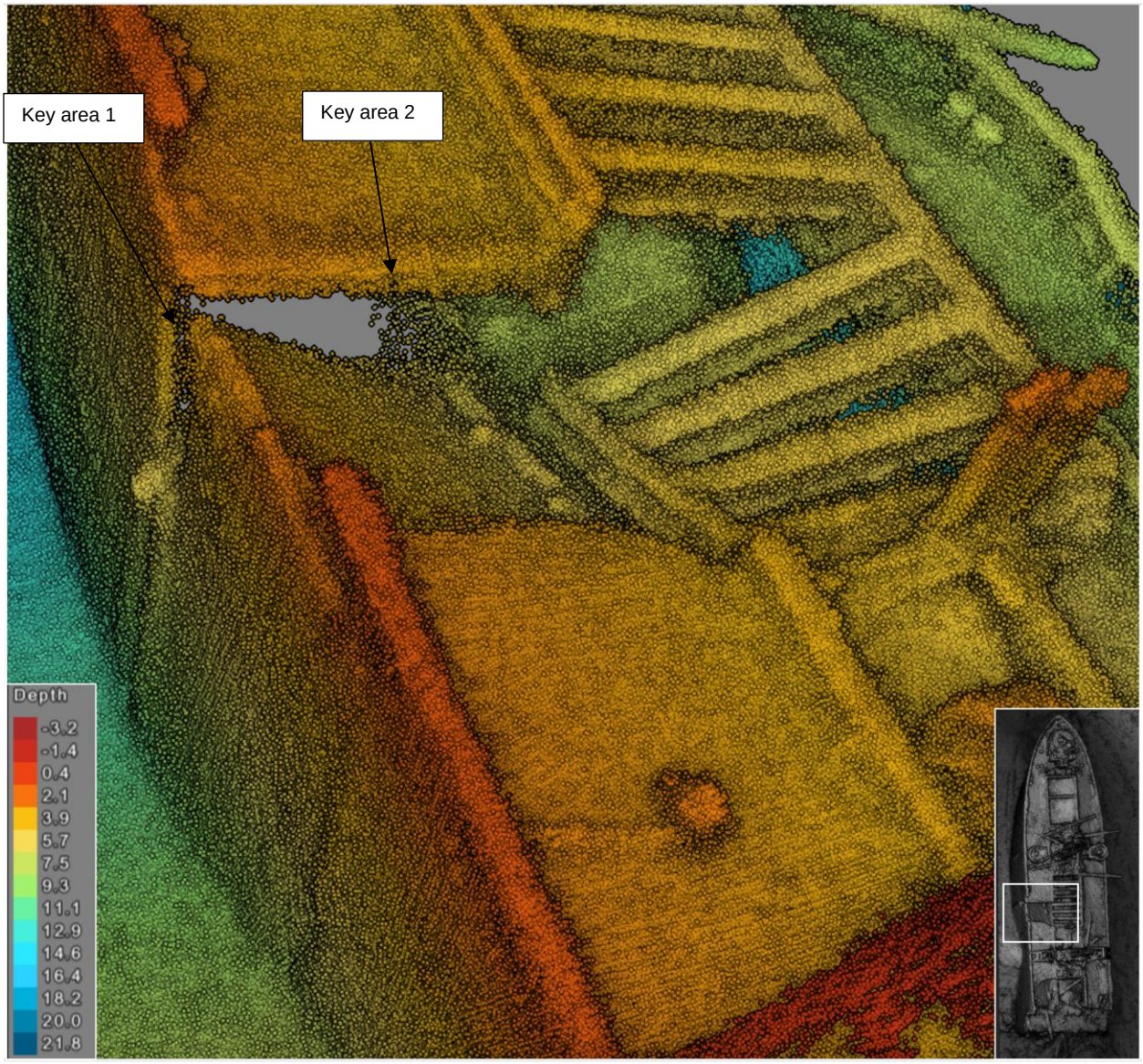

Figure 6. Point cloud image of key areas 1 and 2.

4.1.4 Key area 3, aperture (aft end, forward section) (Figure 7).

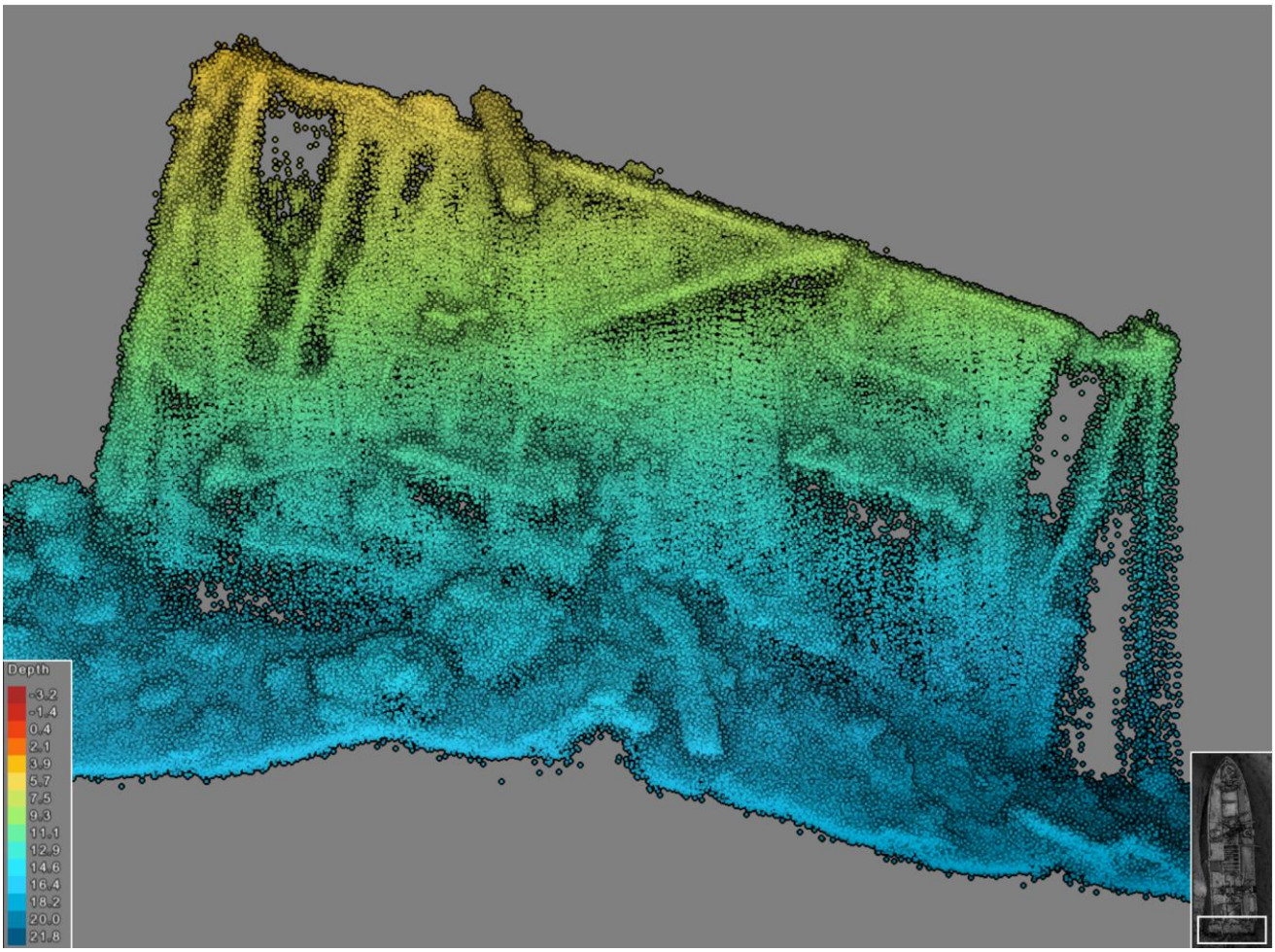

Figure 7. Point cloud image of the apertures, key area 3.

4.1.5 Key area 4, split in the hull (starboard side, aft section near the aft mast house) (Figure 8).

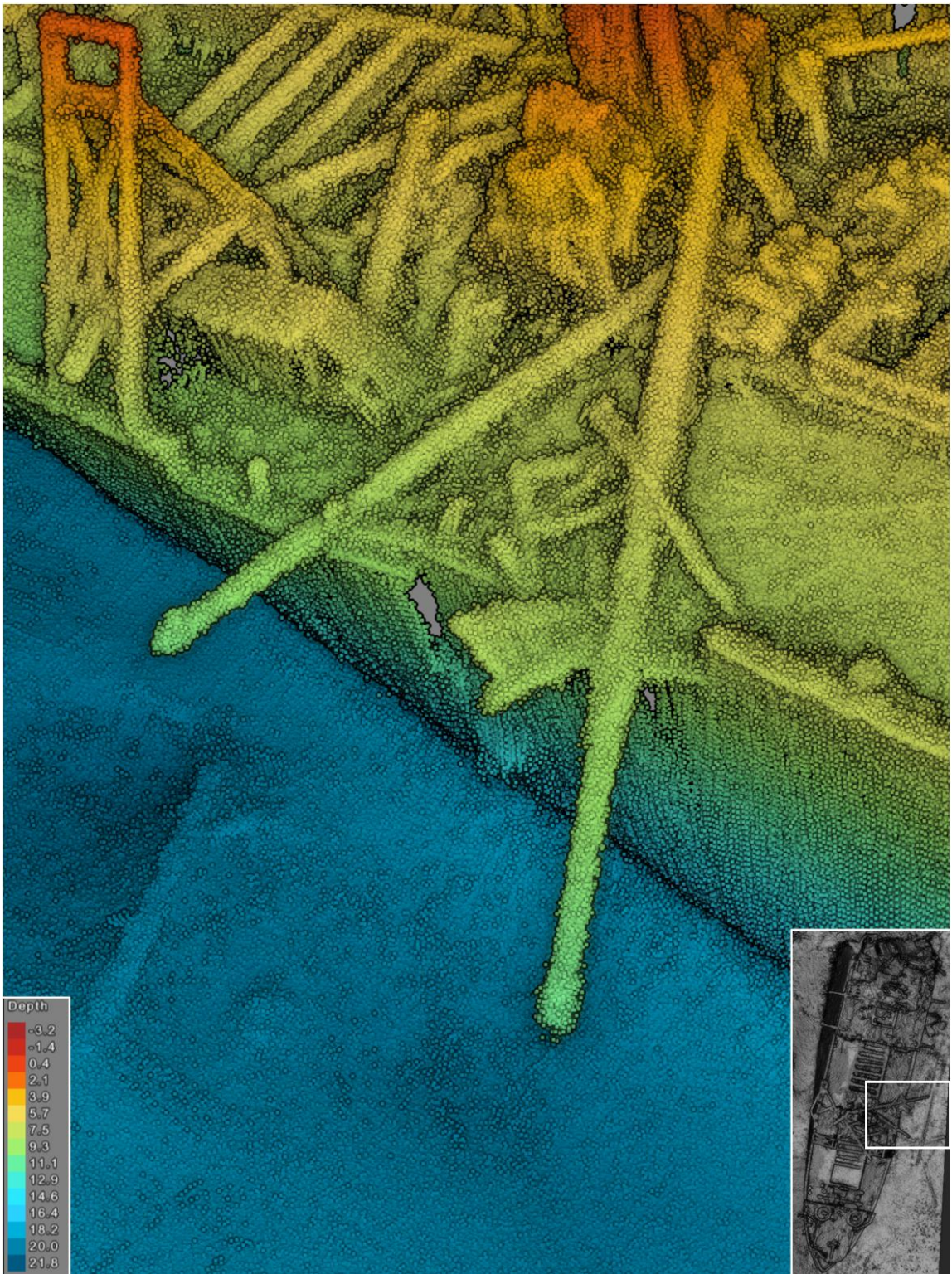

Figure 8. Point cloud image of the split in hull, key area 4.

Key area 5, split in deck and split in the hull (aft section, port side) (Figure 9).

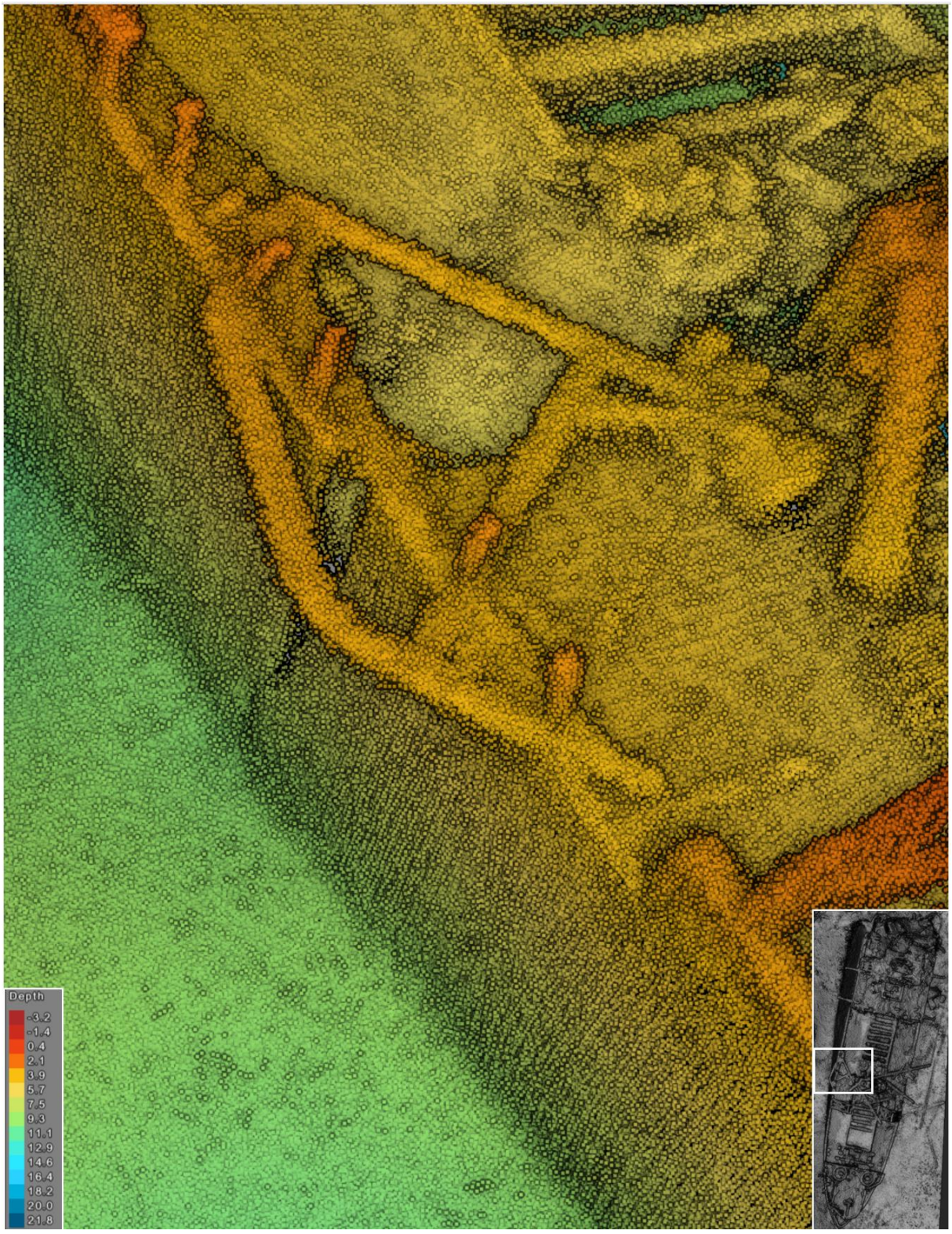

Figure 9. Point cloud image of the split in deck, key area 5.

4.1.6 Key area 6, boiler room casing, collapsing bridge deck and the collapsing boat deck (forward end, aft section) (Figure 10).

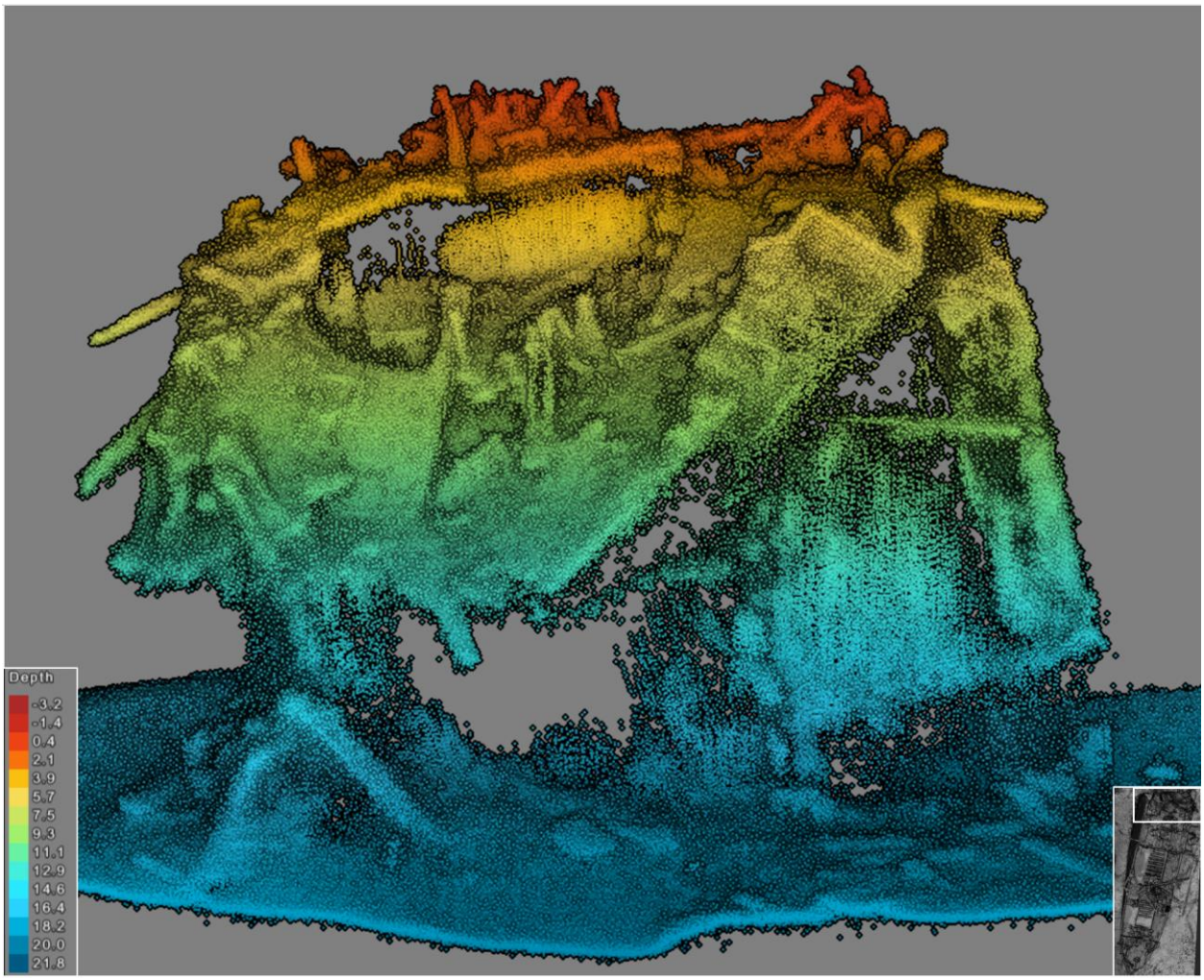

Figure 10. Point cloud image of the collapsing bridge area, key area 6.

