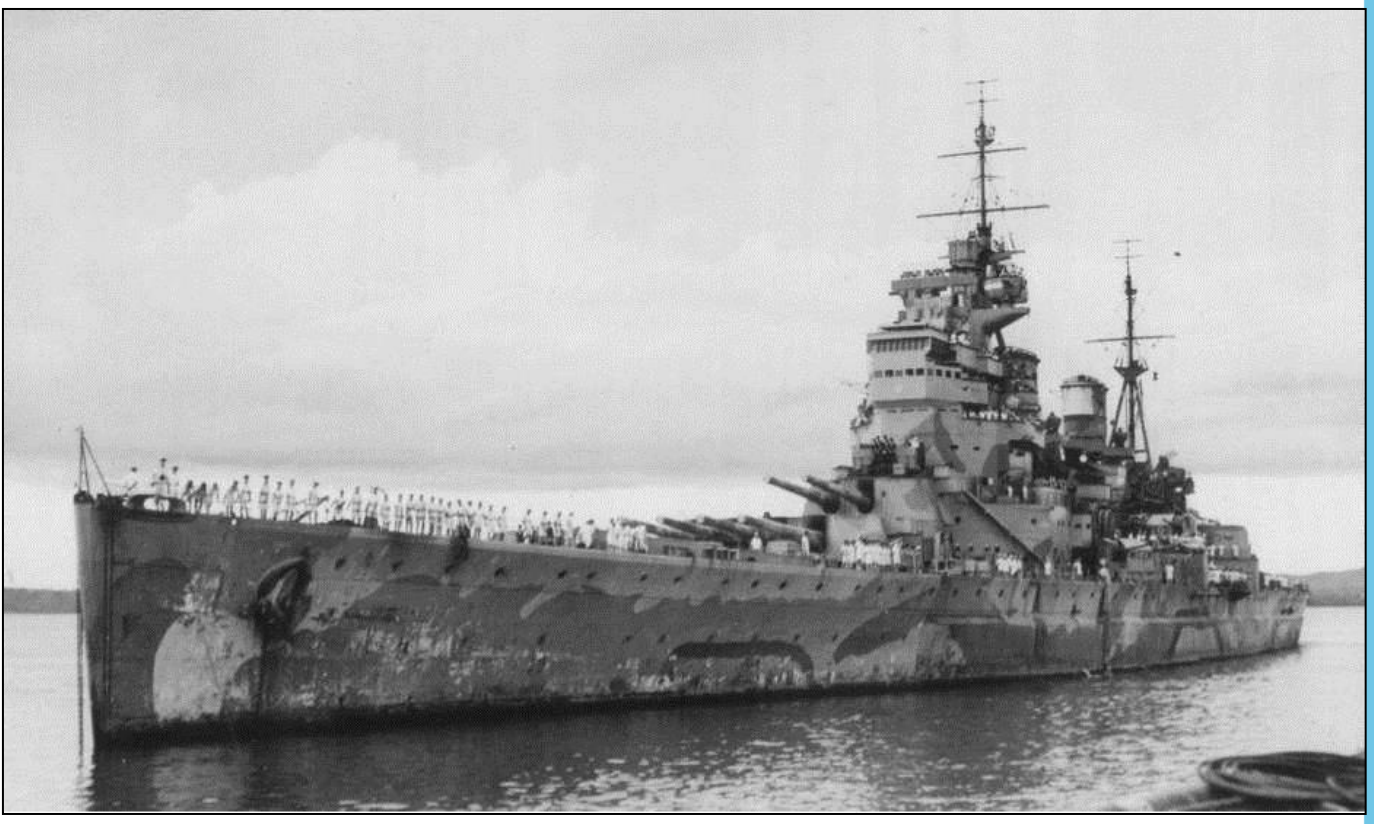
Ministry of Defence

de&s

SALMO
Salvage & Marine Operations

Defence Equipment & Support

Stage 2 Wreck Assessment Report for HMS PRINCE OF WALES and HMS REPULSE



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EXECUTIVE SUMMARY

This report presents the results of an on-site environmental and safety survey of the wreck of the battleship HMS PRINCE OF WALES and the battlecruiser HMS REPULSE. The survey was carried out by Salvage and Marine Operations (SALMO) in March 2019 as part of its Wreck Management Programme (WMP) and in fulfilment of its obligation to manage the environmental and safety concerns associated with post 1870 MOD wrecks. The report focuses on these aspects of the wrecks and does not address the heritage management concerns which fall outside of the responsibility of SALMO.

Historic Desk Based Assessments (Wessex Archaeology 2018(1)/2018(2)) and an Environmental Desk Based Assessment (Arcadis 2016) were completed on the wrecks prior to the survey.

The survey confirmed that both wrecks have been heavily damaged by illegal salvage. Consequently, most of the oil present on them immediately prior to salvage has likely escaped but its exact fate is unknown. The survey found that the salvage has significantly damaged the magazines on the wrecks. While there is no indication that this has triggered any explosion, it has resulted in intact shells and cordite lying scattered throughout the wreck sites.

REPULSE has suffered considerably greater damage than PRINCE OF WALES and may, as suggested by the now missing stern, be in danger of being completely salvaged.

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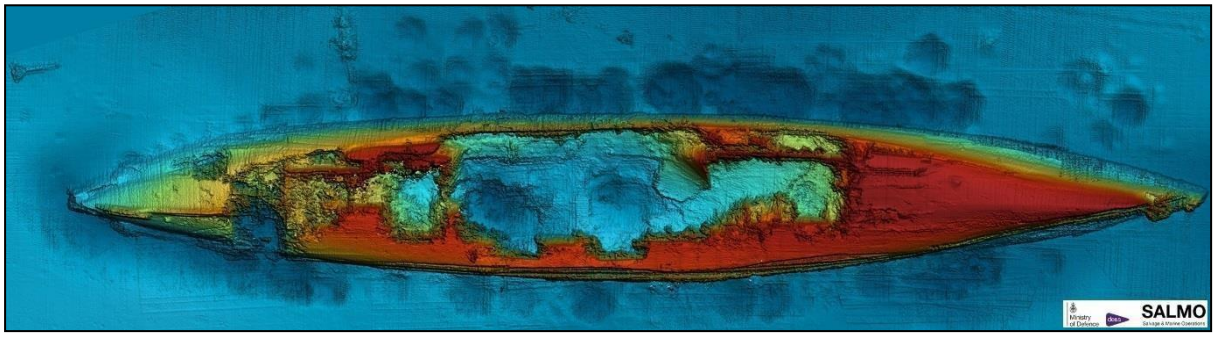
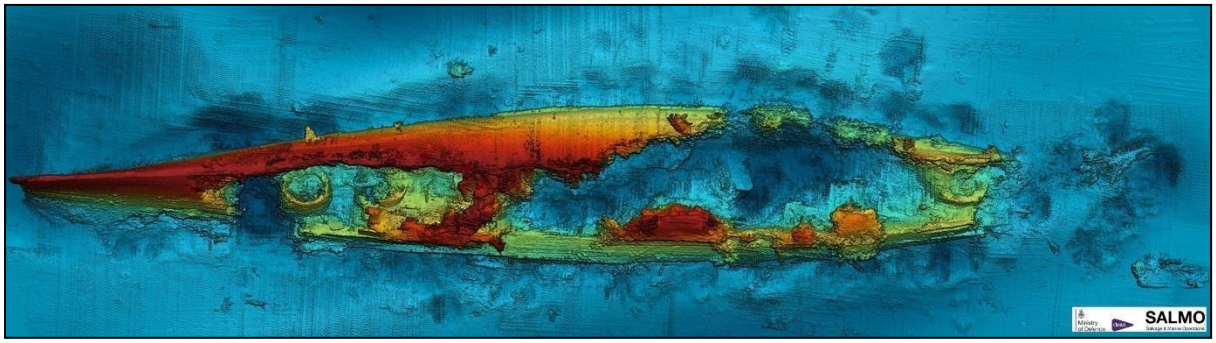


Multibeam image of the wreck of HMS PRINCE OF WALES.



Multibeam image of the wreck of HMS REPULSE.

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ABBREVIATIONS

Abbreviation	Definition
DIFC	Defence Intelligence Fusion Centre
E-DBA	Environmental Desk Based Assessment
EEZ	Exclusive Economic Zone
H-DBA	Historic Desk Based Assessment
PMRA 1986	Protection of Military Remains Act 1986
SALMO	Salvage and Marine Operations
UKHO	United Kingdom Hydrographic Office
WMP	Wreck Management Programme
WROV	Work Class Remote Operated Vehicle

FIGURES

TABLES

1 INTRODUCTION TO THE WRECK ASSESSMENT

1.1 The Wrecks

HMS PRINCE OF WALES and HMS REPULSE were sunk by Japanese aircraft on 10 December 1941 off the east coast of Malaysia (Fig.1). As a result of the attack 327 crew members of PRINCE OF WALES and 508 crew members of REPULSE were lost. In 2001 both wrecks were designated as 'Protected Places' under the Protection of Military Remains Act 1986 (PMRA 1986). However, in international waters the act is only enforceable against British citizens or British-controlled ships interfering with the wrecks.

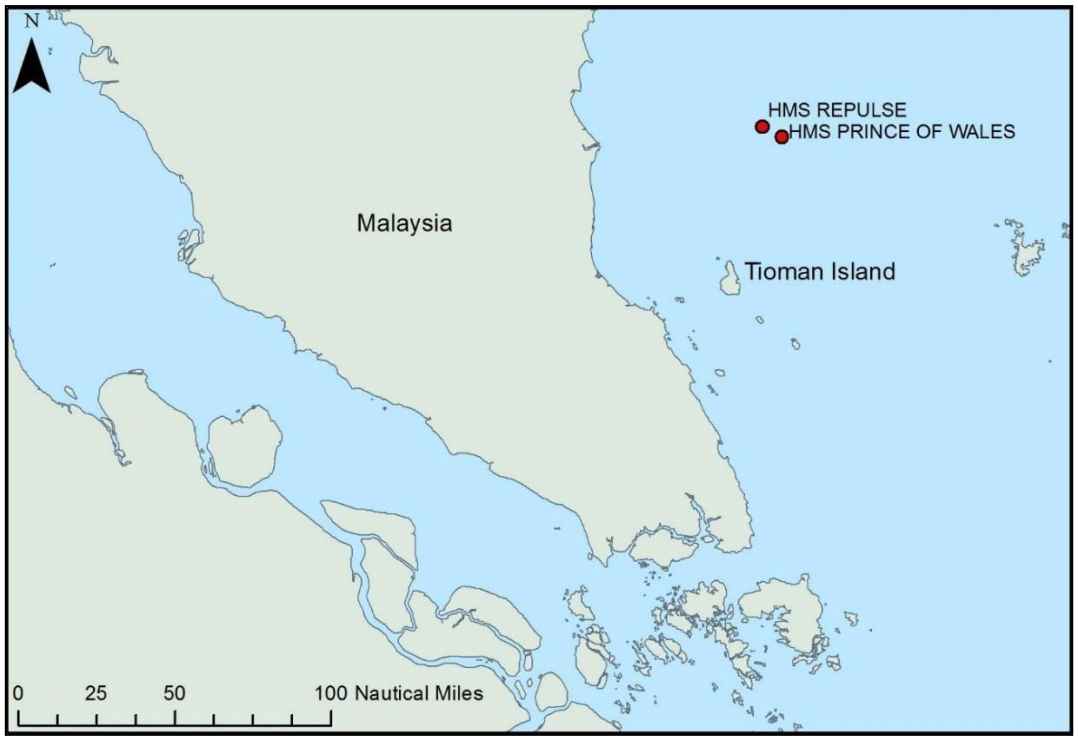


Fig 1. Location of the wrecks of HMS PRINCE OF WALES and HMS REPULSE.

