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Archaeological Services in Relation to Marine Designation

UB 78, off Folkestone, Kent

Archaeological Report

Ref: 83803.40
January 2015

coastal&marine

ARCHAEOLOGICAL SERVICES IN RELATION TO MARINE DESIGNATION

UB-78, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

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UB-78, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

Summary

Wessex Archaeology was commissioned by English Heritage to undertake a condition survey of the wreck of the *UB-78*, a First World War German type UB III submarine. It was lost in April 1918 with the loss of its crew whilst trying to cross the Dover Barrage at the start of a war patrol in the English Channel and Western Approaches.

The investigation comprised two parts: a limited desk-based audit of available primary and secondary sources and a diving survey. The latter was carried out in October 2014 with the help of members of local diving clubs Canterbury Divers and Folkestone 501.

The *UB-78* lies within territorial waters off Folkestone, Kent at 51° 1.034' N, 01° 16.486' E. The NRHE record for the site is 813225 and the UKHO wreck record is 13449. The site is not currently designated. The site is well known to local divers.

The submarine lies in two sections in approximately 23m general depth. The main section comprises the hull forward of the tower and aft including the engine room and lies with its bow to the west-south-west. The stern of the submarine lies approximately 2m to starboard of the stern end of the main section and at 90 degrees to it. The small stern section, which comprises the casing aft of the rudders, is lying on its port side. The main section appears to be upright with an estimated list to port of about 40 degrees. The corroded box keel is visible along most of the length of this side. No evidence of human remains has been observed.

Although the propellers have been salvaged and some fittings removed, the diving survey confirmed that the site is in reasonably good condition. The principal long term threat appears to be the natural process of corrosion. The site has been assessed as being at low risk using English Heritage's *Risk Management Handbook*.

The results of the investigation have been used to compile a site characterisation based upon the established BULSI method of shipwreck 'biography'. This has in turn informed assessment of the site against current EH guidance on the non-statutory criteria for scheduling under the 1979 Act. The *UB-78* scores fairly highly and is perhaps a borderline candidate for scheduling. Whether the protection such scheduling would bring would have a practical effect is uncertain. Perhaps more important than its significance as an individual marine heritage asset, the *UB-78* is part of the archaeology of the vital naval battlefield of the Dover Straits.

In addition to this Archaeological Report, the project has been followed up by a public talk in Folkestone in January 2015 which was attended by more than sixty local divers. The avocational divers involved in the project have expressed a desire to be involved in further EH marine projects.

Acknowledgements

This investigation was commissioned by English Heritage, and the assistance provided by Mark Dunkley of English Heritage is gratefully acknowledged.

Wessex Archaeology worked on site alongside divers from BSAC 326 Canterbury Divers and 501 Folkestone and this report has benefited greatly from their observations and from the dive video footage provided. Particular thanks are due to Robert Harrison, Brian Robinson and Simon Woolett.

WA engaged the local diving charter vessel MV *Neptune* to support the diving and the master Dave Batchelor provided invaluable information based upon his own experience of diving the wreck.

Wessex Archaeology is grateful to *The UB 88 Project* in California for permission to use information published on their website, together with a photomosaic of the *UB-88* wreck. We wish that project well.

A number of published sources were consulted during this investigation and Wessex Archaeology is grateful to their authors, as listed in the References section. Wessex Archaeology is also grateful for information and assistance provided by the staff of the following organisations:

- HM Receiver of Wreck;
- United Kingdom Hydrographic Office; and
- National Record of the Historic Environment

The assessment was carried out by a Wessex Archaeology team comprising:

- Kitty Brandon (illustration);
- Paolo Croce (archaeological diver);
- Patrick Dresch (archaeological diver);
- Toby Gane (project management; QA);
- Andrea Hamel (archaeological diver);
- Richard Milwain (data management);
- Graham Scott (project officer; diving supervisor; report compiler); and
- Euan McNeill (QA).

UB-78, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

1 INTRODUCTION

1.1 Assessment Background

1.1.1 Wessex Archaeology (WA) was commissioned by English Heritage (EH) to undertake a condition survey of the wreck of the *UB-78*, off Folkestone, Kent (NRHE number TR 22 NE 101, monument number 1388897); **Figure 1**).

1.1.2 The work was undertaken as part of a wider First World War (FWW) Submarine Condition Survey project, carried out under the Heritage at Risk - Designated Wrecks at Risk (Dive Contract) 2013-15 contract for archaeological services (HAR). The work was conducted in accordance with a written brief and agreed scope of work (EH 2014).