4.2 Key areas and features

4.2.1 Over the whole of the wreck, 96 specific features have been used in successive surveys as comparison points for quantifying change and deterioration (Figure 11, Figure 12). Two new features are suggested to be added to this list (see section 4.2.8).

In addition to the 96 features, the six key areas that have been highlighted in previous surveys as areas of significant structural change are monitored in each survey. One new key area is proposed to be added (see section 4.2.8).

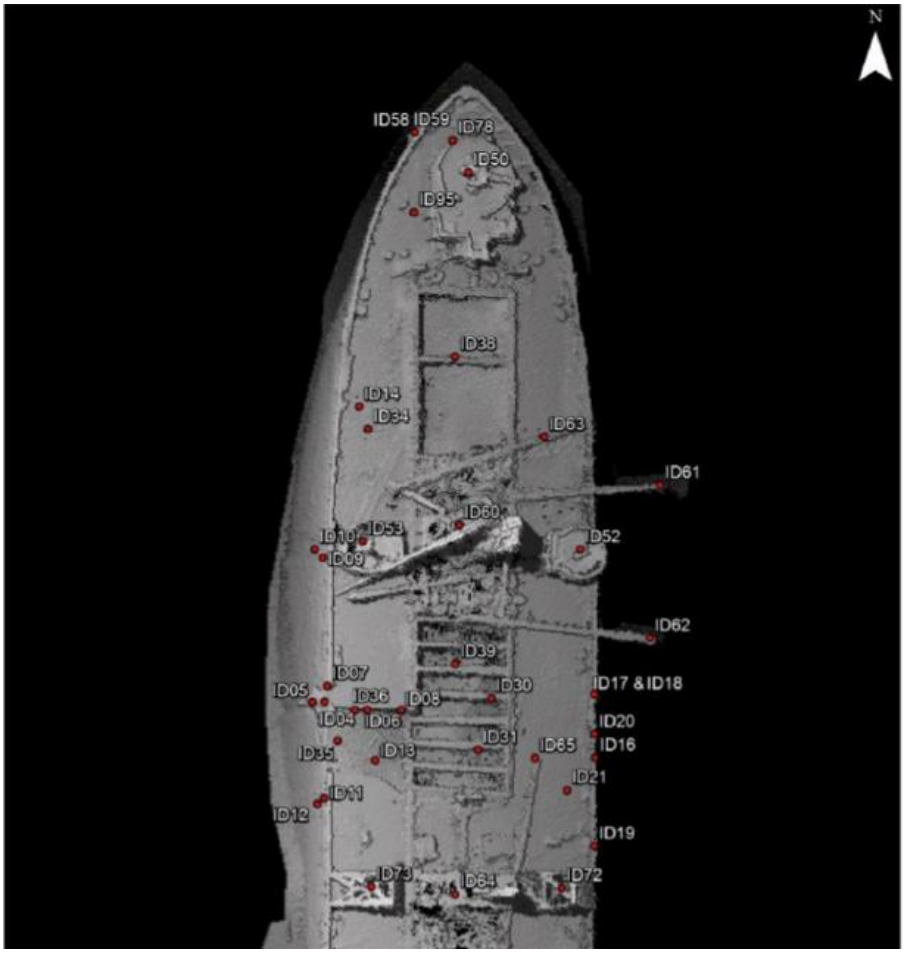

Figure 11. ID features on the forward section of the wreck.

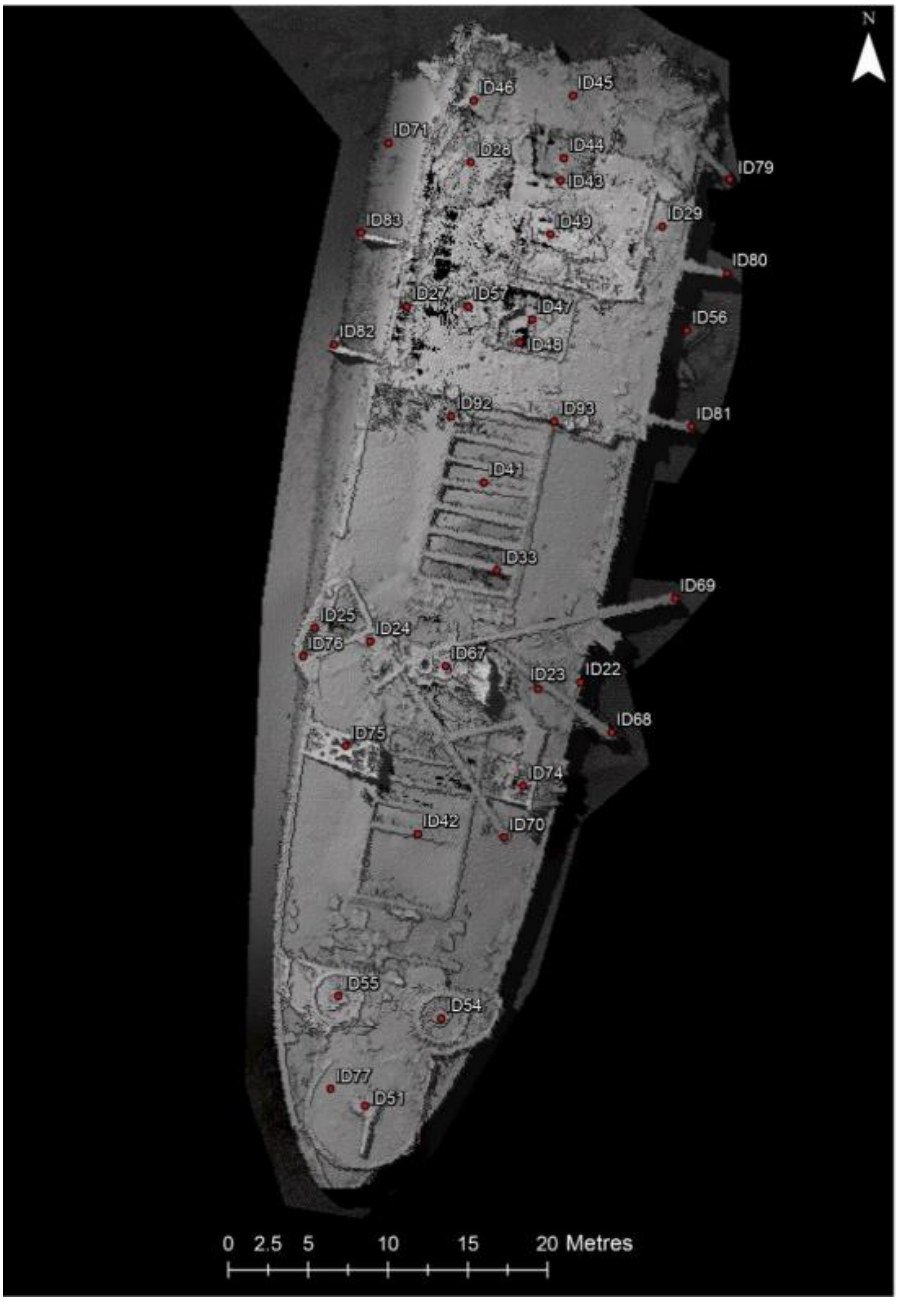

Figure 12. ID features on the astern section of the wreck.

4.2.2 Bow and stern

The degree to which the bow and stern may be being undercut as the supporting sediment is eroded away is a potential concern. For information on the seafloor please refer to section 5.1. Both sections of the SSRM are leaning to the east and are partially submerged in sediments on the west side. The bow section appears to have been undercut to the degree where it has started to move (increased lean) whereas the stern section is unchanged.

4.2.3 Possible increase in tilt of bow section

By comparing the full survey from 2023 with the full survey 2022, all the 2023 data is offset 10-15cm to the east (see examples in Figure 13 and Figure 14). The data has been verified to match very well on known structures on the stern section and objects on the sea floor. This increase in tilt might suggest that the northern part of SSRM has been undercut to the degree where it has started to lean more.

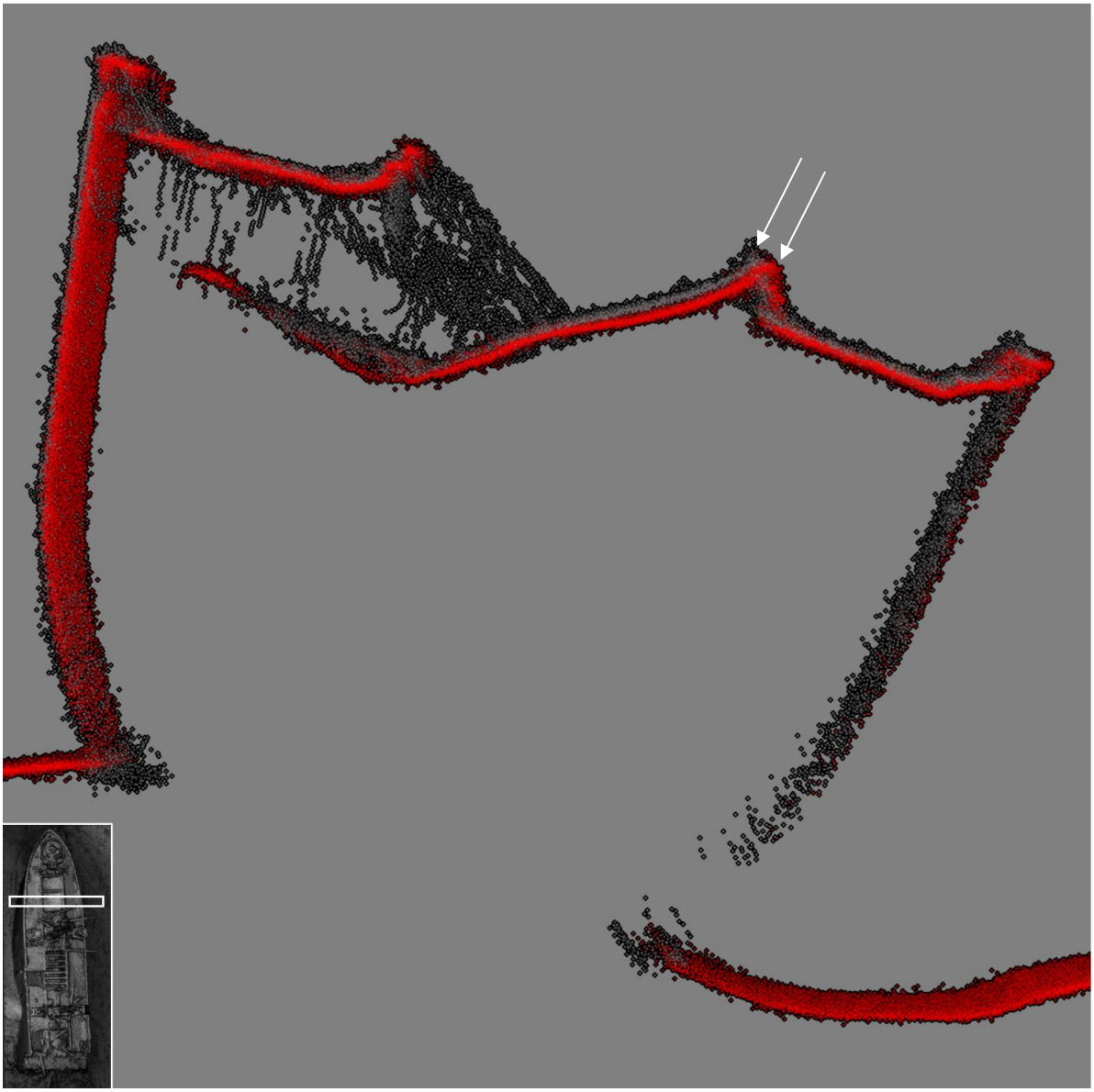

Figure 13. Cross section of point cloud data. Red is full survey 2023 and grey is 2022. Note the position of the coaming in both surveys and that the deck is lower in 2023 data.

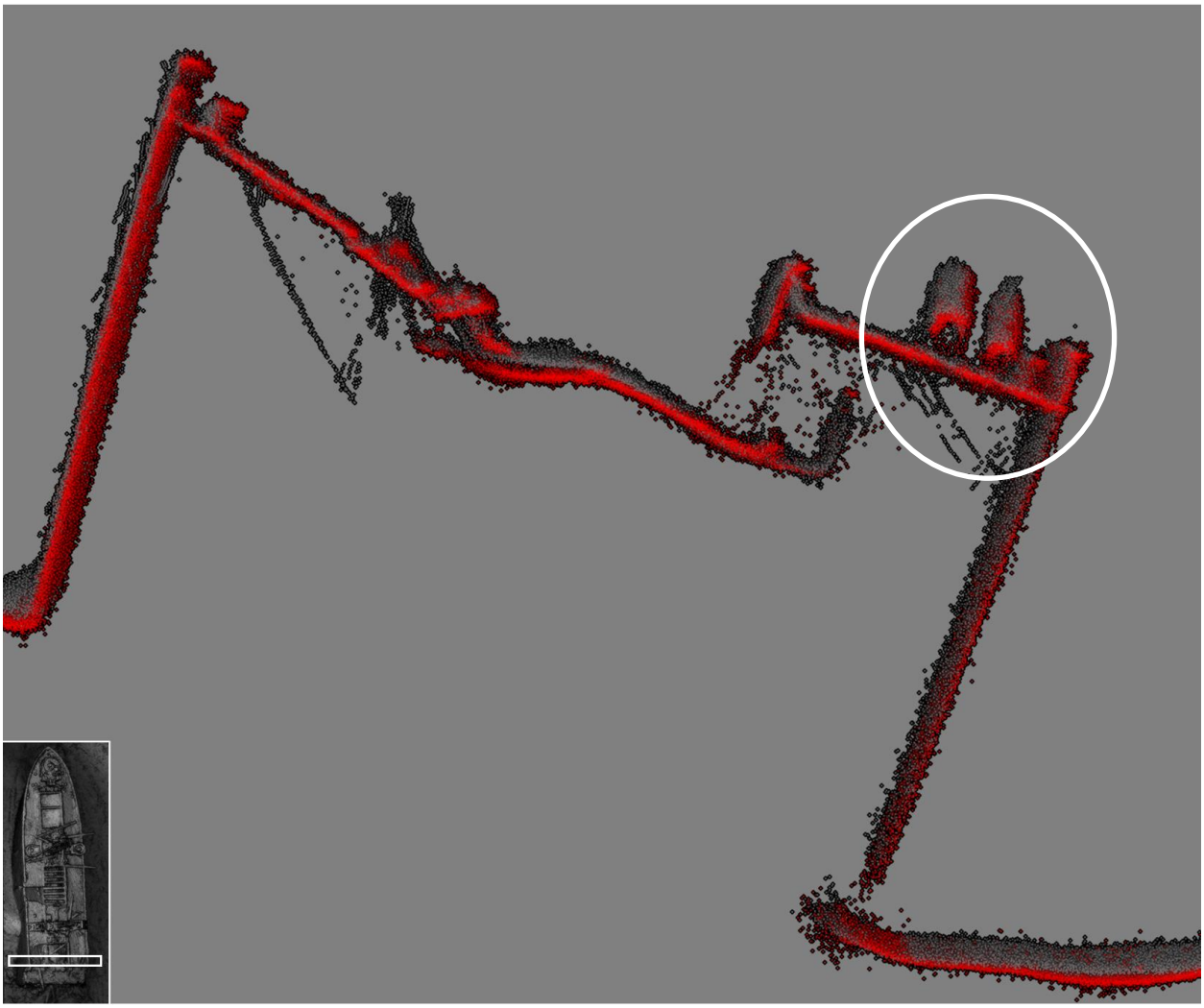

Figure 14. Cross section of point cloud data. Red is full survey 2023 and grey is 2022. Note the two pipes in the circled section showing slight offset to the east.

The position of the stern section has not changed between the two full surveys 2023 and 2022.