1.2 Description of the Vessels

HMS PRINCE OF WALES (Fig.2) was a King George V class battleship, ordered in July 1936, laid down by Cammell Laird Shipyard in Birkenhead in January 1937 and completed in March 1941 (Burt 2012). The particulars of the ship were:

Vessel length: 227.11m
Vessel beam: 34.29m
Vessel tonnage: 43,786 tons

HMS REPULSE (Fig.3) was a Renown class battlecruiser, ordered in December 1914, laid down by John
Brown Shipbuilding & Engineering Company Ltd in Clydebank in January 1915 and launched in January 1916 (Burt 2012). The particulars of the ship were:

Vessel length: 242.01m

Vessel beam: 34.29m
Vessel tonnage: 32,740 tons

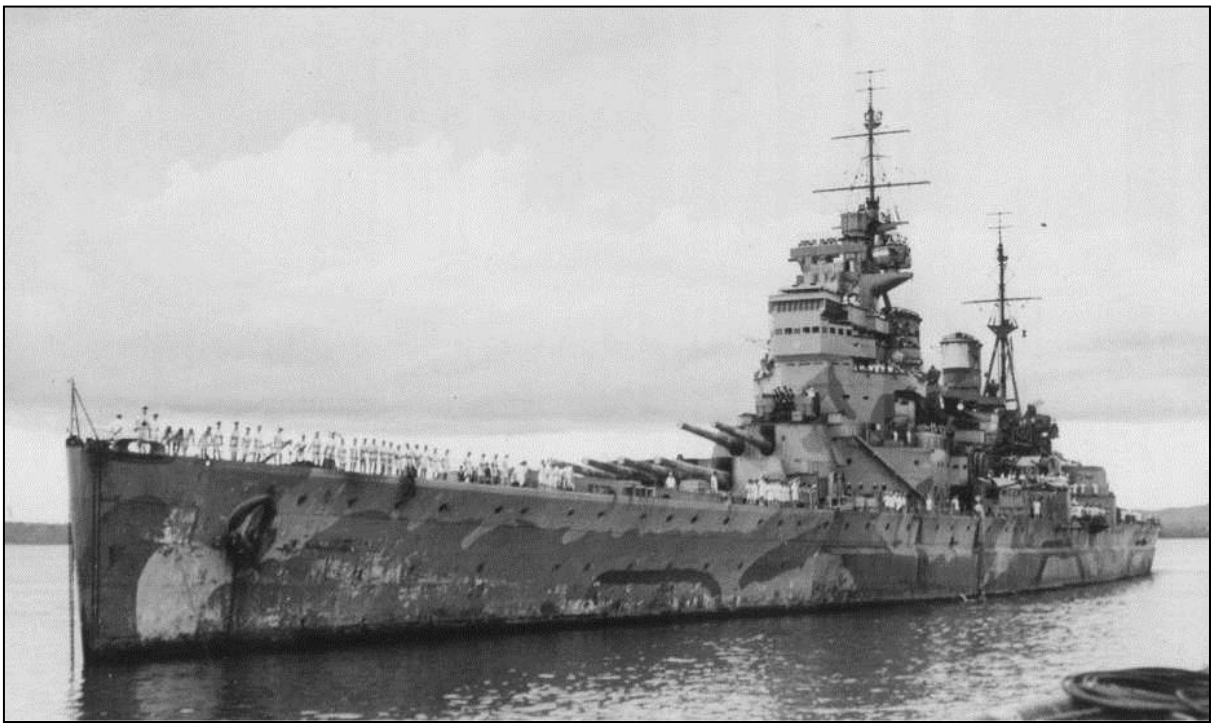


Fig 2. HMS PRINCE OF WALES.

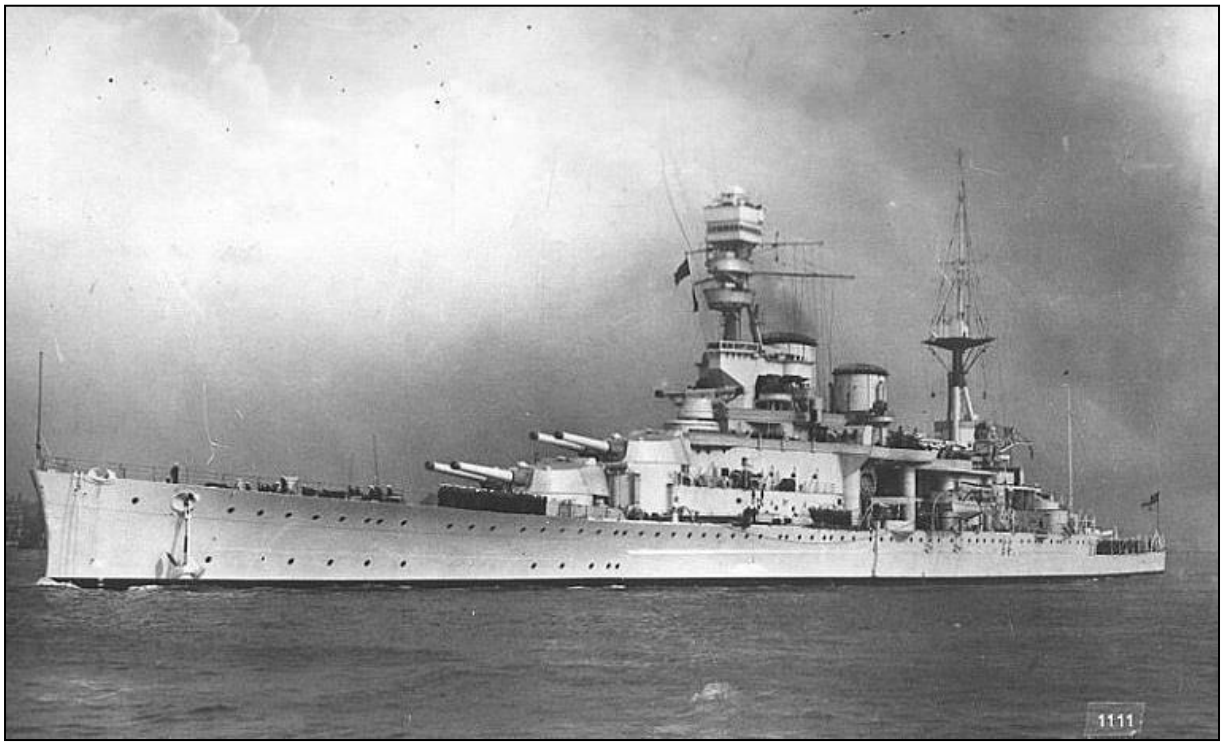


Fig 3. HMS REPULSE.

1.3 Oil Load

On 9 December 1941, one day prior to sinking PRINCE OF WALES reported having 3,390 tons of oil onboard (ADM 199/1149).

The maximum fuel load of REPULSE was 4,289 tons of oil. In the same report as that made by PRINCE OF WALES, REPULSE reported 85.5% of this total (equating to approximately 3,667 tons) remaining on 9 December 1941 (ADM 199/1149).

Both ships expended further fuel in the 28 hours that elapsed between their reports and sinking (note REPULSE was burning fuel at a faster rate). The damage at the time of sinking is likely to have resulted in the loss of significant, though unquantifiable amounts of fuel from both vessels. Thereafter natural decay of the wrecks is likely to have resulted in a slow seepage of oil. Prior to the survey of the wrecks an environmental desk based assessment detailing the potential impacts of the oil remaining on the wrecks was commissioned from Arcadis (Arcadis 2016). For the purpose of the environmental assessment it was assumed that, prior to salvage the wreck of PRINCE OF WALES still contained 1,200 m^3 of oil and the wreck of REPULSE still contained 1,000 m^3 of oil.

1.4 Ammunition Load

It is unclear what quantities of ammunition were carried on each ship. The following figures should therefore be considered approximate. Minor guns, small arms and their ammunition are not listed.

Table 2. PRINCE OF WALES – summary of main armament and ammunition allocation

Main Armament	10 x 14-inch 45 cal Mk VII	2 x quad turrets 1 x twin turret
Secondary Armament	16 x 5.25” 50 cal Mk I HA/LA	8 x twin turrets
	32 – 48 x Multiple 2 pdr	6 x Octuple mtgs
	7-15 x 20 mm	7 x single mtgs
	1 x 40 mm	1 x single mtg
14-inch outload	80 rpg	800
5.25-inch outload	200 rpg	3,200
2 pdr outload	14,450 rp 8 barrel eqpt	86,700
40 mm outload	1,440 rpg	1,440
Depth Charges	Mk VII	24
Catapult Charges	Zone Charges	25
Demolition Charges	Block TNT 1¼ lbs	200
Bombs	dependant on a/c carried: SAP 250 lb – TSR 12, ABR 4 AS 100 lb - TSR 12, ABR 4 GP 40 lb - TSR 12, ABR 4	2 x Supermarine Walrus, so: 8 8 8

Table 2. REPULSE – summary of main armament and ammunition allocation

Main Armament	6 x 15-inch Mk 1	3 x twin turrets
Secondary Armament	12 x 4-inch BL Mk IX	4 x triple mounts PXII
	6 x 4-inch QF	6 x single mounts HA Mk XV
	24 x 2 pdr	3 x octuplet mountings
	8 x 20 mm	8 x single mounts
	16 x 0.5-iinch	4 x quad mounts
Torpedo	8 x 21-inch TT	

15-inch outload	120 rpg	720
4-inch BL outload	220 rpg	2,640
4-inch QF outload	250 rpg	1,500

2 pdr outload	14,450 rp octuplet mtg	43,350
Torpedo outload	Mk IVa	9
Depth Charges	Mk VII	20
Catapult Charges	Zone Charges	25
Demolition Charges	Block TNT 1¼ lbs	200
Bombs	dependant on a/c carried: SAP 250 lb – TSR 12, ABR 4 AS 100 lb - TSR 12, ABR 4 GP 40 lb - TSR 12, ABR 4	2 x Supermarine Walrus, so: 8 8 8

Both ships were in action with aircraft for some time prior to sinking and therefore will have expended considerable amounts of anti-aircraft ammunition. The main batteries were not used and so their ammunition remained undisturbed in the wrecks until salvage commenced.

1.5 Circumstances of Loss

On 10 December 1941 HMS PRINCE OF WALES in company with HMS REPULSE and an escort of four destroyers (designated Force Z) were returning to Singapore following an attempt to intercept a Japanese invasion fleet bound for Malaya. The warships were detected by a Japanese submarine and subjected to a series of attacks by a force of 86 bombers and torpedo bombers. Both HMS PRINCE OF WALES and HMS REPULSE were hit by numerous bombs and torpedoes resulting in their sinking.

1.6 Previous Activity at the Wreck Sites

The ship's bell from PRINCE OF WALES was recovered by an MOD team in 2002 when concerns were raised that it was in danger of being removed from the wreck (http://www.forcez- survivors.org.uk/news/shipsbells.html (Accessed May 2019)). The bell is now on display at Merseyside Maritime Museum.

In 2007 a private research survey Expedition 'Job 74' examined the hulls of both PRINCE OF WALES and REPULSE (Denlay 2007). The survey detailed the nature of the damage to the hull of PRINCE OF WALES resulting from the air attack and the exact location and number of the torpedo hits (Fig 4).

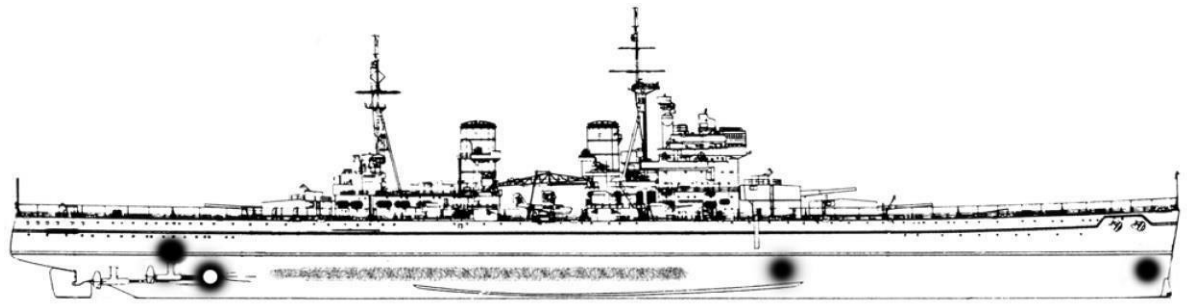


Fig 4. Location of the four torpedo hits on PRINCE OF WALES. Black solid circles = starboard side torpedo hits / Black outline circle = port side torpedo hit. After Denlay 2007.