1.1.3 The text of this report should be understood strictly as read and contains no implied meanings or judgements. Reporting of third party actions, statements and intentions is based upon the information available to WA at the time of drafting. Use of the phrase "It is reported that..." means that WA has received a report from a third party that appears to be credible but which cannot be confirmed as fact from the available evidence.

2 ASSESSMENT OBJECTIVES AND PRODUCTS

2.1.1 The objectives was broken down into the following objectives (EH 2014):

- Undertake documentary research on both sites as appropriate (noting NRHE data provided below), to inform location and condition;
- Contact the Receiver of Wreck to gain a list of droits relating to the site;
- Establish links with local divers, dive groups and skippers to enable future site management options;
- Undertake a diver survey of the remains. Confirm position, extent, stability and character (plotted by diver survey) of the site;
- Locate and accurately position (plotted by diver survey and probing as appropriate) any additional archaeological material; and
- Produce a structured record of field observations (including i) the collection of appropriate bed level pH values and ii) the collection of footage suitable for broadcast); including a photographic record of the site and a basic site plan. Key artefacts are to be subject to detailed examination and recording (position by diver survey, taped measurements, photographs and video and written database entries).

2.1.2 Subsequent to the written brief, WA was asked to carry out the following:

- Assess the site against the criteria for assessing the national importance of monuments.
- Risk assess the site.

2.1.3 The following products were specified in the Brief. This document is P1:

- P1 - Archaeological Report (suitable for public release);
- P2 - Project archive/s compiled in accordance with current accepted standards.

2.1.4 The recording level set in the Brief was Level 3a, detailed diagnostic recording of selected elements of the site. Selection of elements was left to the discretion of WA.

3 METHODOLOGY

3.1 Diving Survey

3.1.1 All WA diving operations complied with the Diving at Work Regulations 1997 and the associated Scientific and Archaeological Approved Code of Practice (ACOP). Diving operations were conducted during daylight hours only on a single shift system by a four person team.

3.1.2 Diving operations were carried out from MV *Neptune*, a Dover-based dive charter and coded work vessel. The master was familiar with the site and had deployed divers there a number of times.

3.1.3 The diving survey was planned and carried out with a separate team of avocational divers from Canterbury Divers and Folkestone 501 BSAC. This team dived from the same vessel.

3.1.4 WA diving was carried out using SCUBA diving equipment. Archaeological, environmental and observational data was recorded using WA's proprietary DIVA MS Access recording system. An accurate position for the site was established with certainty during data audit and geophysical survey and it was decided that acoustic diver tracking was not required in order to meet the client objectives.

3.1.5 Still and HD video recording was carried out using a housed camera system. Additional video recording was carried out using a mask-mounted HD video camera. Artificial lighting was not required as sufficient natural light was available. Batch-captured video stills from the mask mounted camera were experimentally modelled using photogrammetry software (**Plate 3**).

3.1.6 Sampling of pH was carried out by hand. No methodology was provided by the client, so a sample of seawater was obtained from the immediate vicinity of the submarine hull in a small sample bottle, which was sealed. This was then analysed on the surface immediately following the dive using a waterproof pH tester (Hanna Instruments, model HI 98128). The pH readings incorporated automatic temperature compensation.

3.2 Data Audit

3.2.1 A limited audit of existing primary and secondary sources relevant to site location, condition survey and BULSI characterisation has been undertaken. This does not amount to a full desk-based assessment.

3.2.2 The results have been presented in the report using the BULSI characterisation scheme. This scheme presents site and contextual data as a vessel and site 'biography' under the following themes:

- *Build* – the design and construction of the vessel.
- *Use* – the use of the vessel before it was lost.

- *Loss* – how the vessel was lost, including initial shipwreck site formation processes.
- *Survival* – what has happened to the site since, including subsequent site formation and modification processes and the current condition of the vessel.
- *Investigation* – what is known about post-loss salvage and site investigation.

3.2.3 Sources identified and used have been listed in Sections 4.3 and 7. Relevant data published post-fieldwork has been included in the audit (McCartney 2014).