4.2.4 Key areas 1 and 2 – crack in hull (ID04) and collapse of cargo hold on deck 2.

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

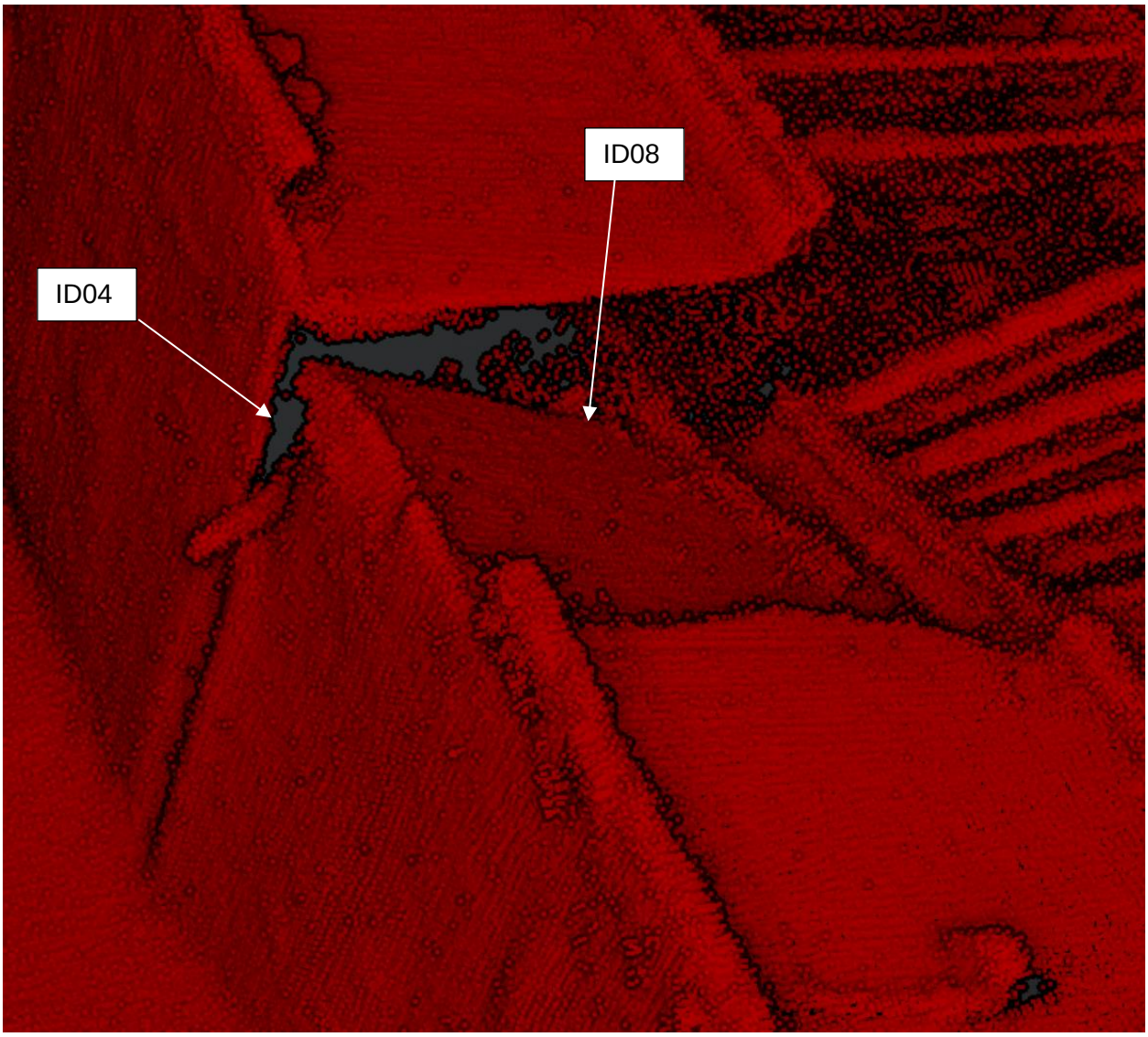

Figure 15. Crack in hull (ID04) and collapsed upper deck (ID 08) overview from the full survey in October 2023.

Overlaying the 2023 and 2022 survey data on a cross section shows the extent of the upper deck collapse (Figure 16). Between the two full surveys, it appears that the deck has collapsed further by approximately 17-20cm.

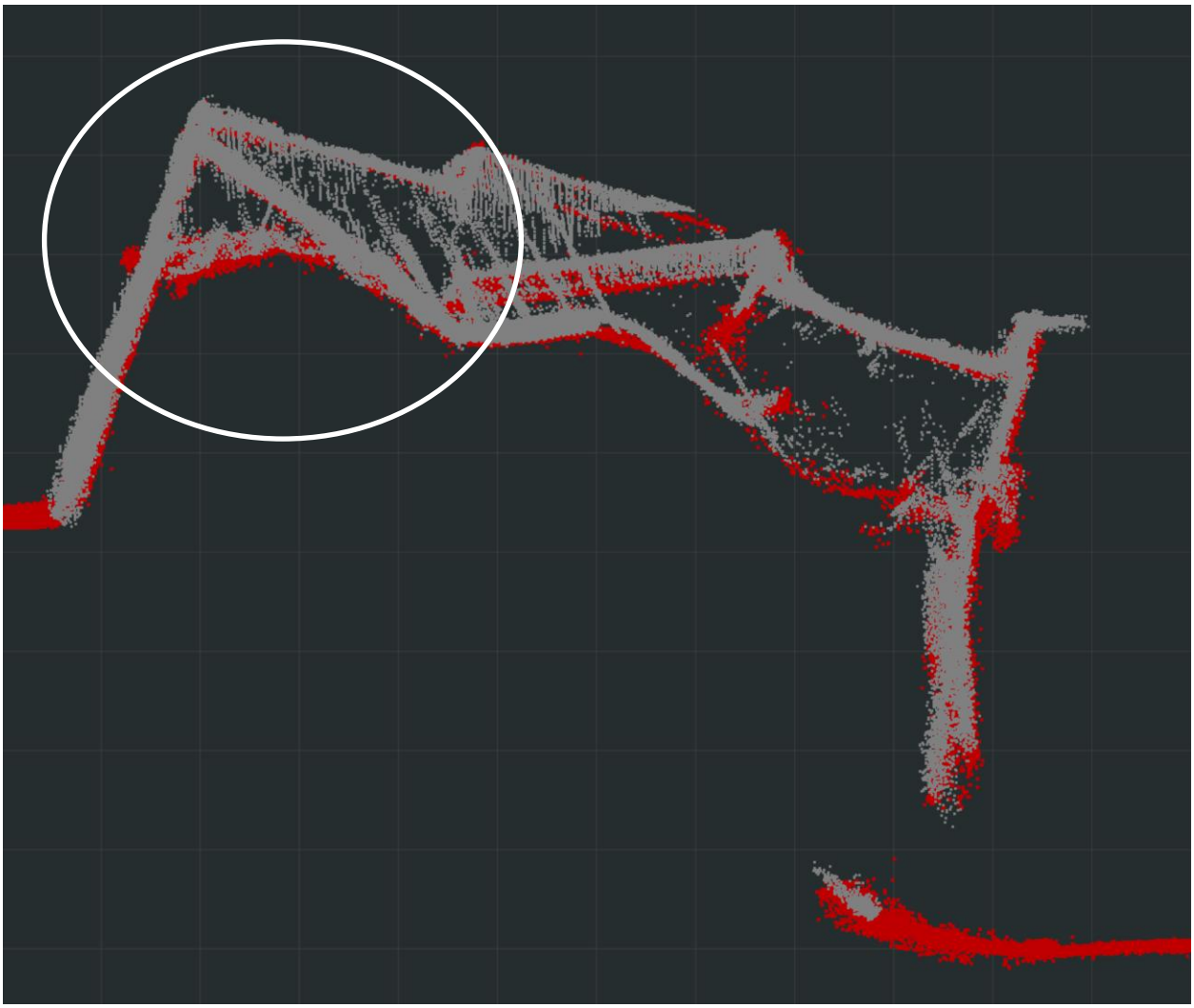

Figure 16. Collapsed upper deck. October 2023 (red) and October 2022 (grey) in a cross section. Cross section is 1m thick.

The crack in the hull is well defined in the 2023 full survey (Figure 17). Comparing the dimensions of the crack with the full survey from 2022 show that there has been an increase in the width by 5cm and 37cm in the length.

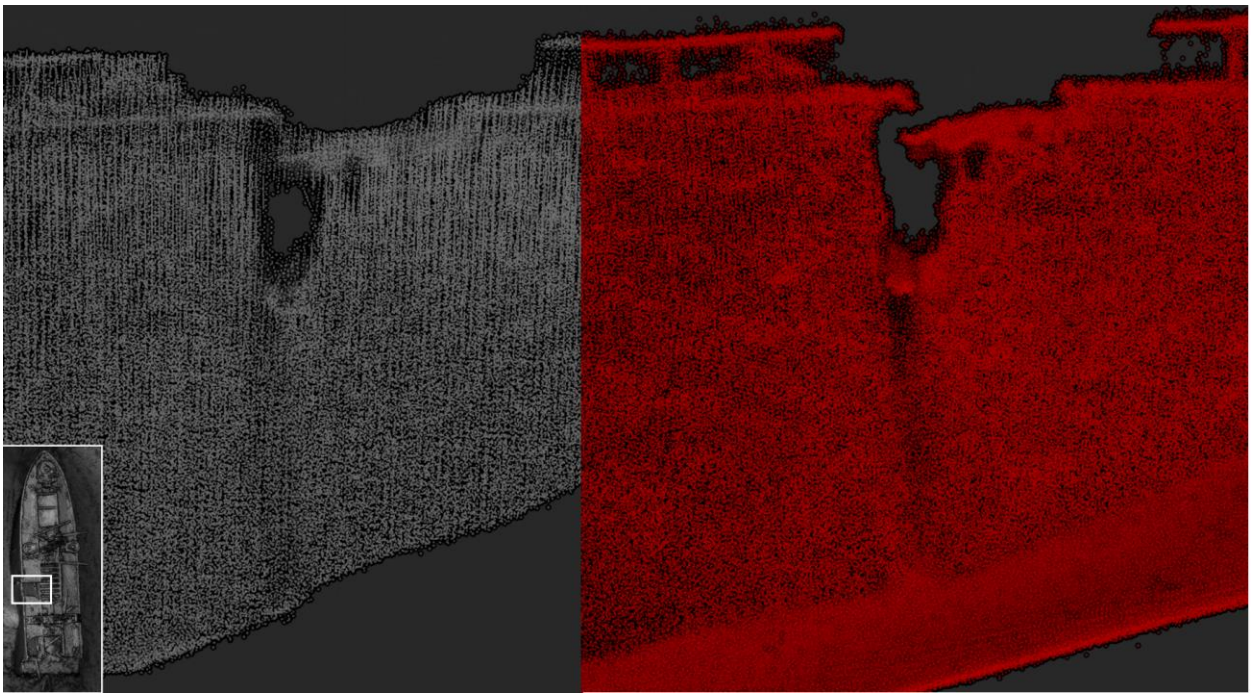

Figure 17. Side by side comparison of the crack in the hull (ID04). Left is 2022 full survey and right is 2023.

Agreeing with the result of the previous full survey 2022, there is no evidence showing sedimentation in the ‘tween deck up to the coaming on the starboard side of the wreck in this area (Figure 18). It is possible that the sediments might wash out into an area that is internally collapsed and not visible in the multibeam data.

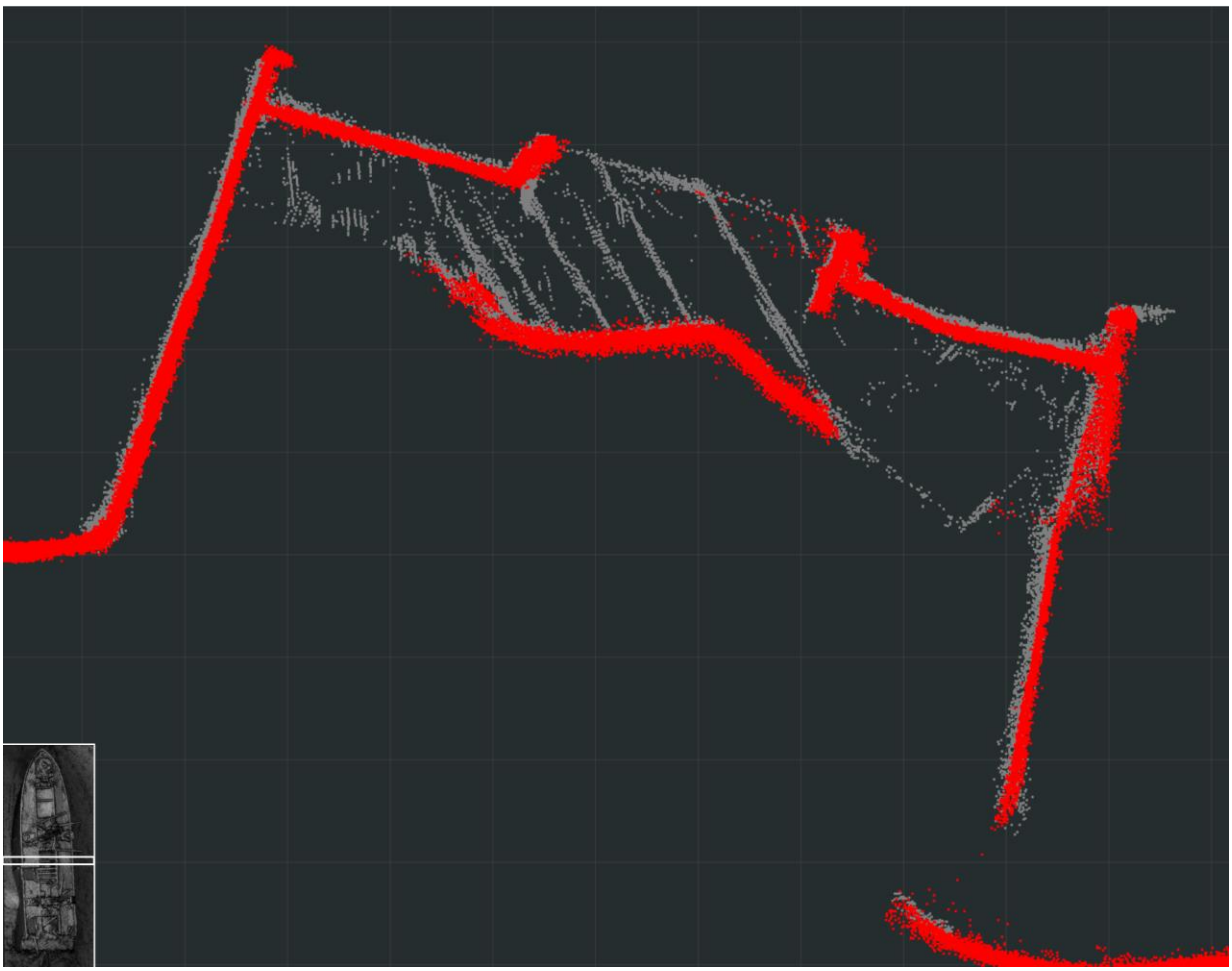

Figure 18. Comparison of a cross section in hold 2 between the 2022 full survey (grey) and 2023 full survey (red).

4.2.5 Key area 3 – aperture

Figure 19 shows the apertures on the bulkhead at the aft end of the forward section, which are clearly visible in the 2023 data. Although no structural differences were found between the 2022 and 2023 survey, the 2023 survey identified an object that seems to hang from the railings (Figure 19, A). The high-resolution data also made more objects visible in the area between the forward section and the aft section (Figure 19, B).

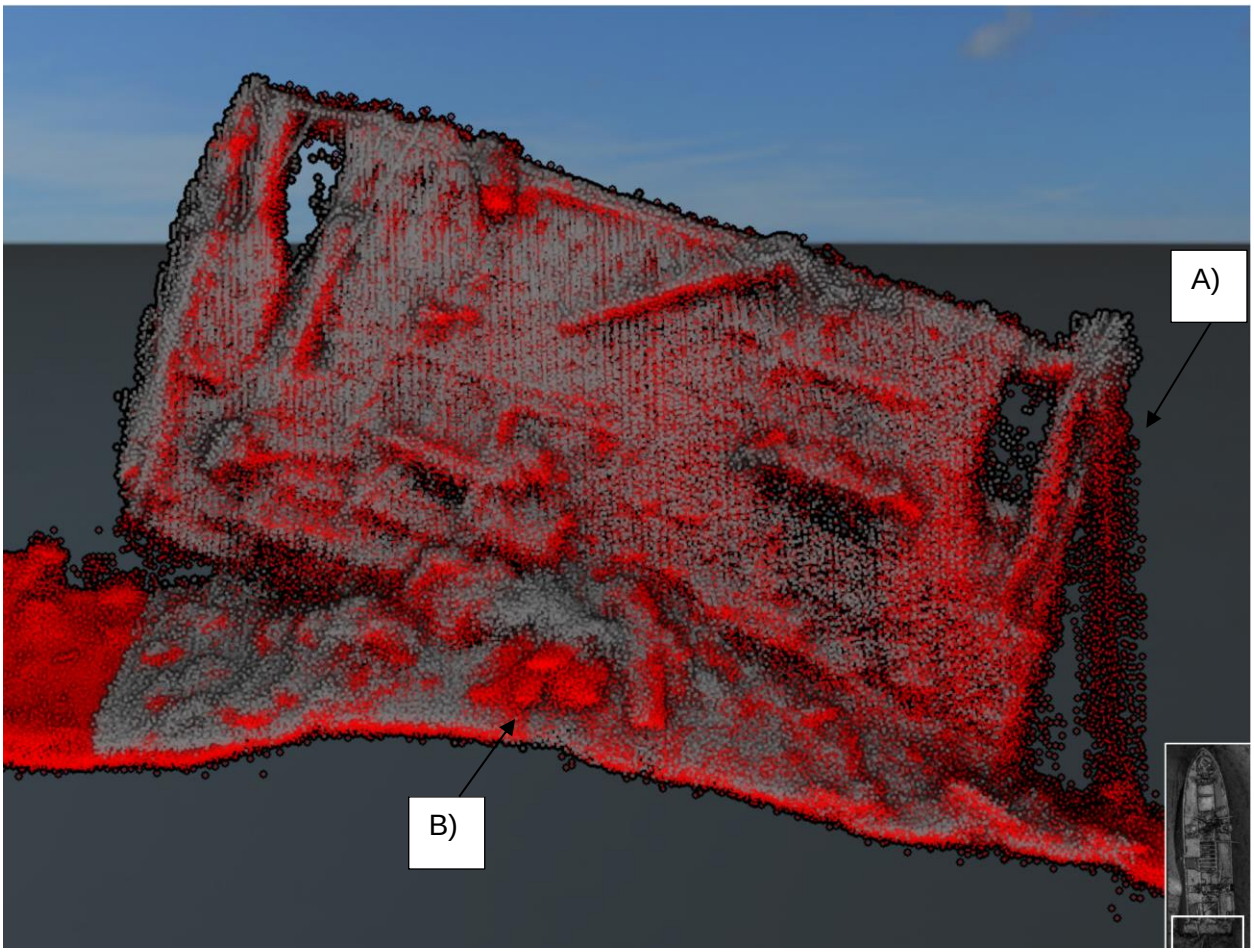

Figure 19. Aperture in the bulkhead to rear of hold 3. Grey is 2022 data and red is 2023 data. Point A) shows the object hanging from the railing and point B) shows an example of an object only found in the 2023 dataset.