The survey also highlighted the damage caused to REPULSE during the air attack although, owing to poor visibility and the build up of sediments along the port hull amidships it was not possible to determine if torpedoes had hit this area (Fig 5).

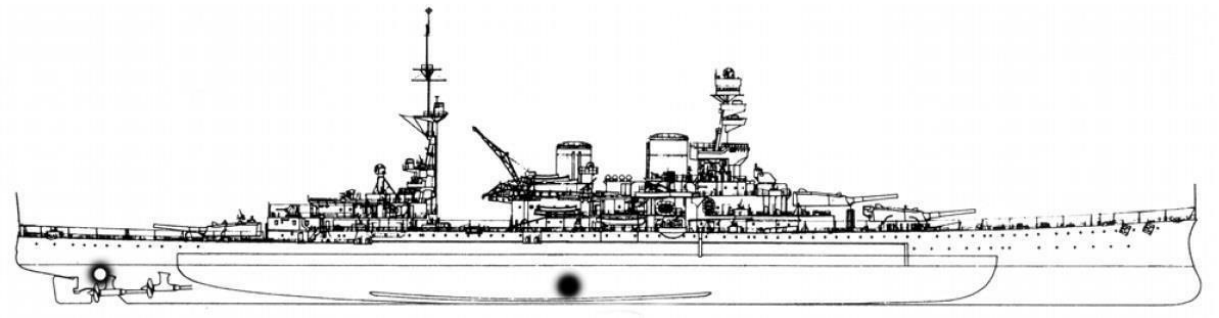


Fig 5. Location of the two torpedo hits on REPULSE. Black solid circles = starboard side torpedo hits / Black outline circle = port side torpedo hit. After Denlay 2007.

The 2007 survey of the wrecks and the subsequent detailed analysis of the damage to PRINCE OF WALES (Garzke et al 2012) are important for showing their condition prior to salvage. At that time the only significant damage to the wrecks was that resulting from the torpedo/bombs which sank the ships, the sinking process and natural decay.

While the damage that caused the ships to sink likely resulted in the loss of significant amounts of oil it is probable that, until disturbed by salvors, considerable quantities remained on each wreck. The same is true of the ammunition onboard them.

Salvage of the wrecks took place from 2013 and possibly earlier. Since then it appears to have occurred with intermittent intensity and has been widely reported in the British press. During this period various attempts have been made in concert with the Malaysian government to stop the activity. While these have resulted in occasional successes the results of this survey indicate that both wrecks have now suffered very severe damage.

Although both wrecks have now been subject to extensive, and likely prolonged salvage the activity has rarely been directly observed. However, various reports on social media suggest that fisherman have dived the wrecks to place explosives on them. These have weakened the structure which has then been 'mined' by dedicated salvage vessels using grabs (see for example https://www.graypage.com/thought-leadership/strange-case-disappearing-ship-wrecks/ (Accessed May 2019)). The preferred targets appear to have been high value items in the machinery spaces (containing copper etc) and armour plate. However, other wrecks in the Far East (notably HMS EXETER) have been removed in their entirety. It appears that REPULSE is particularly vulnerable and is in danger of being completely removed as indicated by the removal of much of the stern from the wreck.

2 ON-SITE SURVEY

2.1 Location of the Wrecks

HMS PRINCE OF WALES lies off the east coast of Malaysia approximately 68NM south east of the port of Kuantan in position 3°34'3.30"N / 104°27'51.78"E. HMS REPULSE is located in position 3°37'14.23"N / 104°20'42.65"E approximately 7NM to the north west of PRINCE OF WALES. Both wrecks lie within Malaysia's Exclusive Economic Zone (EEZ).

2.2 Survey Aims

The aim of the survey was to determine whether oil, ammunition or any other potentially harmful material remains on the wrecks and to assess any risk these still pose. The focus therefore was on the hull rather than on the superstructure of the vessels where the majority of any potentially hazardous material would have been stored.

The survey was undertaken with the consent of the Malaysian government. Two members of the Royal Malaysian Navy accompanied the survey and a copy of the data collected was passed to them.

2.3 Survey Methodology

For the purpose of the survey SALMO chartered multi-purpose service vessel the [redacted] from Itech, the Life of Field business unit of Subsea7. The [redacted] came equipped with i-Tech 7s Centurion SP Work Class Remote Operated Vehicle (WROV) and survey capability and project crew. The contracted team were supported by SALMO personnel.

The work comprised:

- An initial sidescan survey of each wreck to confirm position, general condition and the extent of the surrounding debris field;
- a WROV mounted multibeam echosounder survey of each wreck to capture a 3D model of their hulls and the surrounding seabed;
- a WROV mounted video and stills imagery survey of each wreck;
- the collection of environmental samples to determine whether oil was present in the sediments around each wreck.

2.4 Survey Conditions

The survey was carried out from 22-27 March 2019 immediately following the end of the Northeast Monsoon season. Throughout, the weather was hot and sunny with clear skies, sea surface conditions were calm and no time was lost to adverse weather. Subsea conditions were generally favourable although visibility was somewhat variable likely owing to the stirring up of sediments by the recently ended monsoon.

As a consequence of the relative shallowness of the wrecks, and the brightness of the sunlight, the WROV video and stills survey largely took place at night when more clearly defined results were achievable.

2.5 Survey Findings – PRINCE OF WALES

Note, any reference to port and starboard in the discussion below refers to the ship as afloat. The sidescan of the wreck and a selection of multibeam and stills photographs are in the appendices. Figure 6 shows the wreck as it appeared in 2007 prior to salvage. Figure 7 shows the wreck annotated with the points of interest noted in the following discussion. Figure 8 shows the original distribution of oil tanks on the ship and the areas in which they potentially survive on the wreck.

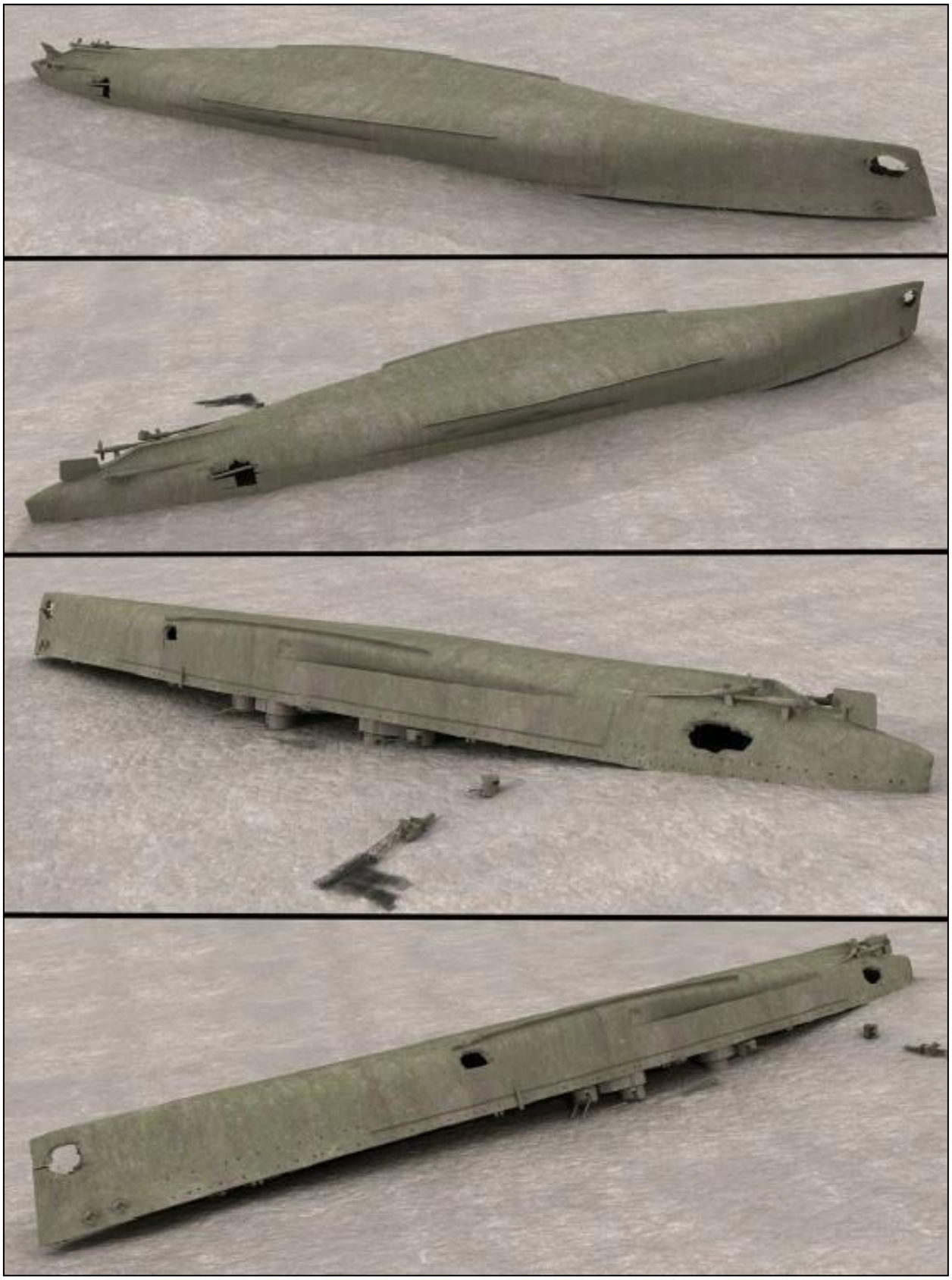


Fig 6. Artists impression of PRINCE OF WALES in 2007 prior to salvage. At that time the only damage was from the torpedoes and bombs that sank the ship. After Garzke et al 2012.

PRINCE OF WALES lies upside down in 68m of water. The wreck is orientated 016/196° at a list to port of between 10 and 15°.

The port side amidships was noted as partially buried by sediment in the 2007 survey (Denlay 2007: 9). However, as discussed below, the salvage has resulted in the removal of this material along both sides of the wreck leaving the section exposed. The superstructure has largely been compacted by the weight of the overlying hull into the soft sediments that characterise the area. However, amidships the superstructure is partially visible and at this point it holds the starboard side of the hull up off the seabed.

The sidescan and multibeam surveys show very little debris around the wreck. It is impossible to determine whether this reflects the original state of the debris field, though there is the possibility that larger items may have been removed by the salvors while smaller items might have been covered by sediment over time. The only significant items appear to be the boat crane which lies off to the starboard side aft and an inverted 5.25-inch turret lying between them (1). These were not observed during the survey but are just discernible on the multibeam. One of the propeller shafts now sits off the starboard stern (2).

The multibeam and video/stills survey of the hull revealed the following. The port side of the vessel is substantially intact from the bow as far back as the torpedo damage at the stern (3). It appears that this has been used as a convenient point of entry by the salvors who have considerably enlarged the hole from its original extent. It now extends for the full height of the side at this point and over onto the bottom of the hull compromising the fuel tanks in this area. Further aft the propellers have been removed (4).

The starboard side of the ship bore the brunt of the torpedo damage (3 hits) and has also suffered greater salvage damage than the port side. The bow stem exhibits damage from the torpedo hit that punched through and out of the port side of the vessel (5). From this point, moving aft the starboard side is relatively intact until, in the vicinity of 'B' turret, a zone of significant damage appears (6). The start of the damage is in the approximate position of the torpedo strike that occurred at this point. Again, the suspicion arises that the torpedo hole has offered a convenient weak point for the salvors. The damaged section extends up and over the bottom of the wreck and runs as far aft as the approximate position of the after funnel (7). For much of this section the side of the ship is degraded to perhaps half its original height. Owing to the extent of the damage it is unlikely that any of the side fuel tanks in this area survive. Aft of this point the starboard side is relatively intact until the torpedo damage at the stern (8). Along both sides of the ship the seabed has been 'scooped' out but this is particularly marked on the starboard side (9). It is likely that the scooping is the result of the actions of the grab/s used by the salvors, perhaps gathering up material that had fallen to the seabed when working the hull.