4 RESULTS

4.1 Progress against Objectives

Objectives	Progress
Contact the Receiver of Wreck to gain a list of droits relating to the site.	Awaited
Undertake documentary research on both sites as appropriate (noting NRHE data provided below), to inform location and condition	Achieved
Establish links with local divers, dive groups and skippers to enable future site management options	Achieved.
Undertake a diver survey of the remains. Confirm position, extent, stability and character (plotted by diver survey) of the site	Achieved.
Locate and accurately position (plotted by diver survey and probing as appropriate) any additional archaeological material	Achieved
Produce a structured record of field observations (including i) the collection of appropriate bed level pH values and ii) the collection of footage suitable for broadcast); including a photographic record of the site and a basic site plan. Key artefacts are to be subject to detailed examination and recording (position by diver survey, taped measurements, photographs and video and written database entries)	Achieved, with caveats
Carry out multibeam swath bathymetry (multibeam) and sidescan sonar (SSS) surveys of the site	Achieved
Assess the site against the criteria for assessing the national importance of monuments	Achieved

Table 1: Progress Against Objectives

4.2 Engagement

4.2.1 Wessex Archaeology has an established working relationship with recreational dive club BSAC 326 Canterbury Divers. Club members participated in the data audit and diving survey and an observer was present for familiarisation during the geophysical survey (**Front Cover**). The video footage they shot was used to compile **4.4** below. In addition Folkestone 501 BSAC participated in the diving survey. WA presented the results of the survey to the Folkestone and Canterbury clubs and their invited guests on 14th January 2015.

4.2.2 Local diving charter business Mutiny Divers participated in the data audit and provided some logistical support during fieldwork. WA engaged the local diving charter vessel MV *Neptune* to support the diving and the crew contributed to the data audit.

4.2.3 A short article on the results of the survey has been submitted to the NAS Newsletter.

4.2.4 In addition WA has been exchanging data with the investigators of *UB-88*, another UB III boat. This vessel was given to the US Navy for trials following the Armistice and its wreck lies off the Californian coast. Its investigators were able to provide a detailed photomosaic of the wreck (which benefits from good u/w visibility), as well as a transcript of a description of the submarine from a participant in the USN trial (**Appendix 2**).

4.3 Data Audit Results

Build

4.3.1 The *UB-78* was a UB III coastal torpedo attack boat built by Blohm and Voss, Hamburg for the *Kaiserliche Deutsche Marine*, the German Imperial Navy, during the First World War. Ordered on 23 September 1916 as part of batch UB 75-79, the boat was laid down as hull number 307 and launched on 2nd June, 1917 (uboat.net website).

4.3.2 As a result of the German decision at the beginning of 1916 to attempt to blockade Britain and the Mediterranean and the subsequent renewal of unrestricted submarine warfare, the Germans realised that they lacked a medium-sized, torpedo-armed submarine that could be built quickly and that was capable of operating both all around the UK coast and in the Mediterranean. The UB II class was too lightly armed and its range limited it to the North Sea and the English Channel. Therefore the Germans modified the successful UC II minelaying class, principally by replacing the minelaying shafts with a torpedo compartment and by adding a more powerful engine and increased bunkerage (Rössler 2001: 56-7). The new type was designated UB III and the first contracts for the new boats were awarded in May 1916. Altogether more than 200 UB IIIs were ordered during the war, of which 96 were eventually commissioned (uboat.net website).

4.3.3 Contemporary plans for the relevant batch, probably produced by Blohm and Voss, survive (**Figure 2**; U-Boot-Archiv). An undated photograph of the *UB-78* in port survives (**Plate 1**; U-Boot-Archiv). A photograph of a slipway launch of an unnamed UB III boat at Blohm & Voss survives (Rössler 2001: 58).

4.3.4 The UB III class had the following technical specifications (from secondary sources - Rössler 2001: 332; Young 2006: 289; uboat.net website). Where sources differ, both specifications have been given. The data audit did not indicate that evidence had been found to suggest that the design or fitting out of *UB-78* differed significantly from this standard specification:

Specification	Progress
Displacement, surfaced	516 tons
Displacement, submerged	651 tons
Length, overall	55.3 m (40.1 m pressure hull)
Beam	5.8 m (3.9 m pressure hull)
Draught	3.7 / 3.68 m
Height	8.25 m
Engines	2 x 550 hp MAN-Vulcan diesels
Electric motors	2 x 394 hp Mafei
Shafts/Propellers	2 / 2 x bronze
Fuel capacity	35 + 36 tons
Batteries	AFA lead acid accumulators
Speed, surfaced	13.6 / 13.3 knots
Speed, submerged	8 / 7.5 knots