Due to the nature of the aperture's location, the density of good quality soundings required for identifying any objects inside them is not enough.

4.2.6 Area 4 and 5 – splitting of hull (ID22) and split in deck & hull (ID24 & ID25)

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

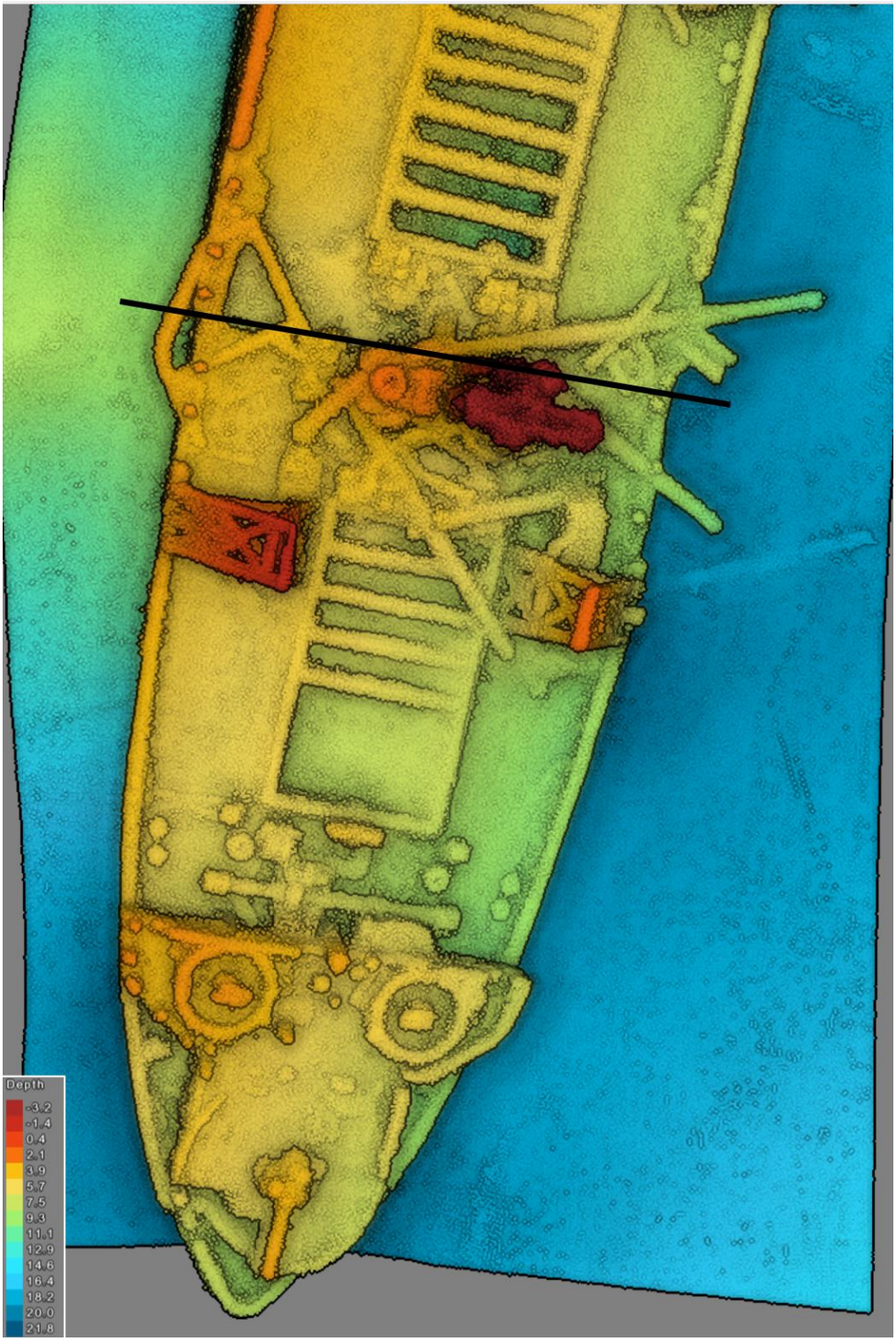

Figure 20. Top-down image of point cloud with line showing the probable split in the rear hull with ID25 and ID22 on port side and starboard side respectively.

One notable change has been observed comparing the 2022 survey and the 2023 survey. The port side deck has collapsed between the ‘tween deck hatch and the outer railings. A noticeable height difference of 0.55m has been observed (Figure 21). The total length of this collapse has been observed to exceed 6m (Figure 22) in north/south direction from the probable transversal split mentioned in section 4.2.6. This area has no ID, but because of the proximity to a key area it is proposed that an ID is assigned to it.

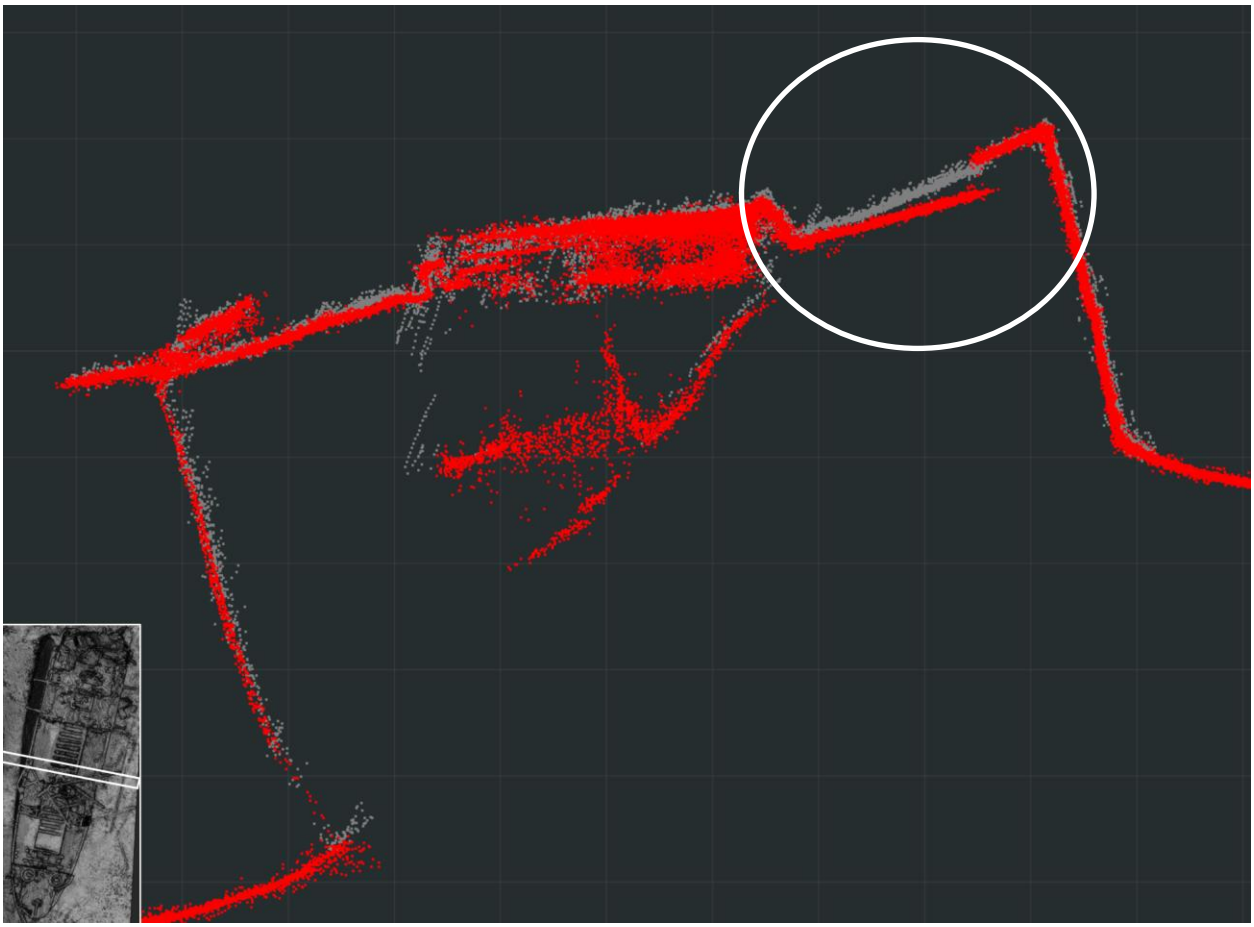

Figure 21. Cross section showing collapse of deck area near key area 5. The difference is 0.55m. Red is 2023 full survey and grey is 2022 full survey.

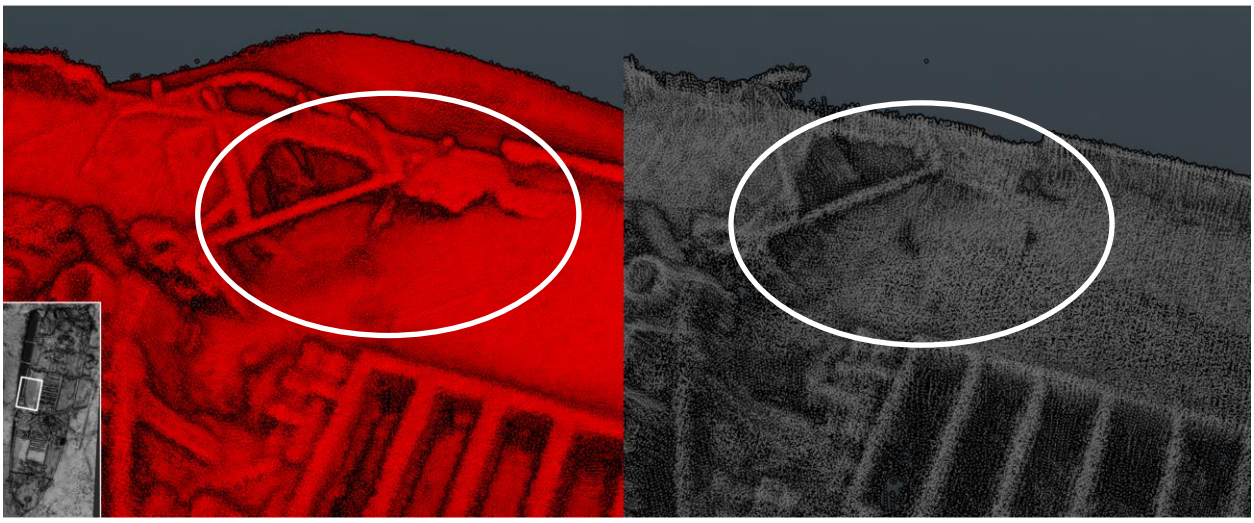

Figure 22. Comparison of point clouds on the newly discovered collapse. Measured distance of collapse is >6m. Red is 2023 full survey and grey is 2022.

4.2.7 Area 6 – collapsing bridge deck area (ID45 & ID46)

This area was left unsupported when the ship broke in two back in 1944. Consequently, it has been badly affected by wave and current action and is steadily collapsing and falling into the gap between the two halves of the vessel. This area has showed significant degradation in earlier surveys and continues to do so between the 2022 and 2023 surveys.

Many more features could be discerned in this area compared to the 2022 survey. This has made analysis of the movement in this area quite robust for the future, with the ability to compare features and measure the differences. However, because of the overhang any features/objects located under it is not possible to analyse.

The further collapse of the area has been determined by comparing the box-like feature (ID46), which shows a difference of 1.5m between the 2022 (A) and 2023 survey (B). The deck does not seem to have collapsed any further between the two areas. However, there are two parts that are only visible in the 2023 survey (C and D) on the deck area, which might indicate that there has been some movement of objects.

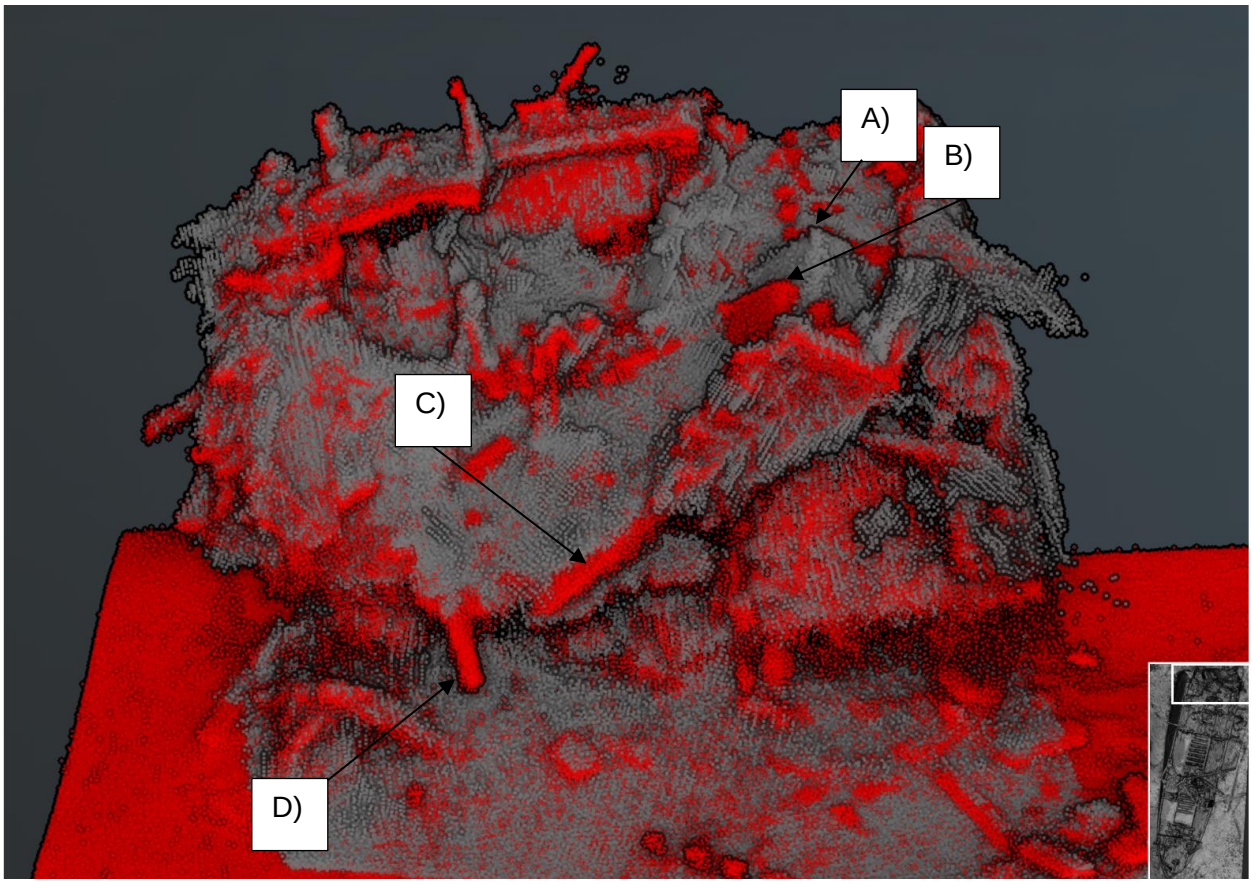

Figure 23. Profile showing the bridge deck area. Red points are 2023 survey and grey are 2022. Points A) and B) show the movement of a well-defined object (ID46) in both surveys. Points C) and D) shows features only found in the 2023 dataset.

The collapse of the unsupported deck seems to be localized to the area around ID46 (Figure 24). Both the 2022 and 2023 survey matches well in the other parts of key area 6, except for more distinguishable objects found in the 2023 survey only.