The bottom of the ship has suffered extensive damage extending from 'B' turret to the after funnel. The salvors have effectively hollowed out the entire midships section to the level of the seabed and have possibly mined into this as well (10). The focus of the activity appears to have been the engine rooms and the items of high salvage value contained within.

The damage to the bottom of the wreck and its penetration to the interior has undoubtedly compromised the majority of the tanks in this area. Potentially some may survive towards the bow (11) but even here, where the hull survives in a more intact state it is doubtful whether they could have survived the combined shock of explosives and grabs in use nearby. Determining the exact quantity of oil remaining onboard the wreck is probably a futile task given the effect of such concussive force.

The wreck is strewn with loose ammunition of various sizes as well as cordite rods. Some of the cordite likely originates from the now rotten silk cartridge bags in which charges for the

larger guns were stored. Smaller guns made use of brass cartridges and it is possible that these have been gathered by the salvors and their contents emptied over the wreck. Consequently, quantifying the remaining ammunition on the wreck is difficult. It is likely that 'A' turret magazine survives relatively intact. However, that for 'B' turret is likely to have been entirely removed leaving what appears to be the barbette of this turret visible in the multibeam (12). There is heavy damage to the hull beneath 'Y' turret although this does not appear to penetrate very deeply into the wreck. It is therefore likely that the magazines in this area have been disturbed but not totally destroyed. The magazines for the secondary, 5.25-inch guns were concentrated in the ship's hold in sections of the wreck (13-14) which have been heavily compromised.

Fishing net was present at various places on the wreck site although any damage resulting from this appears negligible in comparison to that caused by salvage.

No human remains were encountered during the survey.

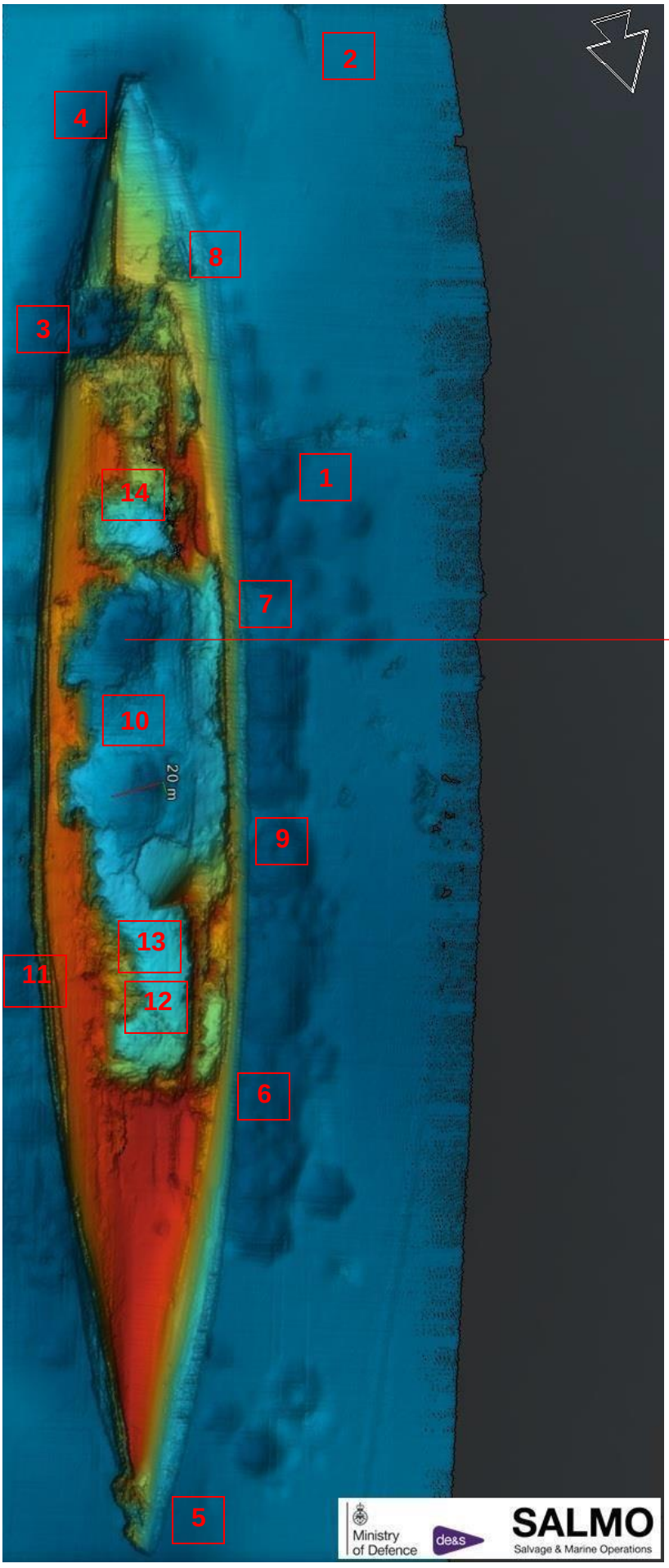


Fig 7. HMS PRINCE OF WALES – Multibeam showing points of interest.

STERN

Approximate location of 'Y' 14-inch turret

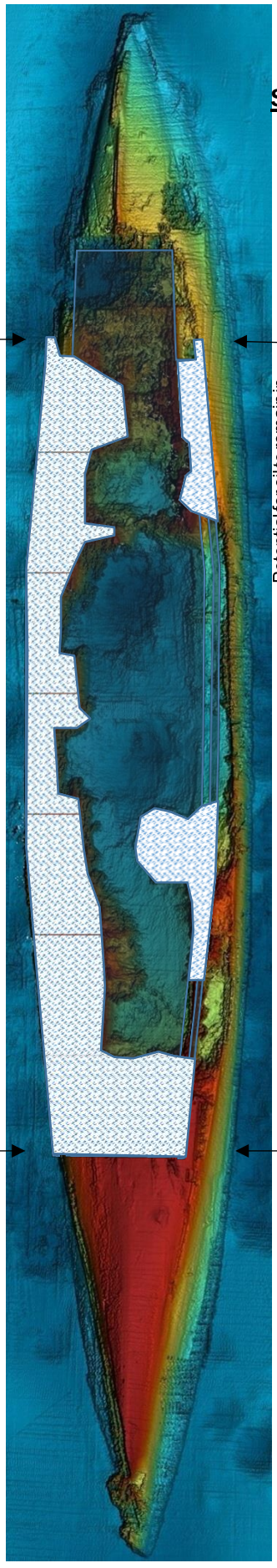
Approximate location of aft funnel

Approximate location of 'B' 14-inch turret

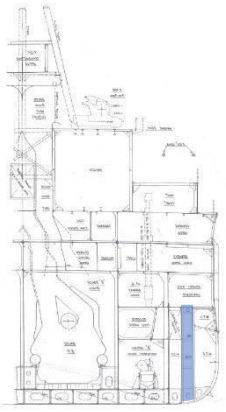
Approximate location of 'A' 14-inch turret

BOW

Fig 8. HMS PRINCE OF WALES – Destroyer and potentially intact fuel tanks.



Arrangement of bottom fuel tanks at Frame 263 (aft)



Arrangement of bottom/side fuel tanks at Frame 156 (amidships)

Arrangement of bottom/side fuel tanks at Frame 89 (forward)

Original extent of bottom/side fuel tanks – note, only major tanks are shown and are offset to compensate for wreck list

Potentially intact bottom fuel tanks

2.6 Survey Findings – REPULSE

Note, any reference to port and starboard in the discussion below refers to the ship as afloat. A key finding from the survey was that this wreck is likely being actively salvaged and that the perpetrators may have been on site immediately prior to SALMO's arrival. During the video survey two lines were detected running up from the wreck with branches, with fresh leaves on, tied at regular intervals along it (Fig. 9). The purpose of the branches is uncertain. It is possible they have been placed to attract small fish which, in turn lure larger fish. These are then targeted by fishing boats. Less innocently, the branches may be being used by the divers involved in the salvage to determine the depth at which they are operating.

Fig 9. Two lines with branches on REPULSE. Possibly used by salvage divers to indicate depth.

The sidescan of the wreck and a selection of multibeam and stills photographs are in the appendices.
Figure 10 shows the wreck annotated with the points of interest noted in the following discussion. Figure 11 shows the original distribution of oil tanks on the ship and the areas in which they potentially survive on the wreck.

The wreck of REPULSE lies upside down in 54m of water. The wreck is orientated 015/195° and the starboard side is held up off the seabed towards the bow by the superstructure.

In the 2007 survey the port side of the hull was noted as partially pushed down into the seabed (Denlay 2007: 9). However, as with PRINCE OF WALES the salvage has resulted in significant scooping and removal of the sediments along the wreck leaving the port side exposed. The wreck has clearly suffered far greater damage than PRINCE OF WALES, possibly because its shallower depth made it more accessible. The damage to the wreck is so extensive that it is no longer possible to discern the torpedo damage which caused the ship to sink.

The sidescan and multibeam surveys show little sign of a debris field around the wreck but exactly why this is is uncertain. Shortly before sinking, and after suffering significant damage the ship was still making 20 knots (ADM 199/1149) but it is not clear whether the ship, at the moment of capsize, was still moving. If it was there is the potential for debris to extend back from the stern. However, there was no opportunity to investigate this. The only two significant pieces of debris detected during the survey lie aft of the remains of the stern (1-2). They were not examined during the survey but are probably items left over from the salvage rather than anything dislodged from the ship during the sinking process.

Moving aft from the bow along the port side the wreck initially appears to be in reasonable condition until approximately midships (3). Up until this point there is potential for the side fuel tanks that began from approximately the position of 'A' turret to survive. However, from this point the line of the side cuts rapidly down and, while the outline of the ship is preserved until a point just aft of 'Y' turret in some places little of the structure survives above the level of the seabed (4). None of the side fuel tanks can have survived in this zone. Immediately aft of 'Y' turret the stern has been removed in its entirety leaving only the scattered items of debris noted above (5).

Immediately aft from the bow along the starboard side the wreck again appears reasonably intact. However, from just forward of 'A' turret a large gap appears cutting down and into the seabed (6). Thereafter the side reappears but is very degraded for its entire length until it stops at 'Y' turret (7). While some remnants of the starboard tanks may survive it is extremely doubtful that they contain any fuel due to the extreme damage apparent in this area.