Range, Surfaced	8,500 nautical miles at 6 knots / 7,460 nautical miles at 13 knots / 9040 nautical miles at 6 knots
Range, submerged	55 nautical miles at 4 knots / 55 nautical miles at 4 knots
Armament	4 x bow and 1 x stern 50.04 cm (19.7 inch) torpedo tubes; 22 pdr Krupp deck gun
Torpedoes carried	10 x 50 cm
Ammunition	160 rounds
Diving	c.75 / 50 m
Design complement	34 (inc. 3 officers)

Table 2: *UB-78* specifications

4.3.5 Following the Armistice, the surrendered *UB-88*, another UB III boat, was given to the US Navy. **Appendix 2** contains full accounts of the vessel and its condition on handover, written by a USN officer (www.ub88.org website). **Figure 10** is a photomosaic of the wreck of the *UB-88*, showing the upper deck minus deck casing and fittings.

Use

4.3.6 *UB-78* was commissioned in Hamburg on 20th October 1917 to Kapitänleutnant Woldemar Petri. From 2nd January 1918 until 15th February the boat was assigned to V U-Flotille (flotilla) based out of Bremerhaven. There it undertook one unsuccessful war patrol in the northern North Sea under Petri. Oberleutnant zur See Ulrich Pilzecker then replaced Petri and sailed *UB-78* to Bruges, where the boat became part of *Flandern I U-Flotille* (Young 2006: 289). Pilzecker then took the boat on an unsuccessful patrol off the east coast of England in late February, returning on 2nd March. He was then assigned to another newly commissioned UB boat, being replaced by Oberleutnant zur See Arthur Stoßberg. He took the *UB-78* on its only successful war patrol on 16th March. He damaged the armed trawler *Strathearn* south of May Island, before sinking the small merchant ship *Polleon* and the armed drifter *Border Lads*, as well damaging the larger merchant ship *British Star*, all off the Tyne. *UB-78* returned to Flanders on 28th March.

4.3.7 Following their failure to capture Calais and Dunkirk in 1914, the Germans decided to use captured Belgian ports as a base for attacks by submarines, destroyers and torpedo boats against Allied shipping. Unlike Ostend, the inland port of Bruges was immune to bombardment from the sea. With canals linking it with Zeebrugge and Ostend on the coast, it provided the Germans with an ideal base for gaining access to the English Channel and North Sea. Being nearer to the English Channel than bases in Germany, submarines based at Bruges consumed far less fuel and spent less time in transit to their patrol areas, allowing them more time to patrol Allied shipping lanes. As a result Bruges became their principal submarine base in 1915, with a workforce of 14,000 (Kendall 2009: 15-45). The U-boat force based there became known as the 'Flanders Flotillas'.

4.3.8 The British responded to the Flanders Flotillas by mining the approaches to Zeebrugge and by a direct attack on the port. Although a number of U-boats were sunk by mines, the Germans were able to control their losses by sweeping channels. The direct attack, the famous Zeebrugge Raid in April 1918, was heroic but not completely successful and the Bruges base survived.

4.3.9 However, the British realised that the German resumption of unrestricted submarine warfare in 1917 and the urgent need in 1918 for the Germans to halt the flow of American troops and war supplies to Britain meant that the U-boats could be defeated by blocking their transit routes to the shipping lanes on the western side of the British Isles. The best place to do this was at choke points and, in the case of the English Channel, this was the

Dover Straits. Whilst these had always been heavily defended, the increased German effort meant that the British had to revamp the defences.

4.3.10 Along with the depth charge, mines were the principal anti-submarine weapons of the First World War and by 1917 technical and manufacturing improvements to British mines had overcome their reputation for being unreliable. This allowed the Allies to build a formidable line of defences across the Straits in 1917. This consisted of two barrages. A net barrage stretched between the Goodwins and Dyck in Belgium. Behind this was a barrage patrol consisting of anti-submarine vessels. To the east, between Folkestone and Gris Nez on the French coast was the main deep mine barrage. This consisted of a deep belt of almost 3,500 mines laid in a ladder pattern at depths of 25, 22, 18 and 12m. This was augmented by anti-submarine nets, searchlights, flares and constant patrols. It was extremely difficult for a submarine to sneak through on the surface and once detected, it would have to dive, with a good chance of then running into a mine (**Figure 9**; Young 2006: 216-7; Grant 2002: 74-6). The boats of the Flanders Flotillas had to negotiate these defences twice each patrol or otherwise sail all the way around Scotland.