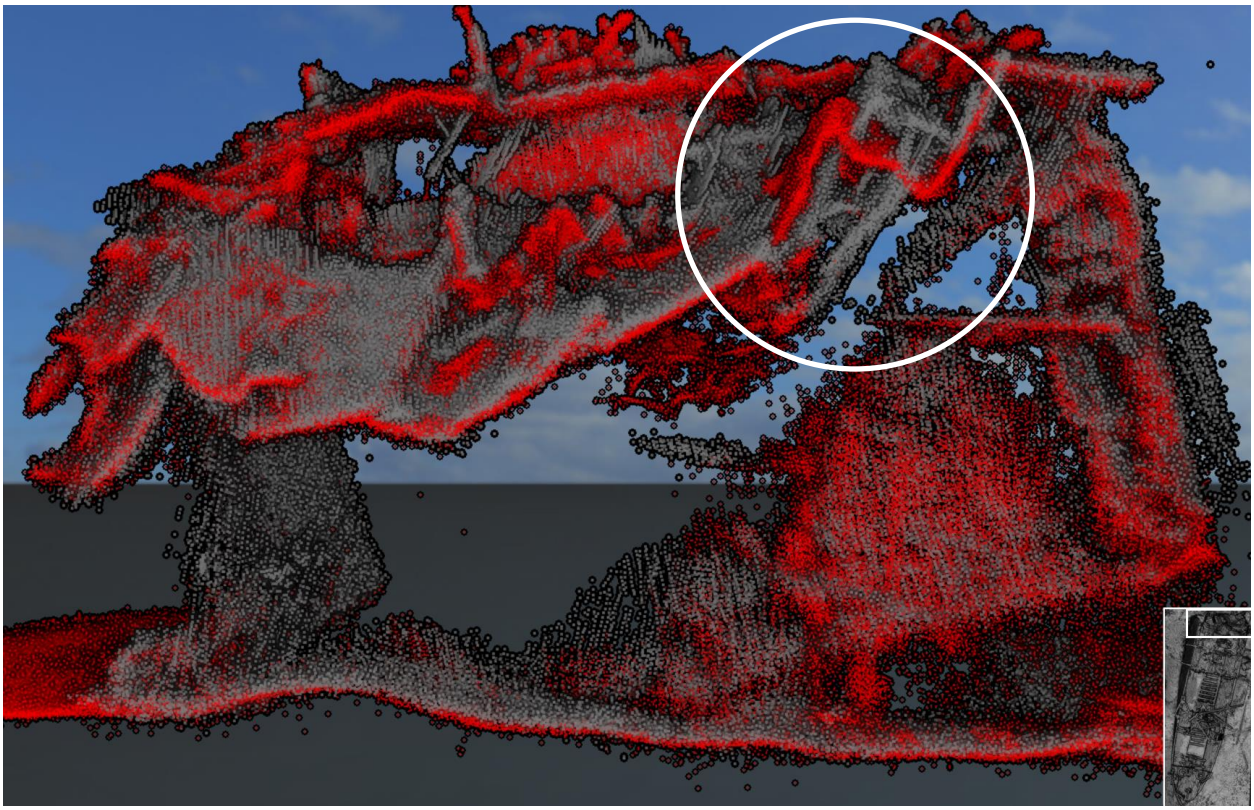

Figure 24. Cross section at ID46 location, showing the difference in the deck area (circled). Red points are the 2023 full survey and grey points are the 2022 full survey.

4.2.8 Suggestions for additions of IDs

Based on the analysis comparing the full surveys 2023 and 2022, a total of one key area and two new ID features are suggested.

Suggested key area is the area already located in key area 6, which is the unsupported deck that has shown significant movement between the two full surveys (see section 4.2.7).

The two new suggested ID features are the collapsed deck (see section 4.2.6, Figure 21, Figure 22) and a collapsed deck underneath the turret on the stern section (Figure 25).

Figure 25. Top-down picture of the stern, showing the difference in the deck supporting the turret. Red points are the 2023 full survey and grey are the 2022 full survey.

4.3 Debris between the hull sections

4.3.1 There have been differences between the two full surveys 2023 and 2022 in the area between the bow and stern section. Many new objects have been found and some objects have been better ensonified, resulting in higher resolution for those objects. Three larger new objects are visible between the two sections; one slightly elongated object (possibly a pipe or part of a mast), one triangular shaped frame with five cleat-like structures sticking up, and one suspected net-like object hanging from south east end on the bow section (Figure 26). Other than the three larger objects, there are numerous smaller objects clearly visible in the 2023 full survey.

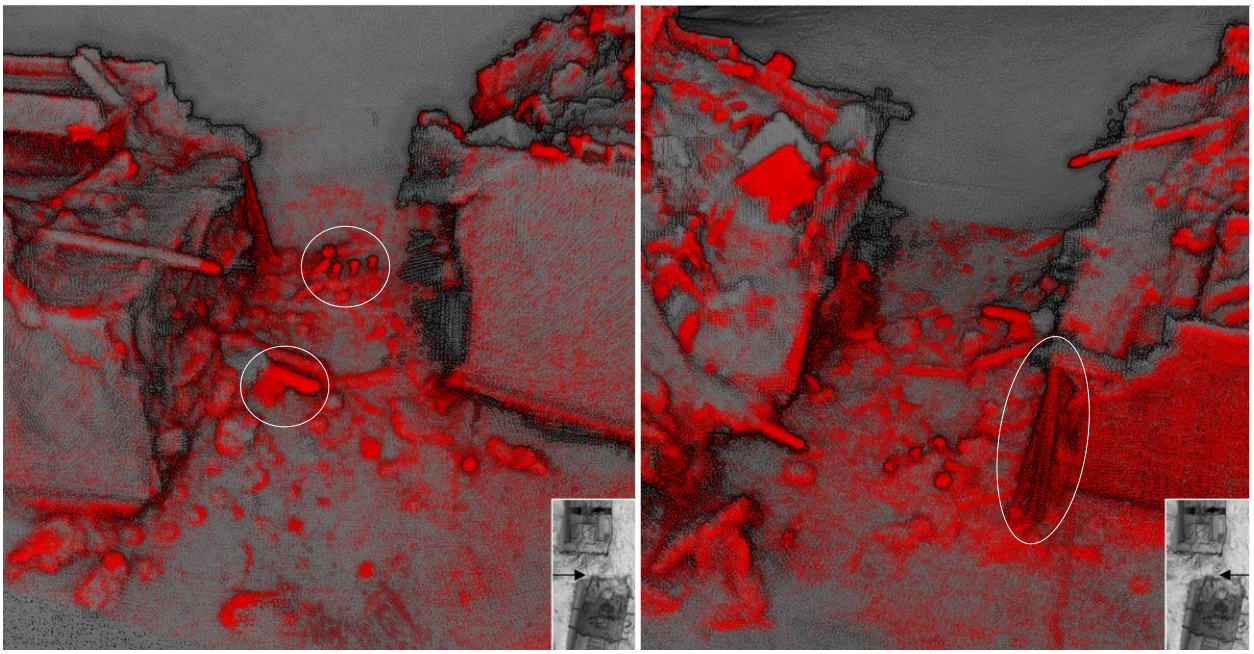

Figure 26. Point cloud images of the area between the two bow and stern sections of SSRM from two directions. Red is the 2023 full survey and grey is the 2022 full survey. The arrows indicate which direction the camera is facing. Objects that are completely red are only found in the 2023 full survey.

4.4 Cargo

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).

The small portion salvaged 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 fine 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.

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 are located over both the hatch on the upper deck and the opening through the second deck into the lower hold. Sedimentation is visible in holds 1, 3 and 4 to various degrees. Hold 3 shows less sedimentation, indicating that sediments might wash out somewhere else not visible in the data.

Since lower holds cannot be visible in the data, it is difficult to determine if sedimentation has occurred in these areas.

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

4.4.1 Hold 1

Hold 1 is the forward most of the five holds on SSRM and, in addition to the ‘tween deck space and the lower hold, hold 1 also contained a third layer of storage at the bottom of the lower hold known as the deep tanks in which additional cargo or ballast could be carried.

The hatch cover is missing as are all but one of the hatch cover supports. Sediment has settled in the ‘tween deck space to a considerable depth, filling the starboard side to the top of the starboard side hatch coaming. The port side remains clear above the horizontal from the starboard hatch coaming. Apart from some undulations in the sediment surface there is no difference between the level identified by the 2022 full survey and the 2023 full survey (Figure 27, Figure 28). Comparisons between the 2022 and 2023 full surveys regarding sedimentation has been difficult in some areas as there has been a high level of noise in the 2022 survey. Because of this it has been difficult to determine what has been sediment or noise (see circle in Figure 28).

Notably there is no indication that the second deck nor the second deck hatch covers have collapsed. However, it is possible, but is very unlikely, that the sediment has filled both the ‘tween deck area and the lower hold.

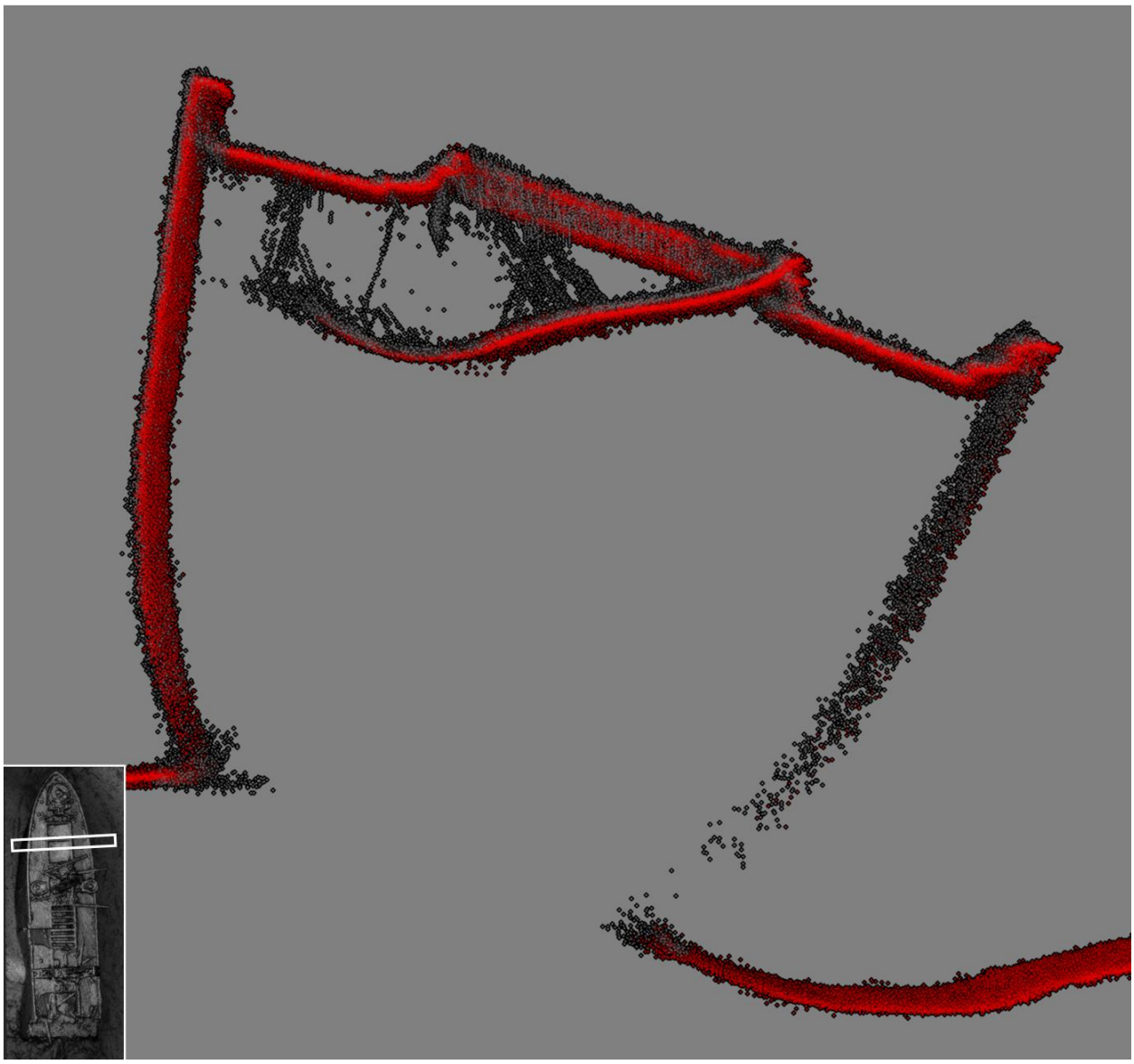

Figure 27. Cross section through the hull at the forward end of no. 1 hatch. Red full survey 2023, grey full survey 2022.

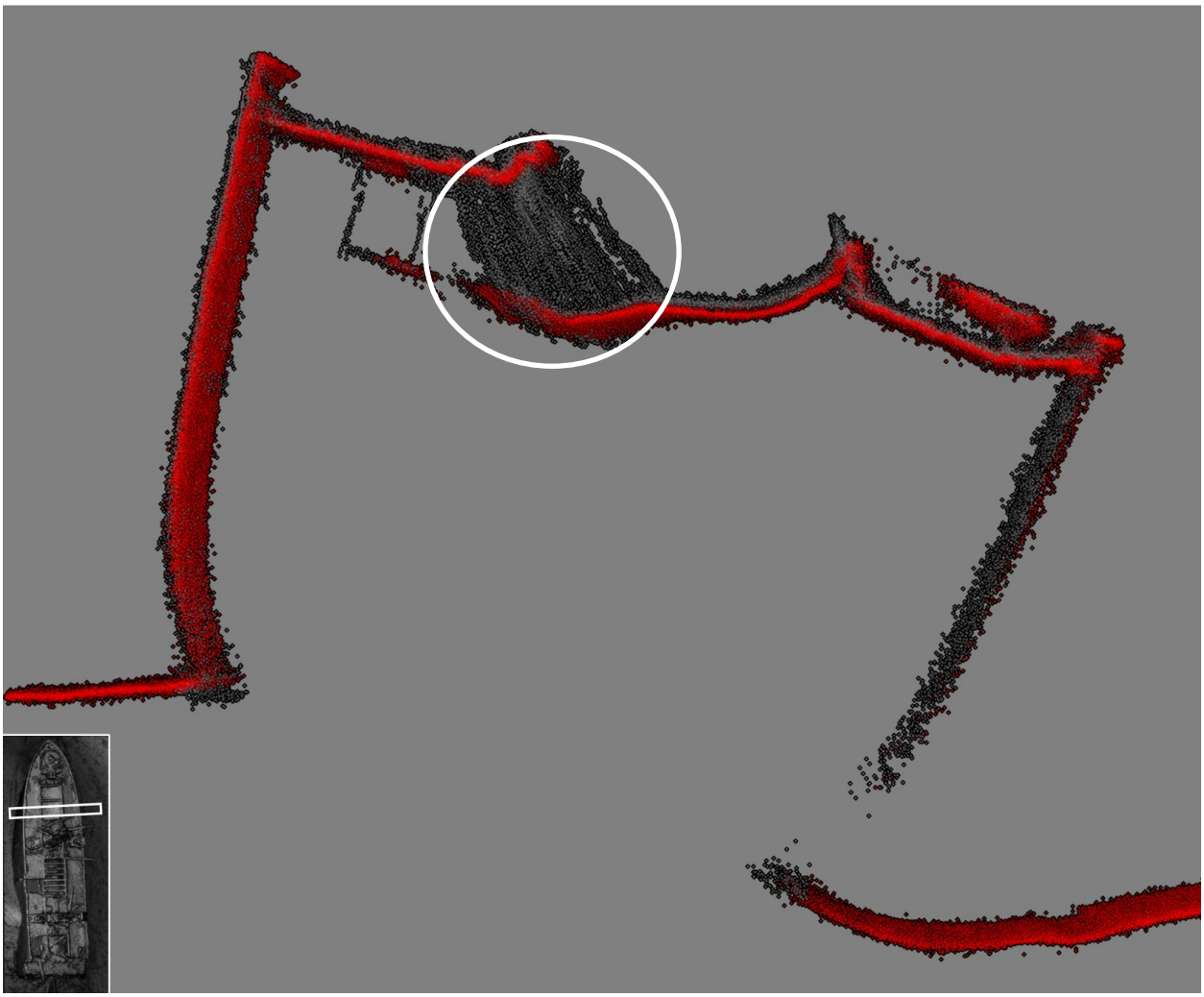

Figure 28. Cross section through the hull at the aft end of no. 1 hatch. Red full survey 2023, grey full survey 2022. Circled is an area where there is a large difference between the surveys, most likely noise in the 2022 survey.

4.4.2 Hold 2

Hold 2 is the second hold from the front. As with hold 1, the outer hatch cover is missing although all the cover supports are in place. The forward section of the wreck is splitting near the mid-way point along no.2 hatch, and this has resulted in part of the upper deck collapsing into the ‘tween deck space bringing the connected hatch cover supports with it.

Sediments are visible in hold 2, but not to the same extent as in hold 1. The sediments have not filled the starboard side of the ‘tween deck area up to the coaming seen in the no.1 hatch (Figure 29, Figure 30, Figure 31). This may be because of cracks in the hull sides at this location which could allow water to flush through and so remove the upper most sediment layers. A previous

report (2022) suggested is also possible that the second deck has partially collapsed where it joins the port and starboard hull (Figure 30), but data collected in the full survey 2023 cannot confirm or deny that statement. However, there is evidence of a reduction in the amount of sediment in the aft end of hold 2 (Figure 31, white circle) of approximately 70cm, which might suggest that the hatch to the second deck may be compromised at this location.