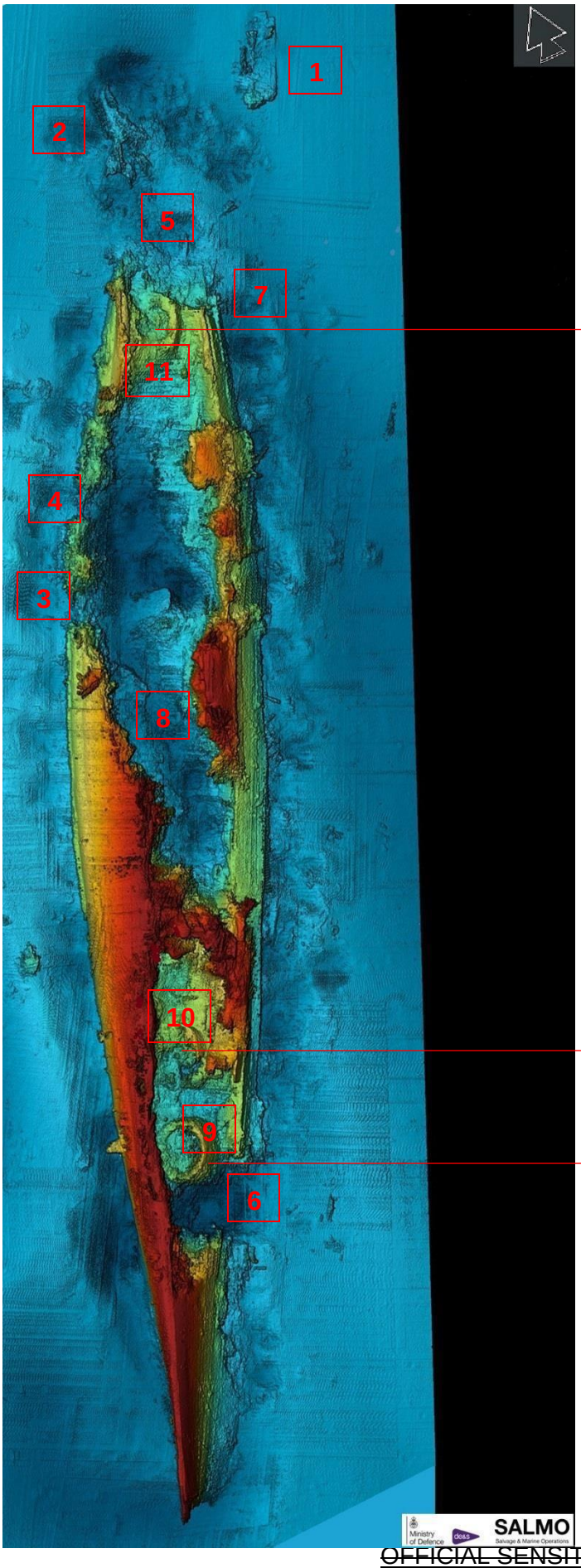
The bottom of the ship has been torn apart and the interior mined down to the seabed for high value metals and machinery. Again, the engine spaces appear to have been preferentially targeted (8) but it is also notable that all three of the upside-down barbettes for the main battery turrets are clearly visible in the multibeam (9-11). Some of the bottom fuel tanks may potentially survive but it is doubtful that they retain much oil given the brutal nature of the salvage combining explosives and grabs. The missing stern suggests that, now that the majority of the high value items have been removed from the interior, the salvors are attempting to systematically remove what remains.

The wreck is covered with cordite and ammunition of various calibres. Given the exposure of 'A', 'B' and 'Y' turret barbettes it is clear that the main battery magazines beneath them have been removed in their entirety. It is likely that the secondary 4-inch magazines have been similarly compromised.

Fishing net was present at various places on the wreck site although any damage resulting from this appears negligible in comparison to that caused by salvage.

No human remains were encountered during the survey.

Fig10.HMSREPULSE-Multibeam showingpointsofinterest.



STERN

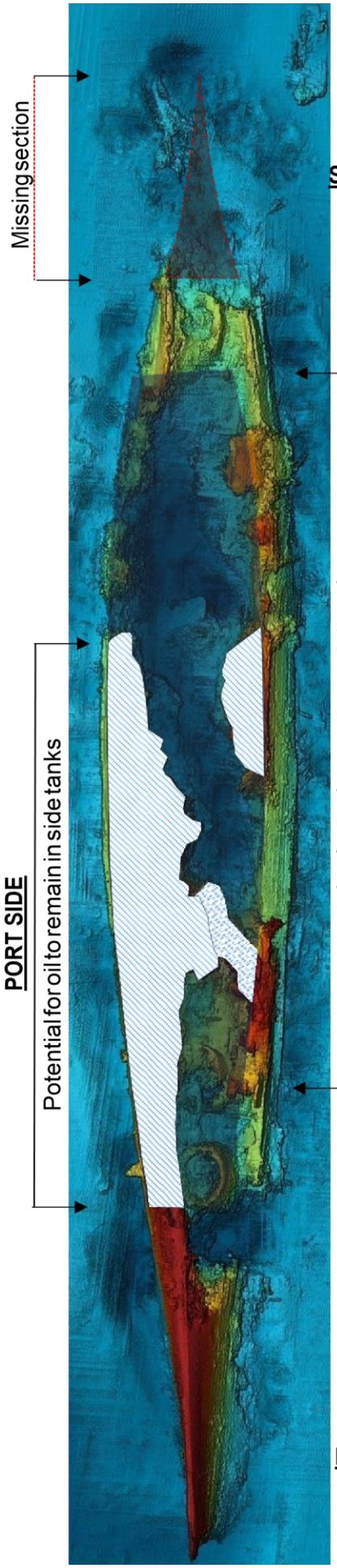
'Y' 15-inch turret barbette

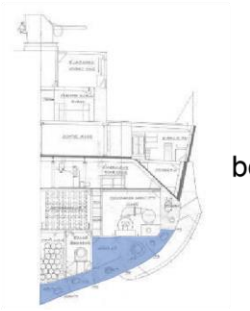
'B' 15-inch turret barbette

'A' 15-inch turret barbette

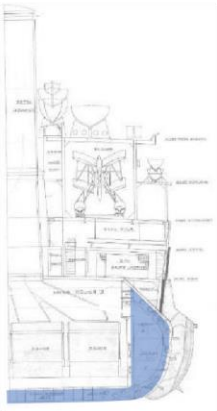
BOW

Fig 11. HMS REPULSE – Destroyed and potentially intact fuel tanks.





Arrangement of bottom/side fuel tanks at Frame 258 (aft)



Arrangement of bottom/side fuel tanks at Frame 165 (amidships)

Arrangement of bottom/side fuel tanks at Frame 54 (forward)

Original extent of bottom/side fuel tanks – note, only major tanks are shown and are offset to compensate for wreck list

Potentially intact bottom fuel tanks

2.7 Environmental Sampling

A study of satellite imagery over PRINCE OF WALES and REPULSE undertaken by the then Defence Geospatial Intelligence Fusion Centre (now DIFC) in 2014 showed that oil had leaked from the wrecks (DGIFC 2014).

To look for evidence of recent oil contamination, a systematic series of sediment samples were collected from different distances and bearings around each wreck using a Shipek grab (Fig.12). The intent was to determine if the heavier fractions of the oil that had escaped the wrecks was still present in the seabed. Details of the sampling points and a physical description of the samples is contained in Table 3.

The sediment was generally quite coarse and grainy at REPULSE and very fine and smooth at PRINCE OF WALES. Only one sample contained a living organism (small fish) large enough to see by eye. Many samples contained cordite rods, possibly indicating that shell cases were being emptied on site by the salvors and their contents returned to the sea. There was no obvious hydrocarbon odour from the samples, but four collected furthest away from PRINCE OF WALES had a distinct thin brown layer which could be hydrocarbon. The samples were shipped frozen to the Institute of Naval Medicine for further analysis, a report on the findings will be issued in due course.

Fig 12. Location of sediment sampling points around the wrecks.

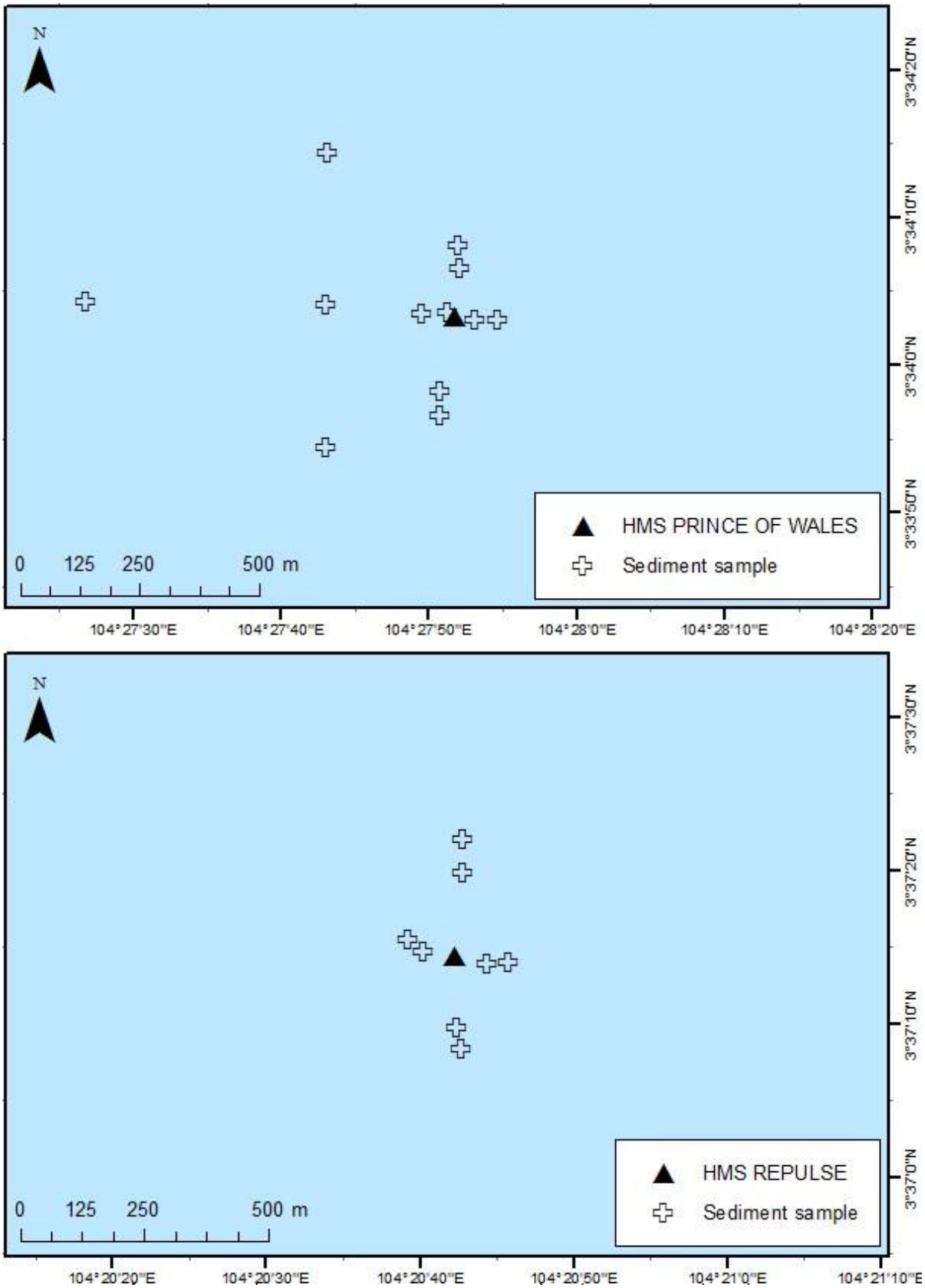


Table 3. Summary of sediment samples from PRINCE OF WALES (POW) and REPULSE (RPLS).

Wreck	Station ID	Latitude	Longitude	Bearing from Wreck	Distance from Wreck	Signs of Oil?	Appearance
POW	P1	003° 34' 08.174" N	104° 27' 52.003" E	North	60 m	No	Smooth
POW	P2	003° 34' 06.577" N	104° 27' 52.077" E	North	13 m	No	Smooth, cordite
POW	P3	003° 34' 03.546" N	104° 27' 51.232" E	West	10 m	No	Smooth, cordite
POW	P4	003° 34' 03.496" N	104° 27' 49.517" E	West	60 m	No	Smooth, clay-like, lots of cordite
POW	P5	003° 33' 58.275" N	104° 27' 50.740" E	South	20 m	No	Smooth
POW	P6	003° 33' 56.595" N	104° 27' 50.759" E	South	70 m	No	Smooth, cordite
POW	P7	003° 34' 03.105" N	104° 27' 53.158" E	East	20 m	No	Smooth with grains, lots of cordite
POW	P8	003° 34' 03.097" N	104° 27' 54.735" E	East	75 m	No	Smooth with grains, lots of cordite
POW	P9	003° 34' 14.391" N	104° 27' 43.148" E	North-west	390 m	Possible	Smooth, thin brown layer possibly oil
POW	P10	003° 34' 04.097" N	104° 27' 43.053" E	West	275 m	Possible	Smooth, thin brown layer possibly oil
POW	P11	003° 33' 54.423" N	104° 27' 43.085" E	South-west	280 m	Possible	Smooth, thin brown layer possibly oil
POW	P12	003° 34' 04.263" N	104° 27' 26.731" E	West	775 m	Possible	Smooth, thin brown layer possibly oil
RPLS	R1	003° 37' 08.380" N	104° 20' 42.749" E	South-east	95 m	No	Grainy
RPLS	R2	003° 37' 09.765" N	104° 20' 42.404" E	South-east	60 m	No	Grainy, possible cordite
RPLS	R3	003° 37' 13.907" N	104° 20' 44.419" E	East	45 m	No	Grainy
RPLS	R4	003° 37' 14.011" N	104° 20' 45.755" E	East	85 m	No	Grainy
RPLS	R5	003° 37' 22.110" N	104° 20' 42.825" E	North	130 m	No	Grainy
RPLS	R6	003° 37' 19.894" N	104° 20' 42.841" E	North	55 m	No	Grainy
RPLS	R7	003° 37' 14.760" N	104° 20' 40.251" E	West	65 m	No	Clay-like
RPLS	R8	003° 37' 15.497" N	104° 20' 39.266" E	West	105 m	No	Grainy

2.7 Environmental Impact of Salvage

In addition to causing oil to be released, the physical damage to the wrecks resulting from the use of explosives and grabs has severely damaged the marine communities inhabiting them. Photographs taken by recreational divers in the years prior to the salvage show that PRINCE OF WALES and REPULSE were once home to a diverse community of marine life, including corals and sponges, providing safety for small fish and food for parrotfish, manta rays and sea turtles. Bluestreak cleaner wrasse had cleaning stations where fish would come to have ectoparasites and dead cells gleaned from them.