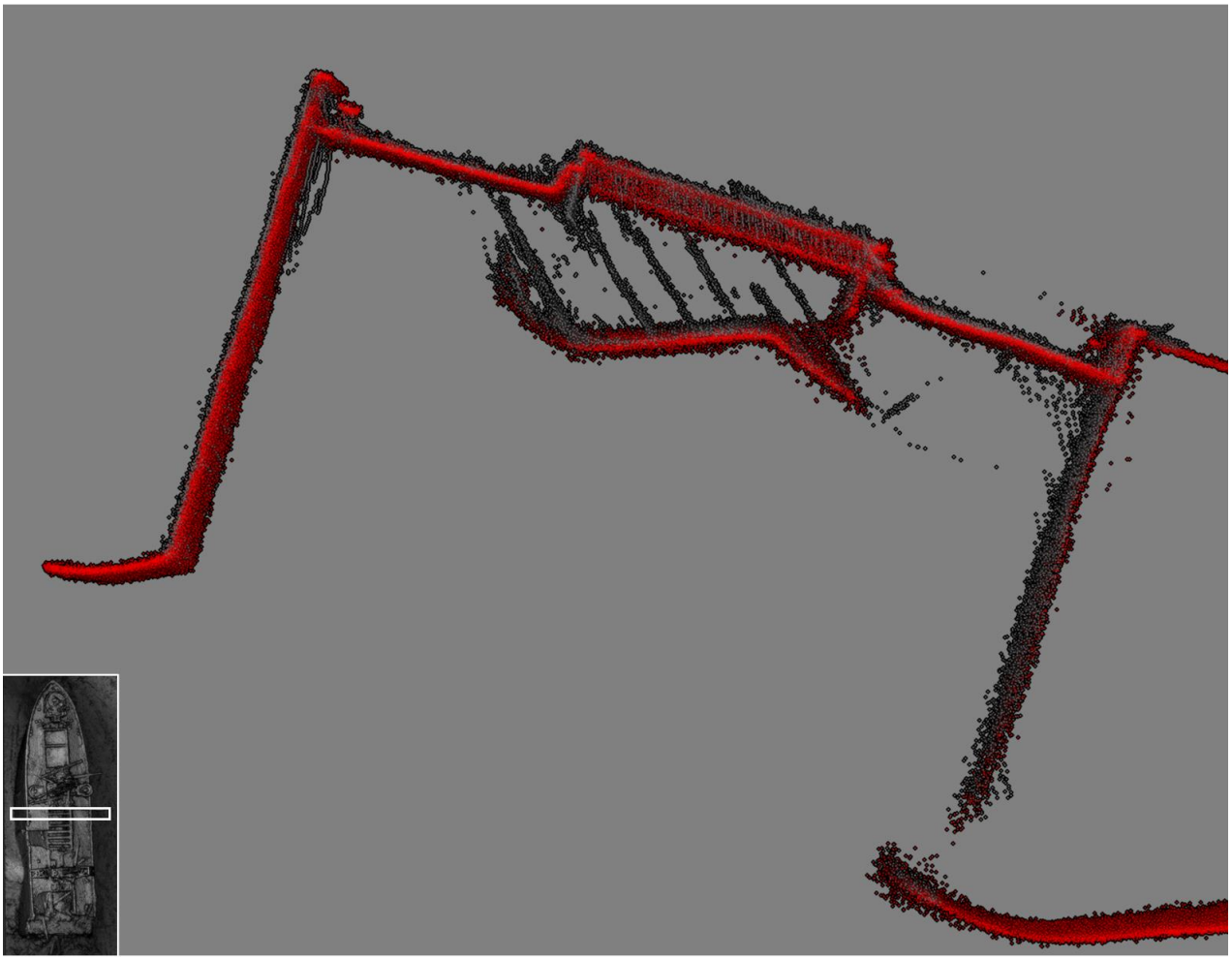

Figure 29. Cross section through the hull at the forward end of no. 2 hatch. Red 2023 full survey, grey 2022 full survey.

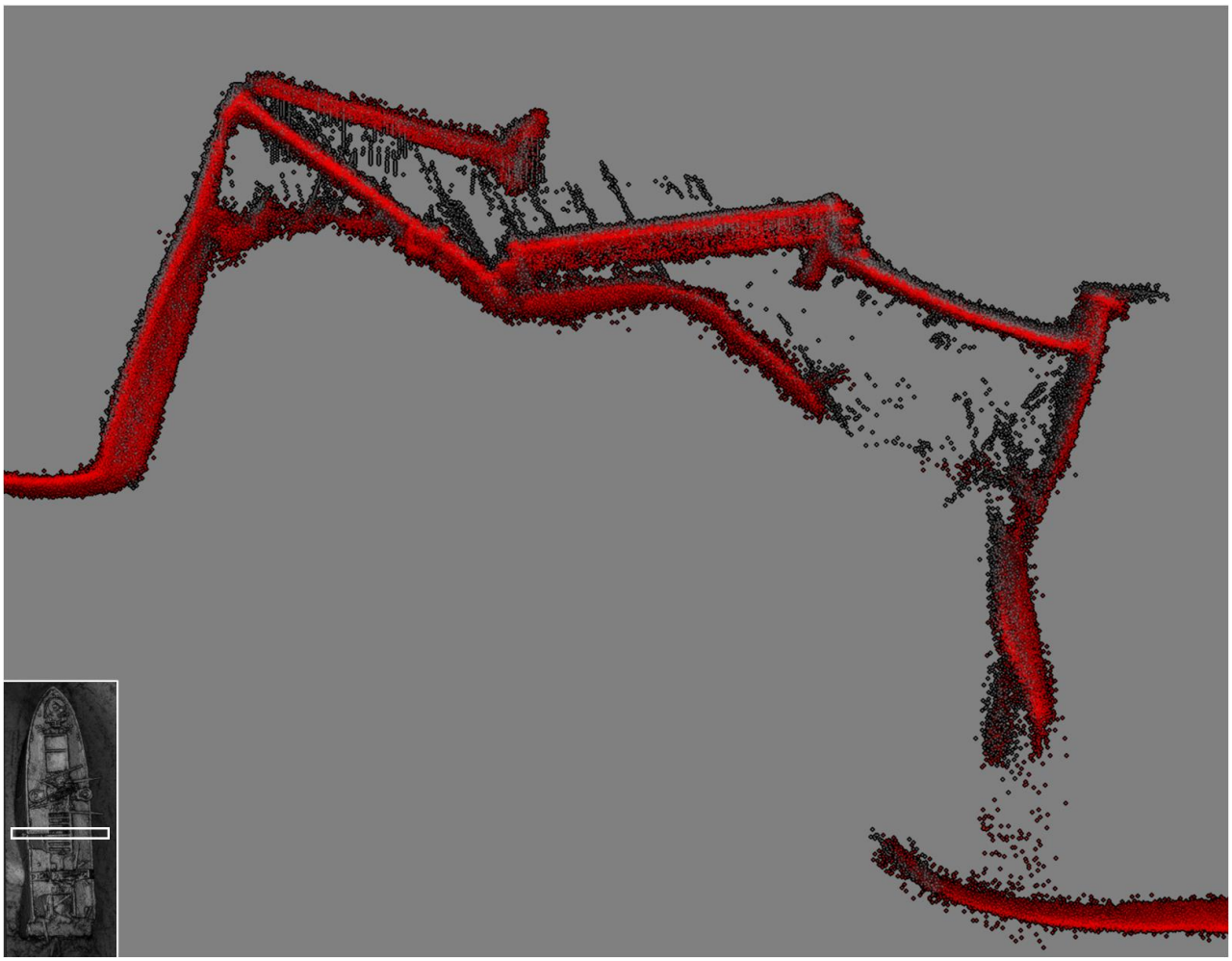

Figure 30. Cross section through the hull where the forward section is breaking in two. Red 2023 full survey, grey 2022 full survey.

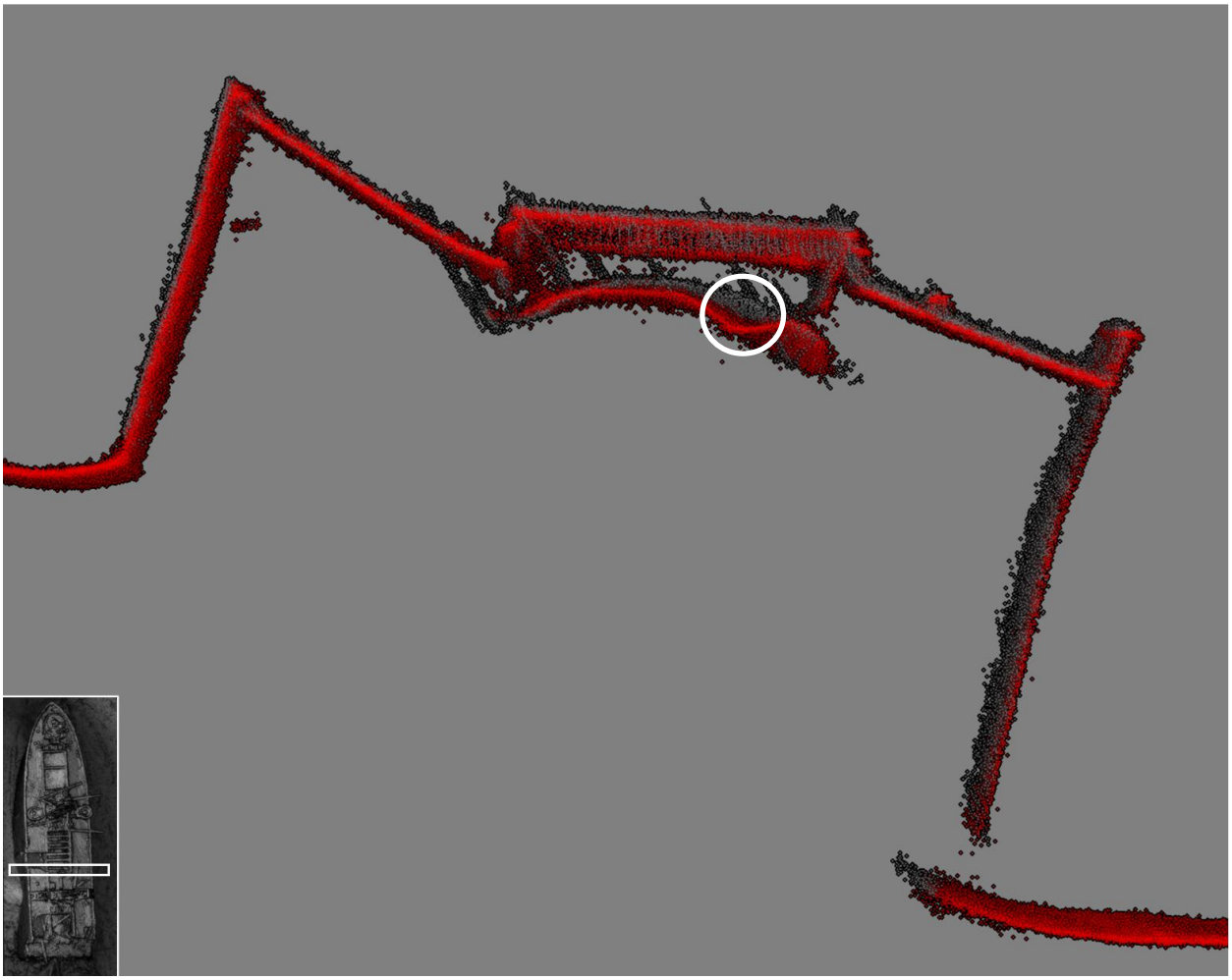

Figure 31. Cross section through the hull at aft section, red full survey 2023, grey full survey 2022. Area of changed sedimentation circled.

4.4.3 Hold 3

4.4.4 Hold 3 is the rearmost hold of the forward section. The rear bulkhead of this hold forms the rear of the forward section, the vessel having broken in two immediately aft. Although the lower hold remained with the forward section, the bulkhead at the rear of the ‘tween deck space and the section of the upper deck above it were carried away leaving this area open. The outer hatch cover has gone as have all the cover supports although there is a beam, most likely a cover support, lying on the starboard side (Figure 32).

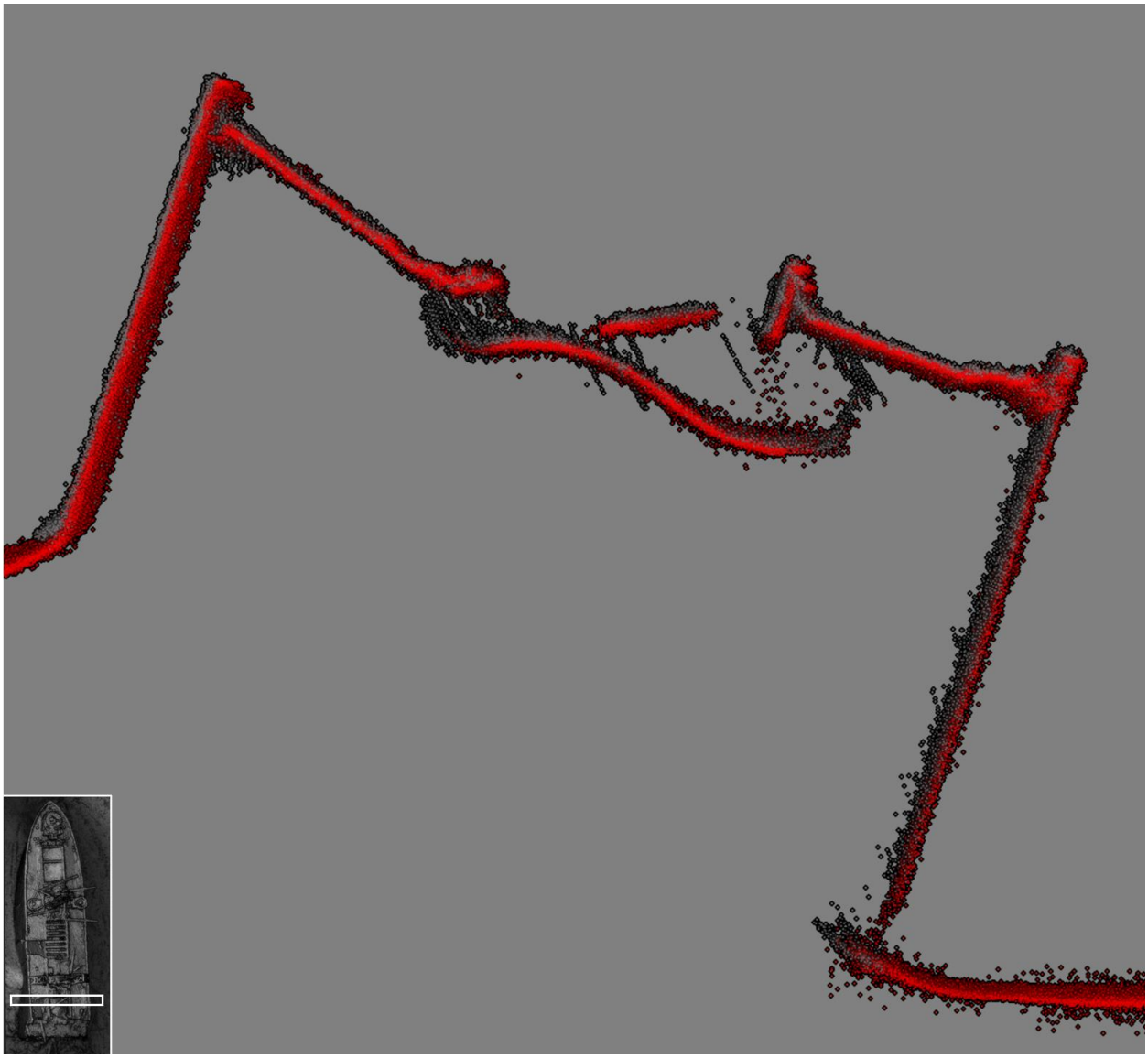

Figure 32. Cross section through the hull at the forward edge of no. 3 hatch. Red full survey 2023, grey full survey 2022.

Sediment accumulation is largely limited to the forward part that still retains the protection of the upper deck. Similar to hold 1 and 2, there is no clear indication that the hatch leading to the second deck has collapsed. However, there is a change in the sediment level in the middle part of the hold where the 2023 full survey shows sediment level has dropped 45cm (Figure 33). It is possible that the sediment has washed of the broken aft end of the forward section of SSRM.

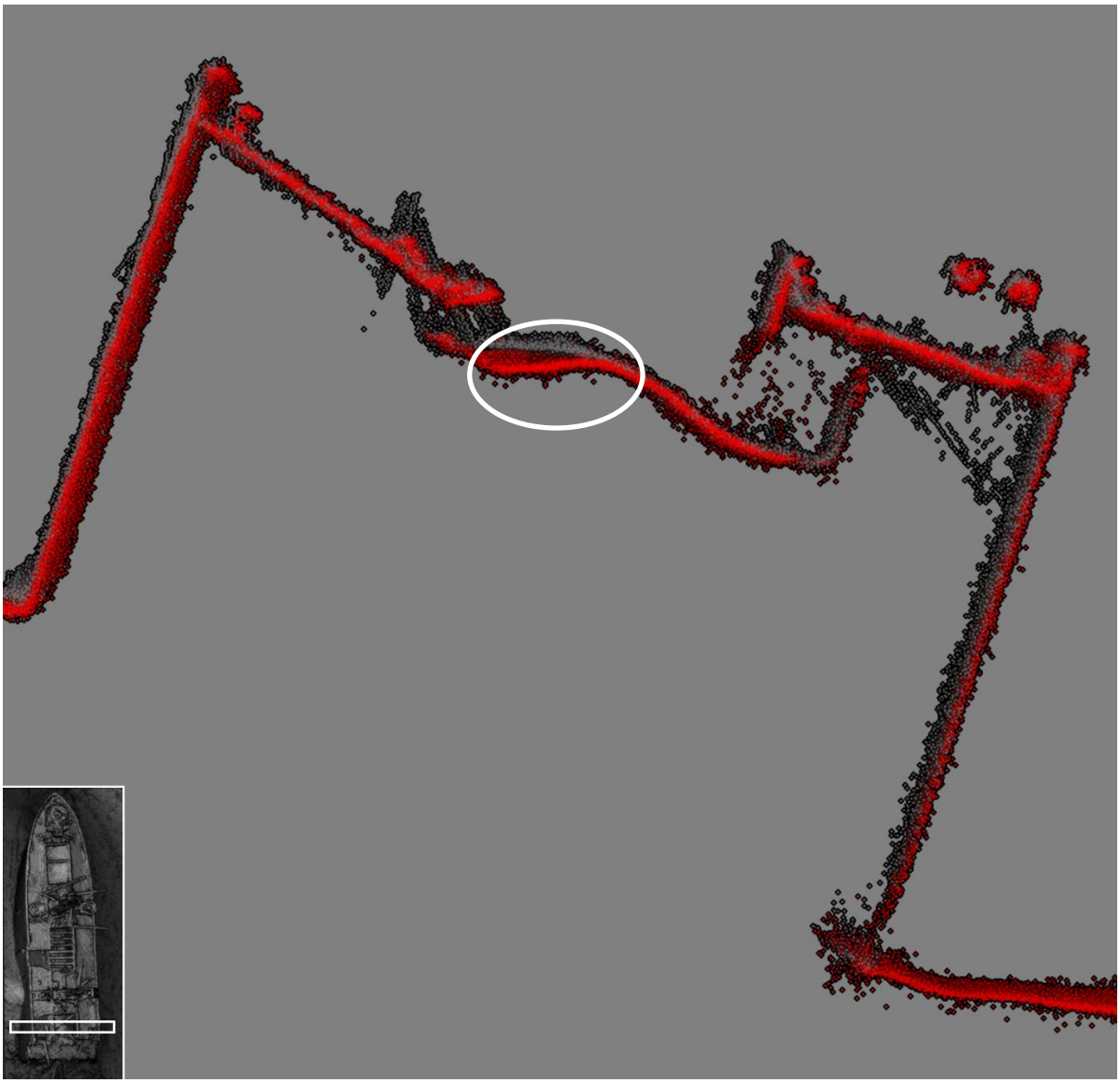

Figure 33. Cross section through the hull at the middle of no. 3 hatch. Red full survey 2023, grey full survey 2022. Difference in sediment level circled.

4.4.5 Hold 4

Hold 4 is the most forward of the two holds in the stern section. Since the two stern holds are reported to have been emptied during salvage operation conducted soon after the grounding, it is not known if the lower hatch covers were replaced. However, since the upper hatch supports are in place it seems likely that the salvors did replace the covers once they were finished.

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

coaming (Figure 34). There is a slight difference in sediment depth on the starboard side between the 2023 and 2022 full surveys.

The rear of the hatch area shows the sediment layer descending below the level of the second deck due to some form of collapse (Figure 35, Figure 36), probably a partial collapse of the lower hatch cover which occurred between 2010 (where the survey showed the sediment above the second deck) and the 2017 survey where the sediment was just below the second deck. The data from the full survey 2023 does not differ from the 2022 data. However, comparisons between earlier surveys were not possible as that data has not been supplied.

Overall, there has been little change in the overall volume of sediment within the hold between the full surveys 2023 and 2022.

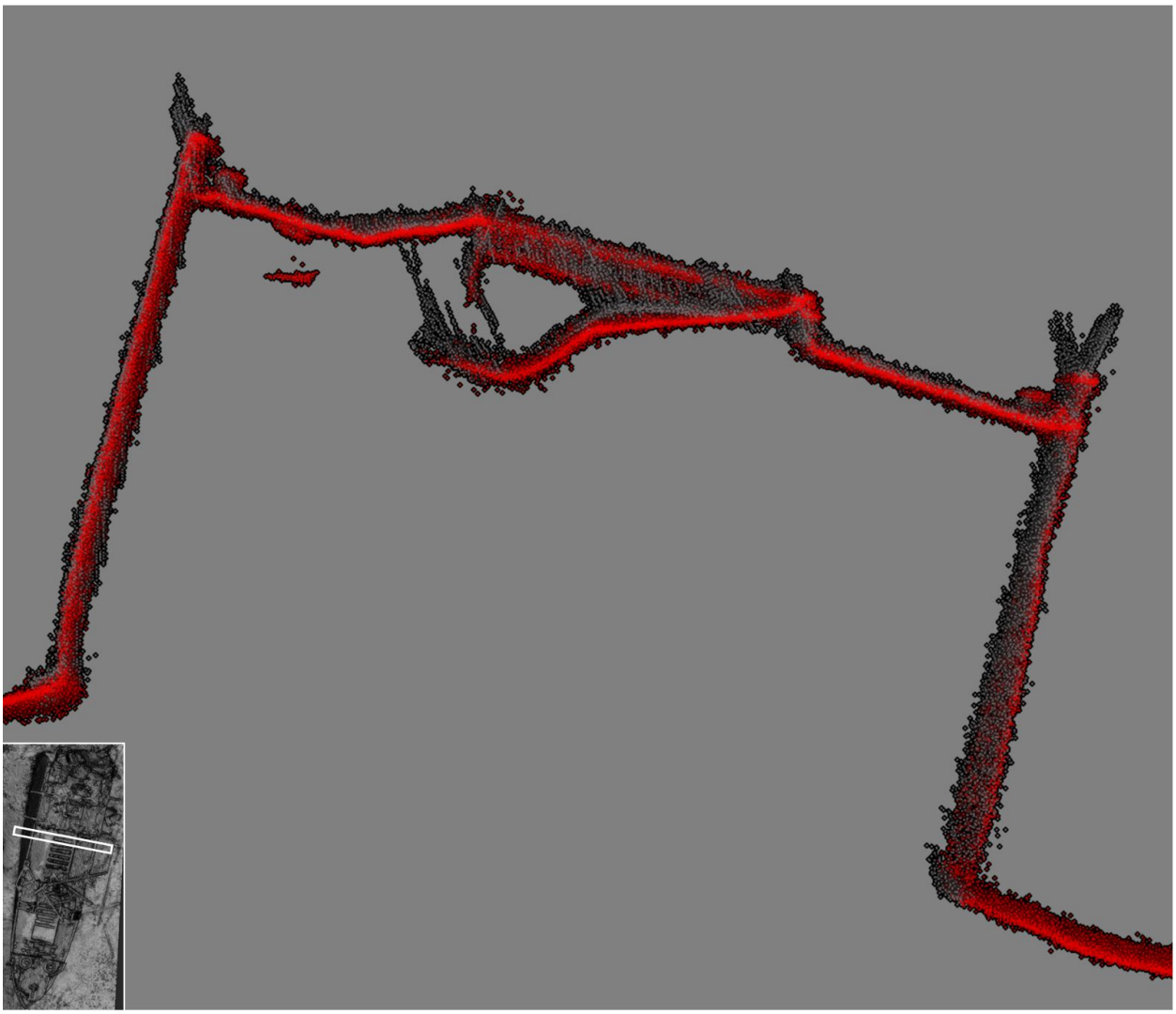

Figure 34. Cross section through the hull at the forward end of no. 4 hatch. Red full survey 2023, grey full survey 2022.

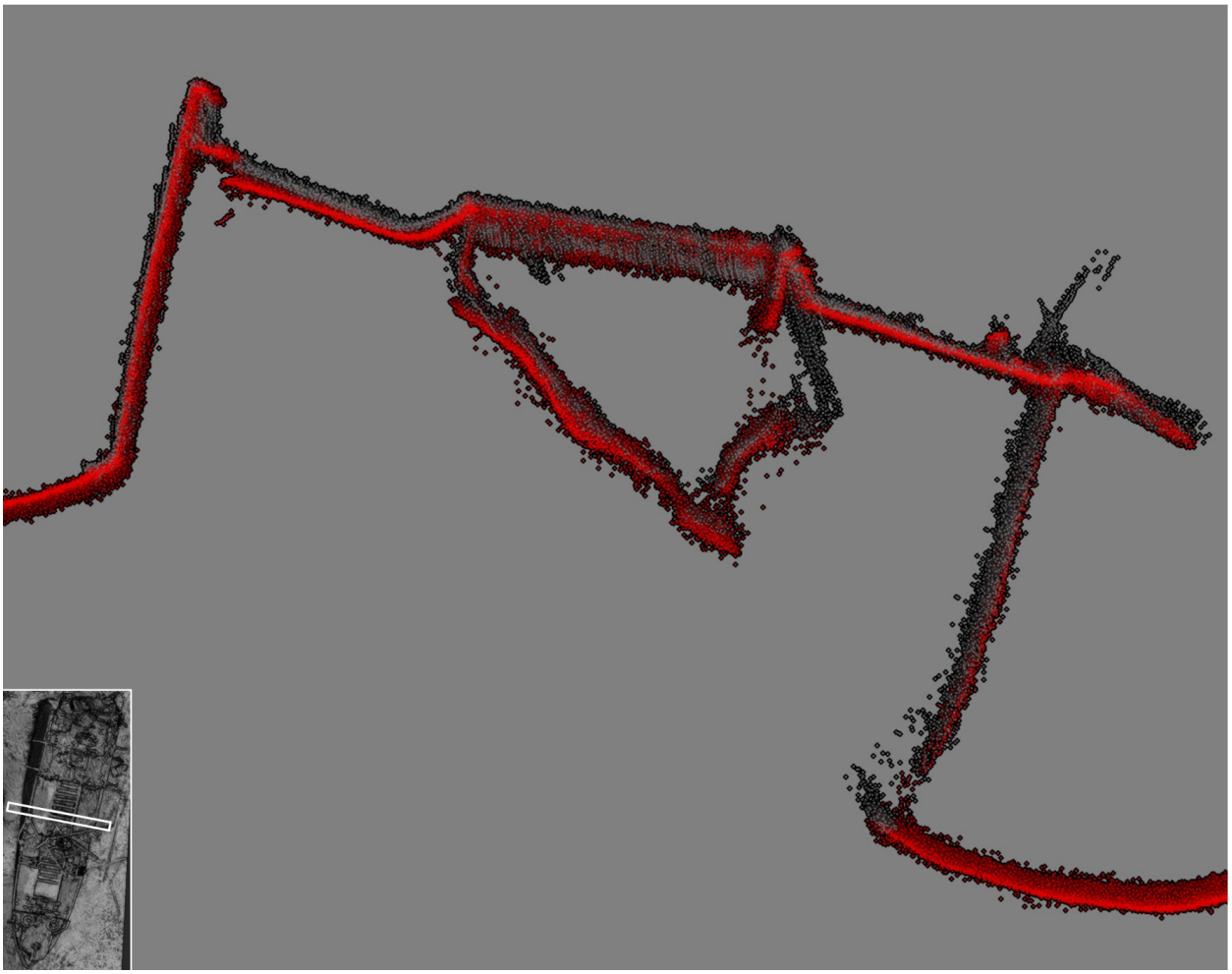

Figure 35. Cross section through the hull at the rear end of no. 4 hatch. Red full survey 2023, grey full survey 2022.

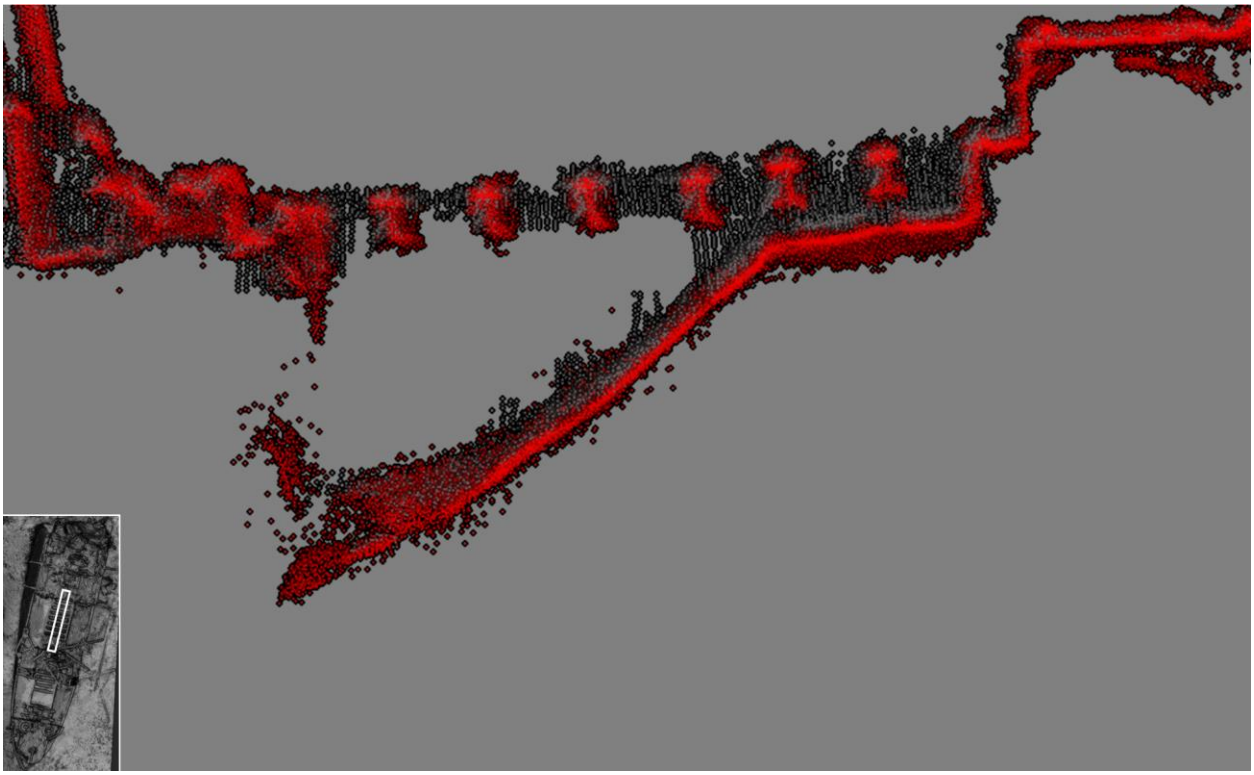

Figure 36. Longitudinal cross section through hold 4. Red full survey 2023, grey full survey 2022.

4.4.6 Hold 5

Hold 5 is the rear most hold. The forward four of the six hatch cover supports remain in place. Sediment levels in the ‘tween deck space looks like hold 1, 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 (Figure 37). There is no indication that the second deck or the lower hatch cover have collapsed. There is less sediment in this hold in the 2023 full survey than the 2022 full survey but no indication of any structural differences.

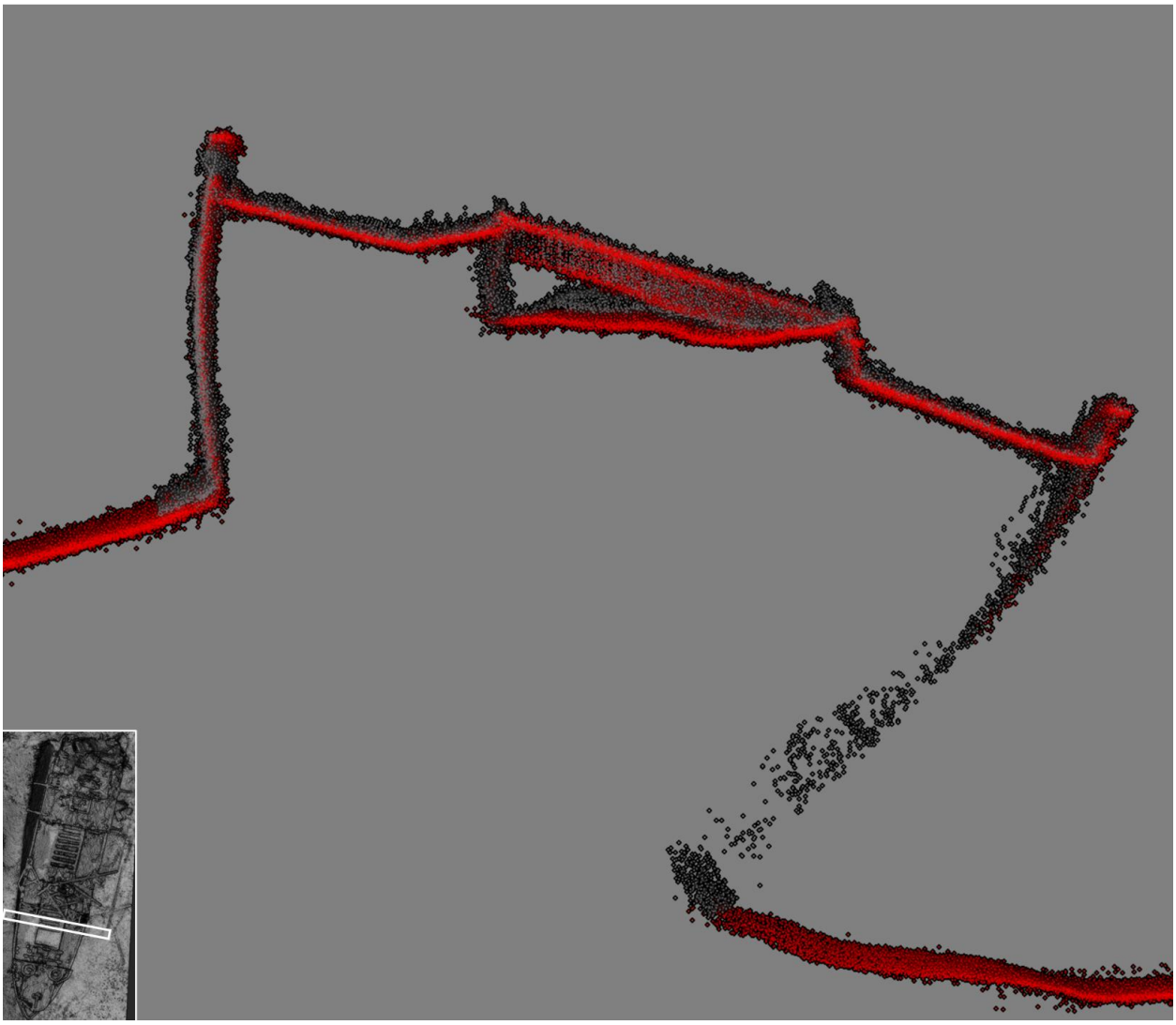

Figure 37. Cross section through the hull at the forward of no. 5 hatch. Red full survey 2023, grey full survey 2022.

5 Seabed survey 2023

The seabed data collected is of high quality and adheres to the density requirement. Previously identified seabed targets from the gazetteer of observations were overlaid and the presence of the targets noted, and new targets added.

5.1 General

An overview of the seabed surrounding the wreck of the SSRM is illustrated in Figure 38.