The explosions used to gain entry to the wrecks have dislodged the organisms that once encrusted them and removed the habitat. The hard coral now lies in bone-like fragments on the seabed; the wrecks are colourless and lifeless except for a few fish and cleaning stations. A selection of photographs taken of the wrecks before the salvage are shown in appendix 7.4.

3 ASSESSMENT

3.1 Assessment of Oil Remaining on PRINCE OF WALES

The survey revealed that although the wreck is in better condition than REPULSE the majority of the fuel tanks have either been completely destroyed or seriously compromised by the salvage. Estimating the likely remaining amount is difficult. For the purposes of the environmental assessment commissioned from Arcadis it was assumed that, prior to salvage the wreck contained 1,200 m³ of oil. It now appears that at least two thirds of the oil tanks on the wreck have either been destroyed or have suffered damage (Fig 8). Therefore, it is possible that perhaps 400 m³ now remains. Any intervention to remove this oil would require contracted-in commercial support to achieve and the cost effectiveness, and viability, of this approach is doubtful. The wrecks, as evidenced by the lines detected on REPULSE are likely being actively salvaged and it is doubtful that an oil removal operation could be arranged before further significant damage occurs.

3.2 Assessment of Ammunition Remaining on PRINCE OF WALES

Several of the main and secondary magazines have been heavily damaged and stray ammunition and cordite is distributed in and around the wreck. It is interesting that, despite the use of explosives and the brutal mechanical means used to carry out the salvage, there has been no report of any of the ship's ammunition detonating. This has implications for the management of ammunition on other legacy wrecks. While the collective explosive risk of the ammunition is now likely to be negligible individual exposed munitions could be picked up by divers and may prove hazardous to them. A risk is also potentially posed by chemicals leaching from the explosives in to the seabed as the now exposed ammunition degrades. Clearing the ammunition that now lies round about is technically possible, but the time needed to carry out such work and the costs involved will be significant. It may be preferable to better advertise the potential risks posed to recreational divers.

3.3 Assessment of Oil Remaining on REPULSE

The wreck has suffered far greater damage than PRINCE OF WALES and little oil is now likely to remain. It appears that the salvors are actively working the wreck and that their intent is to remove it in its entirety, as evidenced by the missing stern. For the purposes of the environmental assessment commissioned from Arcadis it was assumed that, prior to salvage, the wreck contained 1,000 m³ of oil. It now appears that around three quarters of the oil tanks on the wreck have either been destroyed or have suffered damage (Fig 11). Consequently, it is possible that only around 250 m³ still remains on the wreck. For the reasons noted above with respect to PRINCE OF WALES it is unlikely that, even if an intervention to remove the oil was pursued, it would be possible to make the necessary commercial arrangements before the wreck suffers further damage.

3.4 Assessment of Ammunition Remaining on REPULSE

All of the main battery magazines appear to have been either heavily damaged or completely removed by the salvage. Consequently, the wreck and surrounding seabed is littered with cordite and ammunition of various calibres is strewn throughout. As with PRINCE OF WALES clearing this ammunition, while feasible is not likely to be worthwhile. The collective explosive risk posed by the ammunition has been negated by the destruction of the magazines and the removal or scattering of their content. The residual risk is primarily to recreational divers who might handle the ammunition. However, this is probably no worse than other wrecks of the period which are routinely dived and which often have ammunition on them. To date, it has not been MOD policy to clear wrecks of ammunition and the value of attempting to do so here is

questionable. However, as noted with PRINCE OF WALES greater efforts to highlight the risks to divers of interfering with loose ammunition would be advisable.

4 CONCLUSIONS

The Stage 2 survey has shown that the wrecks, as a consequence of salvage, now no longer pose a significant pollution risk as the majority of the oil once contained within them has escaped. However, this is not a positive outcome as it is most likely that at least hundreds, and probably over 1,000m³ of oil has escaped with unknown environmental consequences.

5 RECOMMENDATIONS

[redacted]

Relatively small amounts of oil are likely to remain on the wrecks and the value of attempting to remove it is doubtful given the strong possibility that further damage, or complete removal of the wrecks could occur before an intervention could be organised. For this reason, no further action with respect to the oil is recommended.

The risk posed by the ammunition on the wrecks is likely to be relatively low. However, there is a possibility that recreational divers might injure themselves if they handle the intact ammunition and cordite or bring it to the surface and allow it to dry out. For this reason the potential risks posed by this material should be highlighted.

6 REFERENCES

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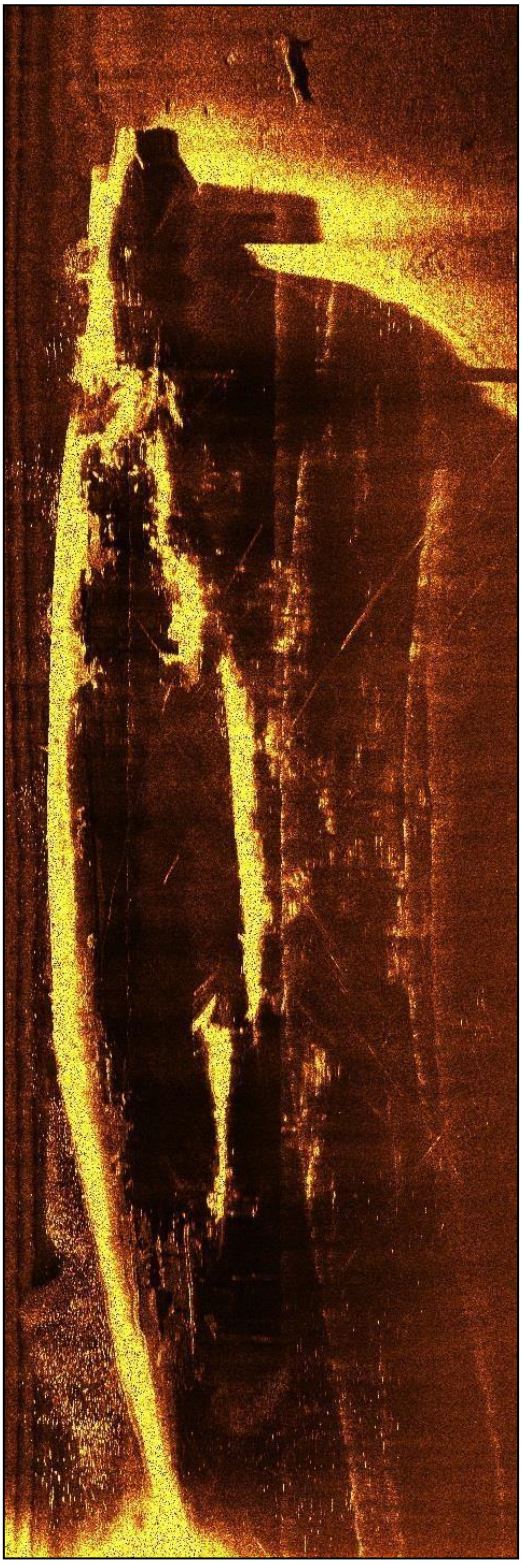
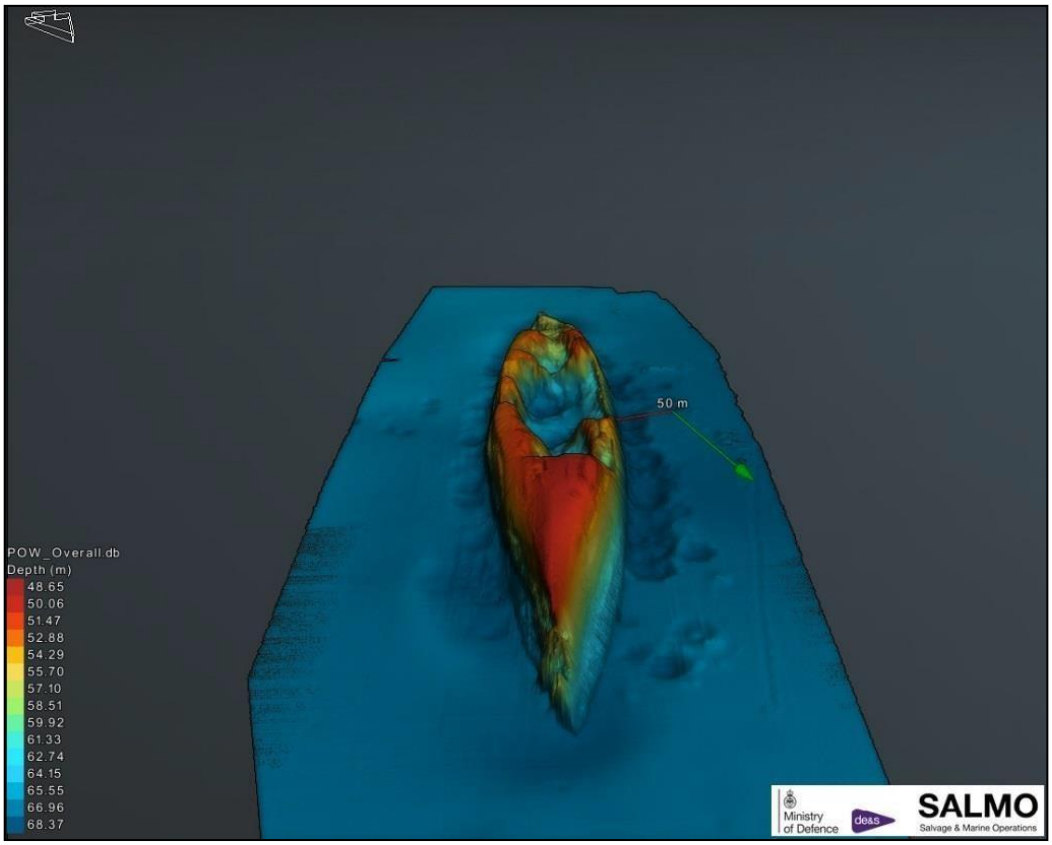
Wessex Archaeology 2018 (2) *HMS REPULSE – Salvage and Marine Operations Stage 1 Wreck Assessment*. Report compiled for the MOD, 2018.