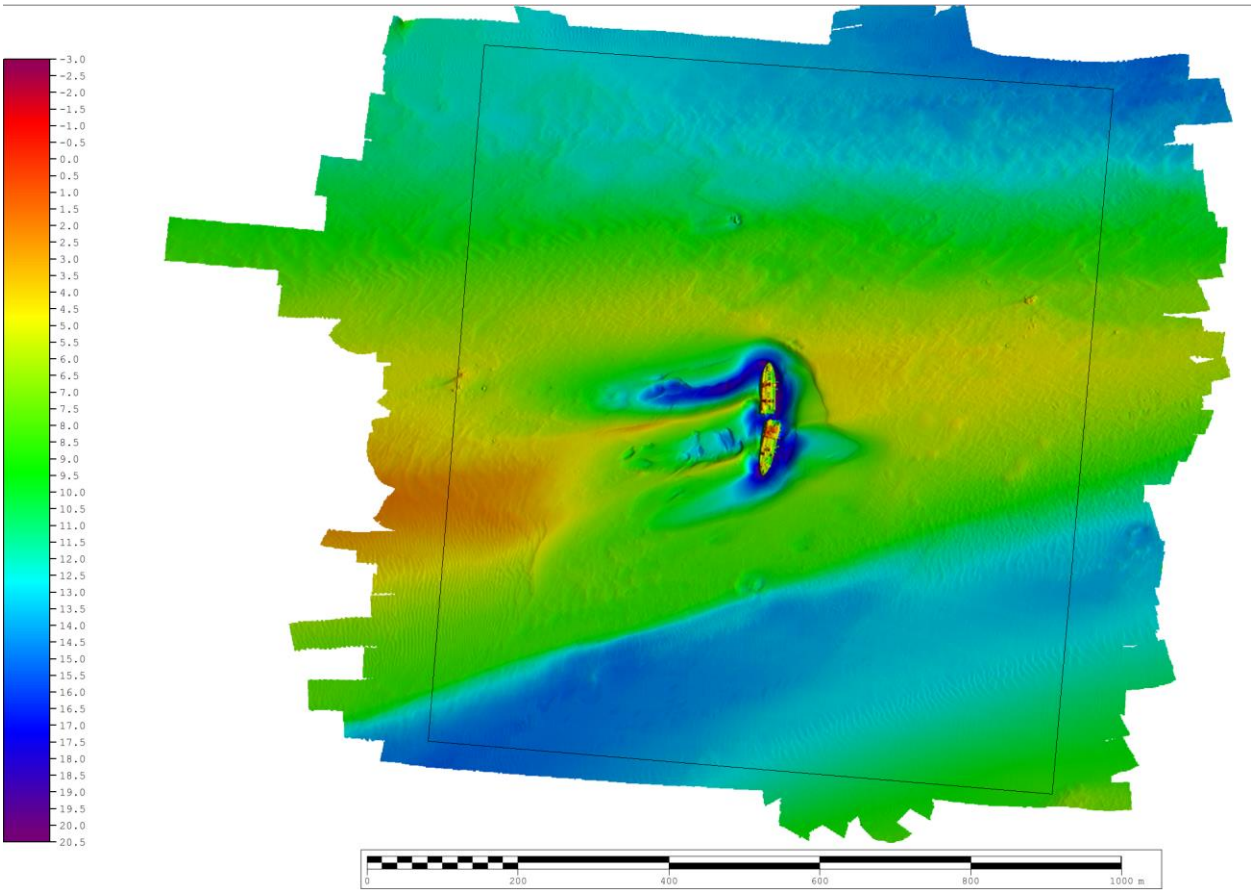

Figure 38. Minimum surface of SSRM and the surrounding seabed.

The analysis of the results of the survey of the seabed around the wreck was carried out with the calculation of a difference surface. The October 2022 data was set as the reference and October 2023 data as the comparison.

In the immediate area surrounding SSRM, a slight decrease in sediments has been observed east of the wreck in the range of 0-0.33m on the forward section. A larger decrease in sediments is visible by the bow section in the range of 0-0.6m. West of SSRM there has been an increase in sediments of 0.33-1m, suggesting eastward movement of the sediments in the immediate area of SSRM (Figure 39).

A general increase of depth has been observed in the seafloor around the wreck between the surveys in 2022 and 2023 in the range of 0-0.33m, with some areas west of SSRM showing greater difference.

The difference model shows that the eastern part of the seabed near SSRM has decreased in depth by 0.3-0.5m, possibly indicating westward movement of the sand previously on the sand ridge. West of the SSRM, there has been some increase in the height of the scour ridges. Some of these ridges show an increase height up to and exceeding 2m.

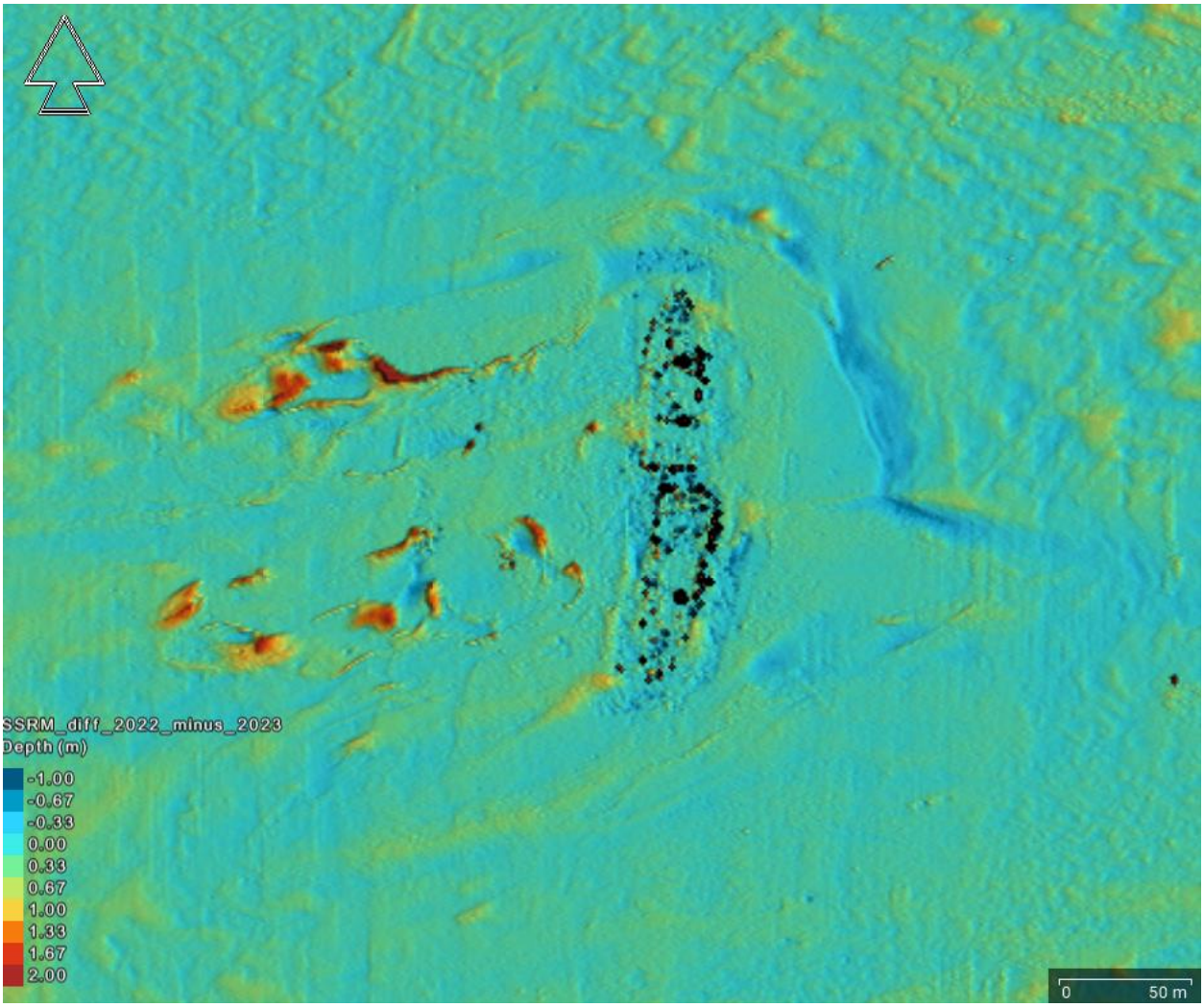

Figure 39. Difference model with full surveys from 2022 and 2023, showing the immediate area around SSRM.

Changes to the wider seafloor around SSRM has occurred mainly directly west of the wreck and northeast of it (Figure 40). On the west side (A) there is a build-up of sediments in in the 2m range in the scour ridges. Further southwest (B) and northeast (C) there are some changes in the sand waves where accretion has occurred. In southwestern area (B) there are slight differences of sand waves increasing by 0.5-1m, but also some erosion of 0.5-1m. In the northwestern area (C) there is a larger increase of height by 0.5-1.5m.

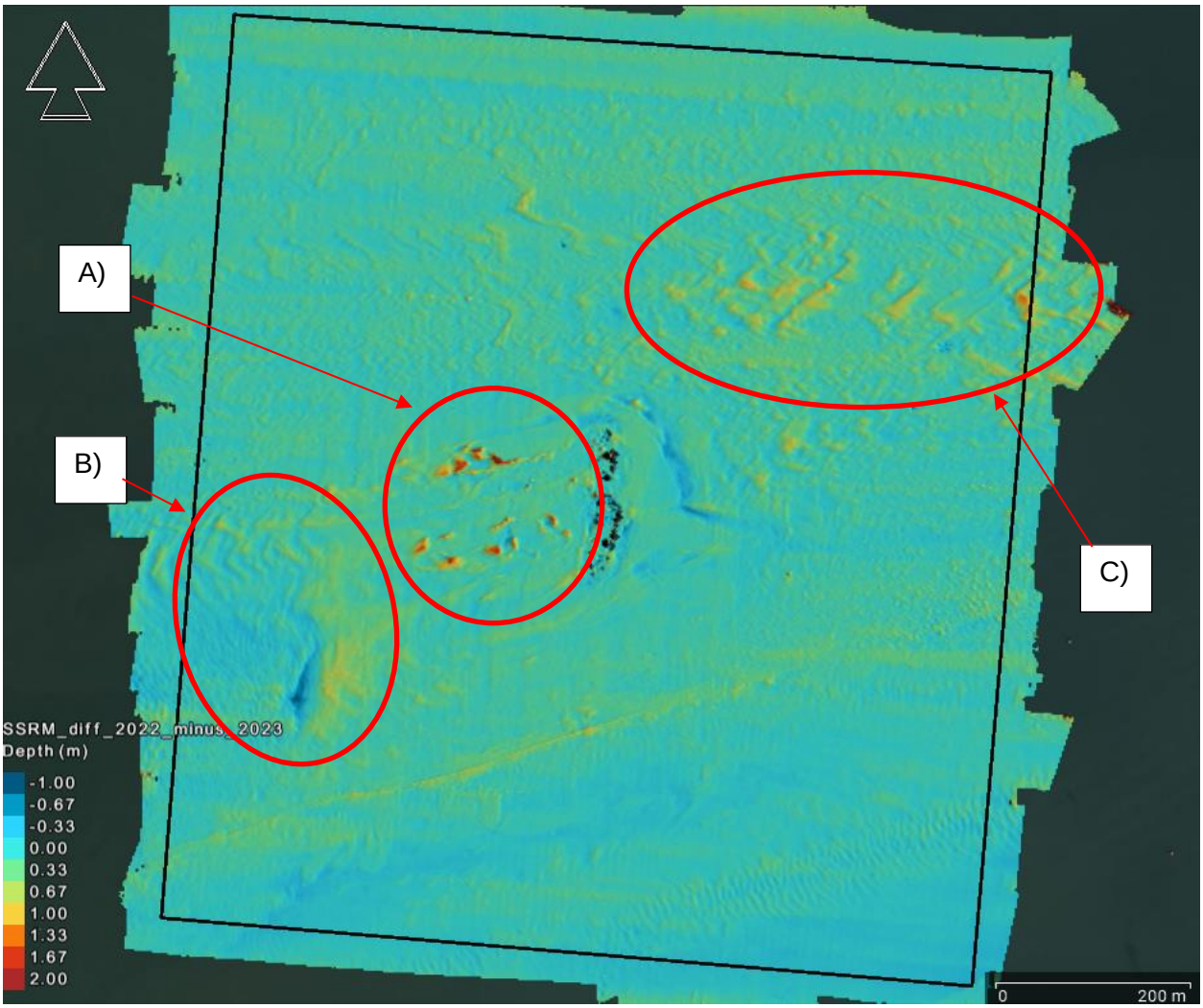

Figure 40. Difference model between 2022 and 2023 full survey, showing the complete full survey area.

5.2 Seabed contacts

Objects on the seabed surrounding SSRM that could be from the wreck, are termed seabed contacts. The seabed contact list from 2017, with a total of 66 contacts was compared against this year's bathymetry. Analysis of the 2023 dataset has added 85 further targets to the contact list, totalling to 151 objects (Figure 41). 17 items from the 2017 contact list are not apparent in the 2023 data. 7 objects were not found at their listed location, but close by, which might indicate movement of the object. One contact was added, although outside the survey area, because of the size of the structure. The seabed contacts, especially the smaller or lower lying ones, are subject to a pattern of being buried and uncovered by moving sediments. Consequently, their presence or not in any year's data set is largely a function of the movement of sediment around and over them.

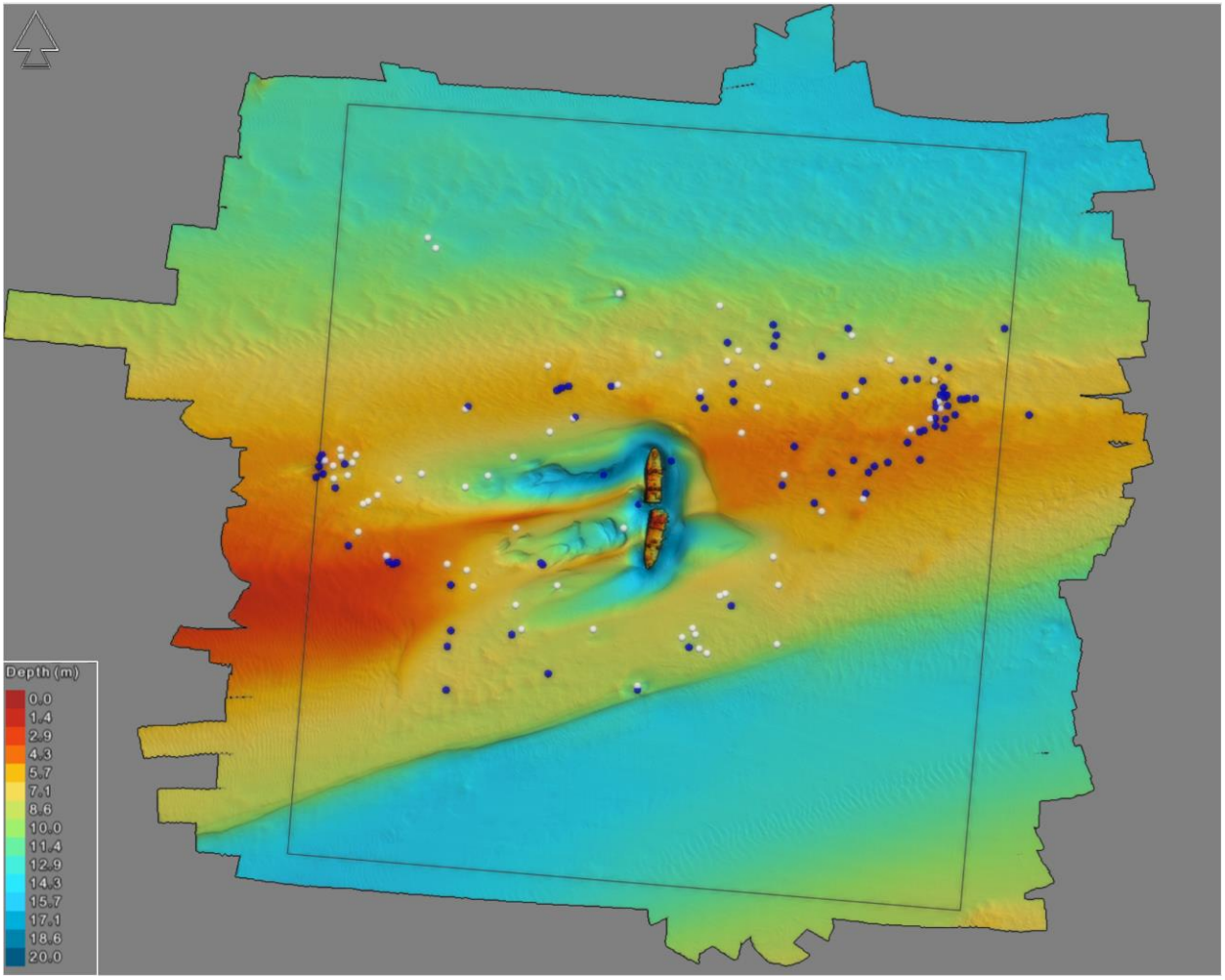

Figure 41. SSRM seabed area with targets (2022 contacts in white) and the added targets from 2023 full survey (in blue)

6 Conclusions

6.1.1 The 2023 survey successfully covered all significant portions of the wreck with high quality MBES data. All key areas and features are well ensonified, providing good resolution of the whole wreck. The surrounding seabed was very well ensonified, enough so that 85 new objects could be detected and added in the gazetteer of observation in the 2023 full survey.

6.1.2 The comparisons between this survey's data (October 2023) and the preceding full survey (October 2022) indicated that changes have occurred in various areas (for example: increase in size of cracks in key areas, more objects hanging over the railing, increased lean of the forward section). However, if all these changes are only due to actual changes or better-quality data and processing of the data cannot be said for certain.

6.1.3 The sea floor survey showed an overall accretion of up to 0.3 m of sediment, with over 2m being deposited in several areas around the scour pit. There is a continuation from prior reports of scour/removal of sediment with a net transport running east to west across the site.

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