7 APPENDICES

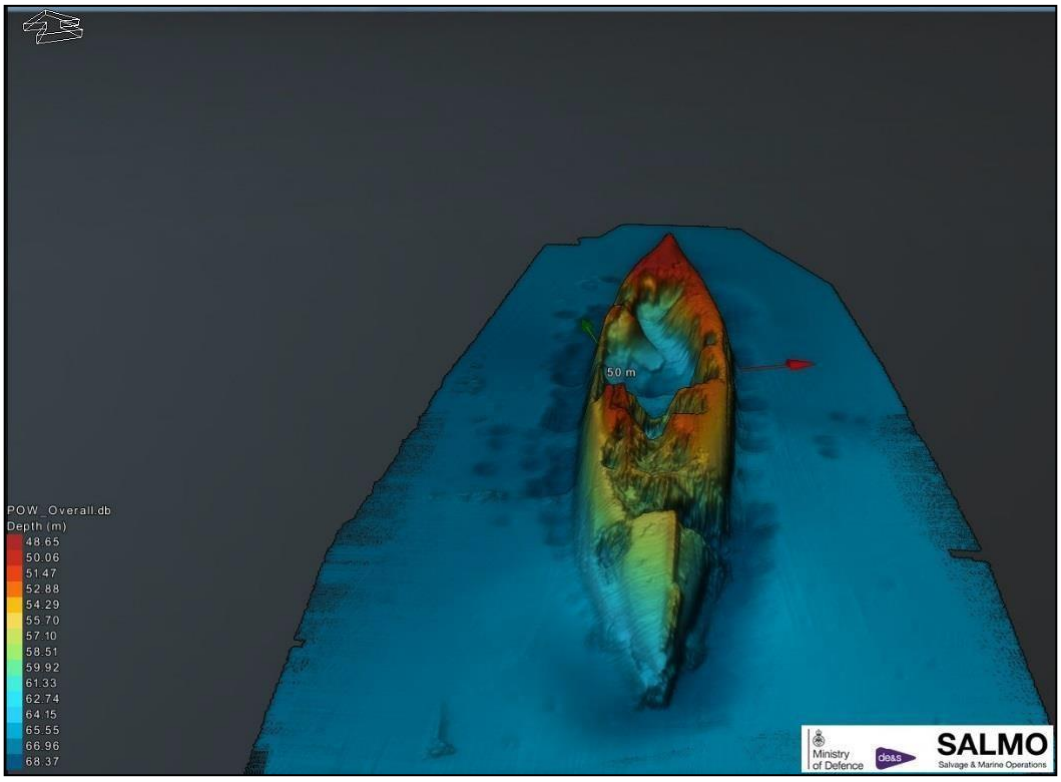
7.1 Sidescan and Multibeam – PRINCE OF WALES



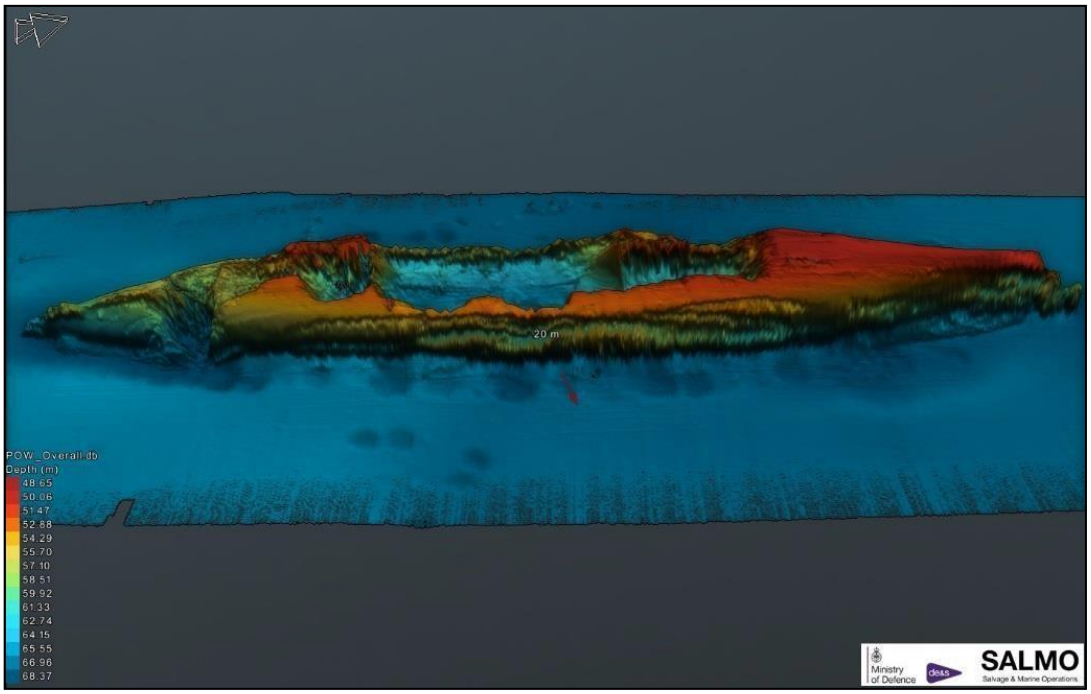
PRINCE OF WALES - sidescan survey showing the wreck and the salvage damage to the midships section.



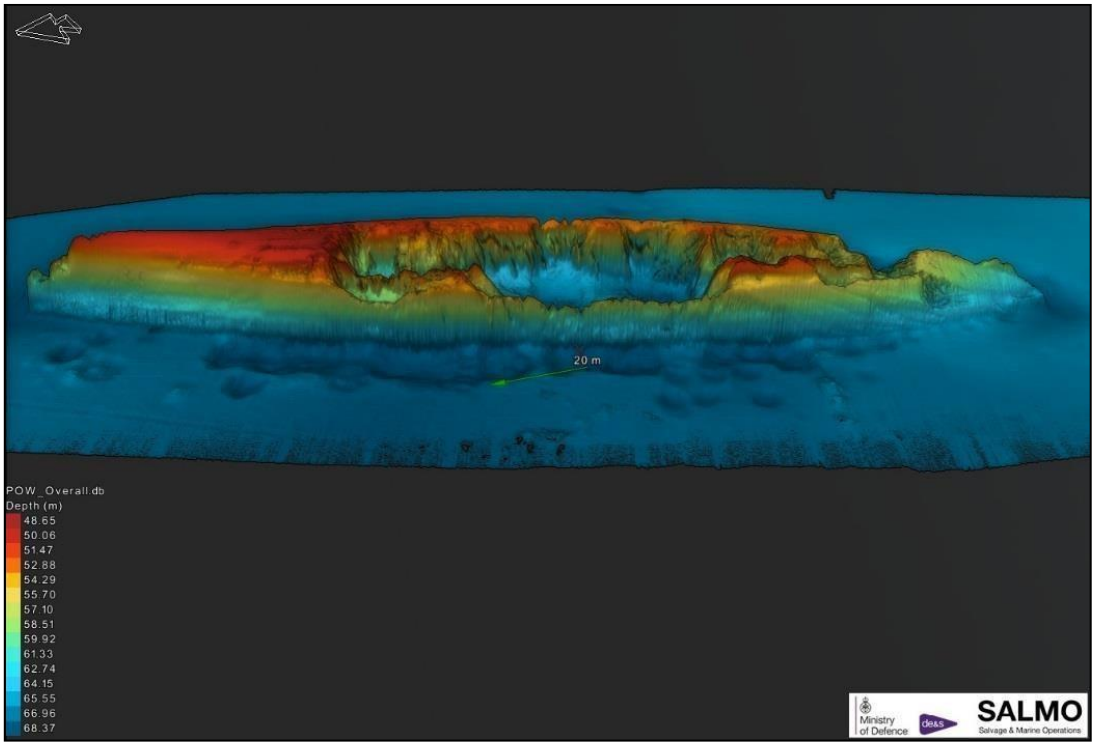
PRINCE OF WALES – multibeam image of bow.



PRINCE OF WALES – multibeam image of stern.



PRINCE OF WALES – multibeam image of port side.



PRINCE OF WALES – multibeam image of starboard side.

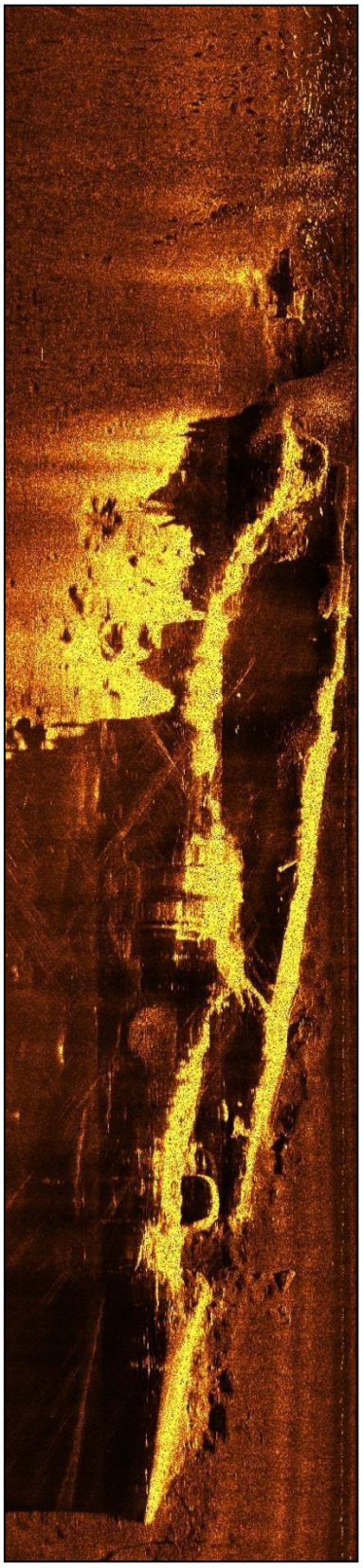
7.2 Selected Wreck Photos – PRINCE OF WALES

PRINCE OF WALES – 5.25-inch barrel with ammunition.

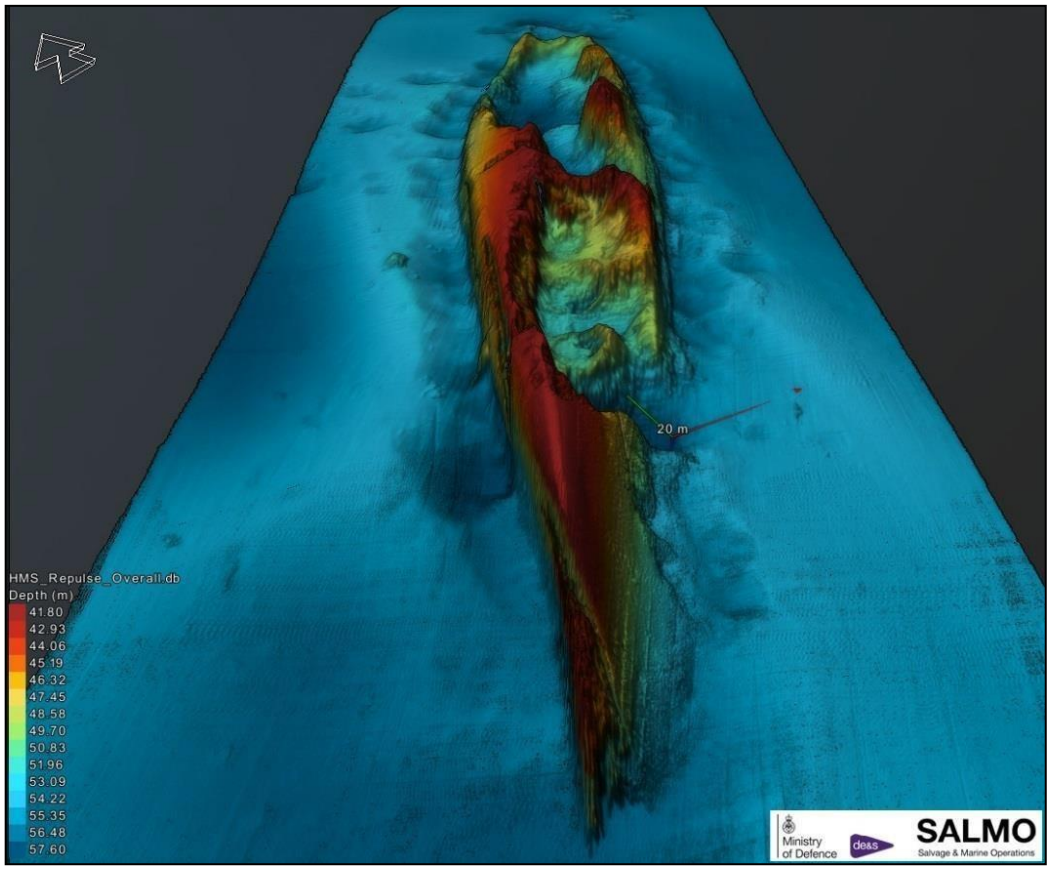
PRINCE OF WALES – Fishing net with ammunition caught in it.

PRINCE OF WALES – Bottom of the hull showing section of plate peeled back by salvors.

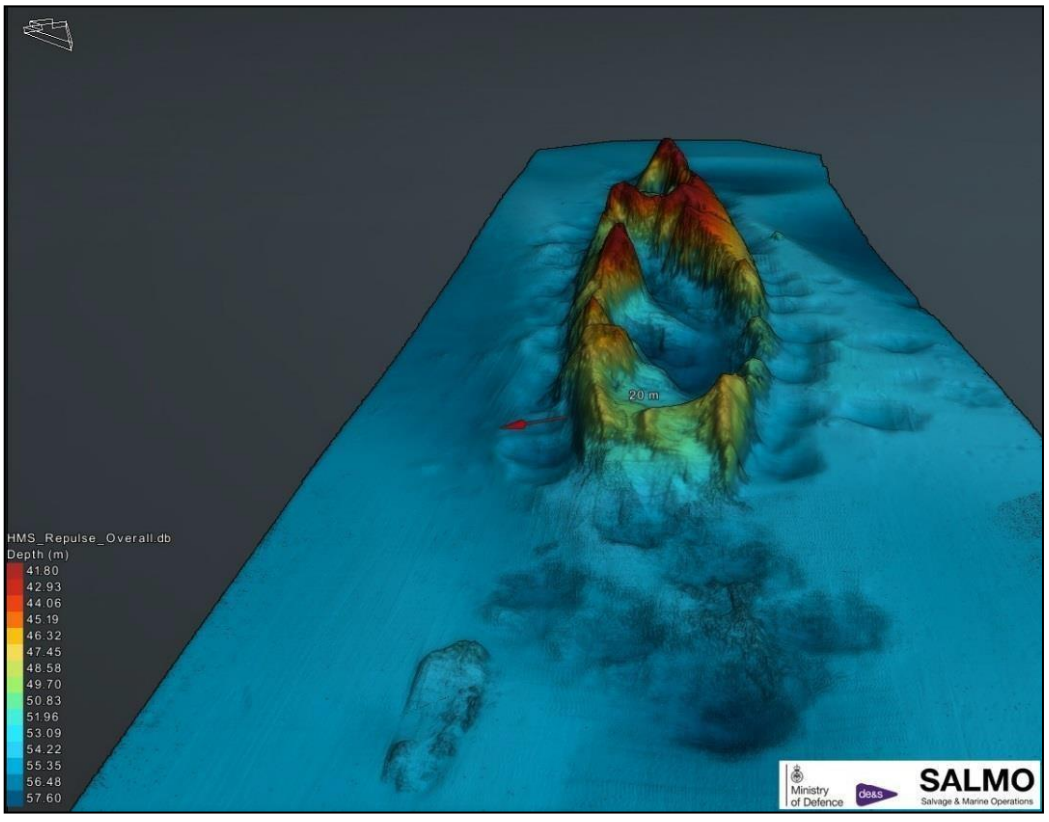
7.3 Sidescan and Multibeam – REPULSE



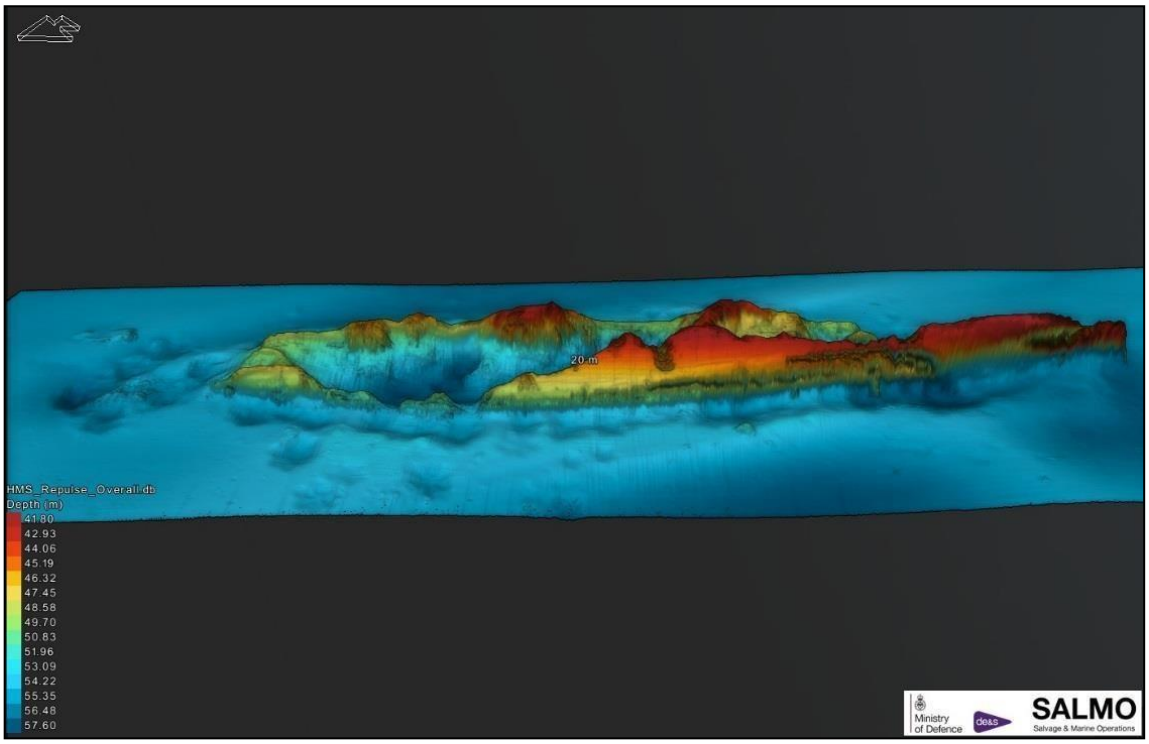
REPULSE - sidescan survey showing the wreck and the salvage damage to the midships section.



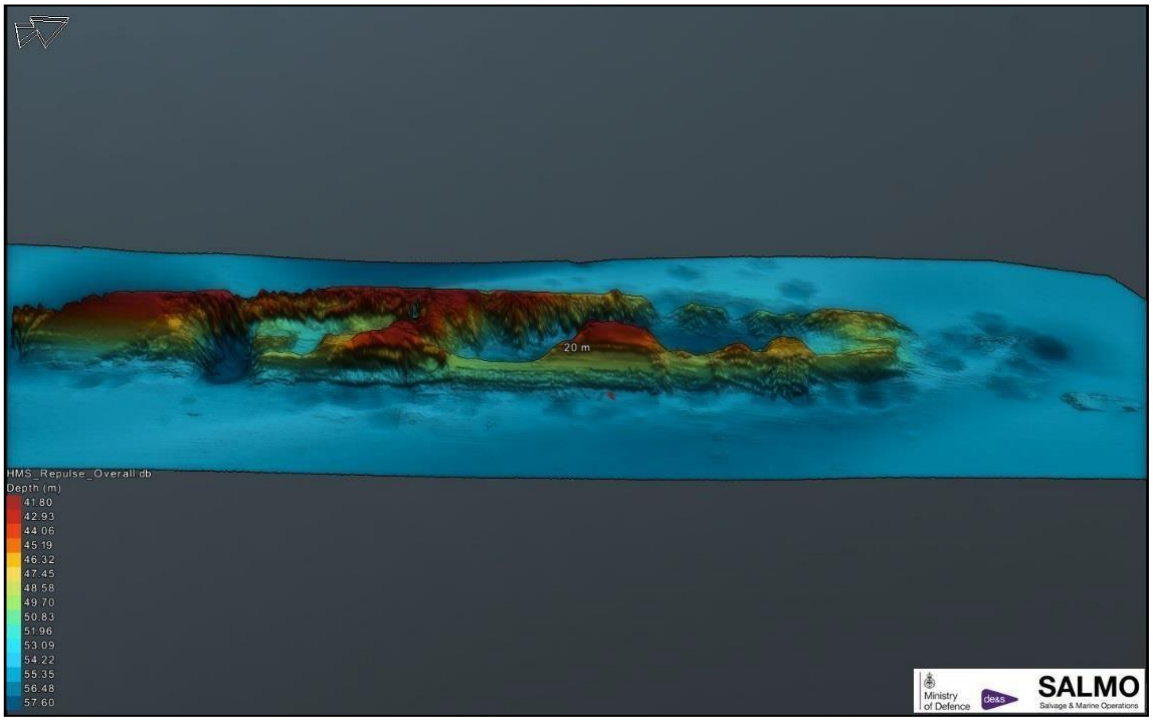
REPULSE – multibeam image of bow.



REPULSE – multibeam image of stern.



REPULSE – multibeam image of port side.



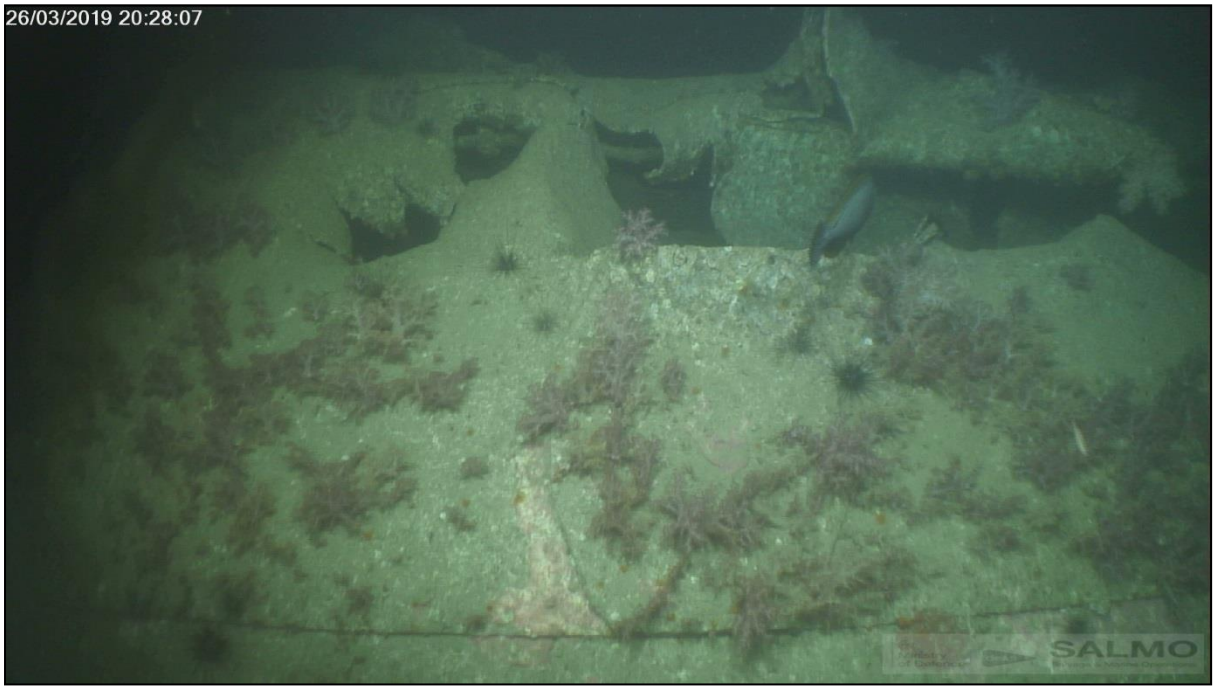
REPULSE – multibeam image of starboard side.

7.4 Selected Wreck Photos – REPULSE

REPULSE – Salvage damage at the bow.

REPULSE – Gun barrels of ‘Y’ turret. The inverted turret is buried in the seabed beneath the hull.

REPULSE – 15-inch shell lying in the wreckage.



REPULSE – Sparse marine growth remaining on the wreck.

REPULSE – Fishing net on the wreck.

7.5 Selected Photographs – Marine Life on the Wrecks Before Salvage (supplied by a recreational diver)