4.3.11 *UB-78* left Zeebrugge on 18th April 1918 to begin its final war patrol. The patrol area assigned was the English Channel and the Western Approaches, with the main target being troop transports. This meant that Stoßberg had to take the boat through the British defences in the Straits.

Loss

4.3.12 Traditionally it was thought that *UB-78* was sunk by the cross channel transport SS *Queen Alexandra* on the morning of the 9th May north of Cherbourg at 51° 6' N, 1° 28' W. After a lookout on the ship spotted a submerging U-boat it turned and rammed the submarine at twenty knots, just as its conning tower was leaving surface. The steamer's escort P-35 dropped a depth charge at the location, followed by a marker buoy. Later that morning the escort returned to the location and found a seven mile slick of oil and debris. The *Queen Alexandra* was dry docked and its stem, rudder and screws were found to be badly damaged. The *UB-78*, which had been recorded as having been spotted mid-Channel on 7th May, was listed as 'Known Sunk' by the Admiralty (ADM 137/3917). Subsequent post-war German study also concluded that the ship had probably rammed and sunk the *UB-78* (Messimer 2002: 199).

4.3.13 However, this loss account was called into question by the recovery of the propellers from the wreck. These were stamped *UB-78* (Canterbury Divers website) and "B&V" for Blohm and Voss. WA has not come across any evidence to suggest that these propellers were not recovered from this wreck.

4.3.14 With the identity of the wreck as *UB-78* proven, the circumstances of loss were investigated by McCartney (2014: 71-3). He pointed out that the bow of the wreck is pointing south-west, suggesting that the *UB-78* was outbound, rather than returning damaged. Furthermore, British naval records indicate that the detonation of a mine was detected in the vicinity of the wreck at 00:30 on 19th April, which is consistent with when Stoßberg's departure suggests he would have been attempting to breach the Barrage. The British concluded that a U-boat had been destroyed by that explosion but were unable to confirm this by diving or sweeping because of the presence of mines (ADM 137/2097). Furthermore, the missing stern of the wreck reported by divers is only likely to have occurred as a result of a large explosion or impact, such as a mine. It therefore seems overwhelmingly likely that the *UB-78* was sunk by a mine whilst trying to penetrate the Dover Barrage outbound on the night of 19-20th April 1918.

4.3.15 The U-boat sunk by the SS *Queen Alexandra* north of Cherbourg is now believed to be the *UC-78*, a coastal minelayer (see NHRE number TR 43 NW 196; monument number 1536009).

4.3.16 McCartney has suggested that the aft and conning tower hatches of *UB-78* were opened by the blast. Whilst this is not certain, it is the case that there were no survivors from the thirty-five onboard. The dead were as follows (Young 2006: 303). Where known their Royal Navy equivalent ranks are given:

- Bauer (Stoker)
- Bloss (Seaman)
- Borgmann (Stoker)
- Brandenburg (Sub-Lieutenant)
- Böhler (Stoker)
- Dengler (Stoker)
- Doerfert (Navigating Petty Officer 1st Class)
- Ducke (Telegraphist)
- Feyertag (Engine Room Petty Officer 1st Class)
- Hale (Seaman)
- Heimbech (Stoker)
- Helmer (Leading Seaman)
- Herchenröder (Engine Room Petty Officer 2nd Class)
- Knofler (Telegraphist Petty Officer 1st Class)
- Koch (Stoker)
- Kressmann (Engine Room Petty Officer 2nd Class)
- Kundschaft (Seaman)
- Kübler (Navigating Petty Officer 2nd Class)
- Künnert (Ob.Masch.Anw)
- Morgenstern (Seaman)
- Nahrstedt (Stoker)
- Nix (Stoker)
- Przibylla (Engine Room Petty Officer 2nd Class)
- Reckmann (Masch.Anw)
- Rusp (Seaman)
- Schramm (Engine Room Petty Officer 2nd Class)
- Schulz (Mn.Ing.Asp.)
- Schück (Seaman)
- Specht (Engine Room Petty Officer 2nd Class)
- Steen (Engine Room Petty Officer 2nd Class)
- Stoßberg (Lieutenant-Commander)
- Weinrich (Seaman)
- Wolf (Seaman)
- Zickoll (Seaman)

Survival and Investigation

4.3.17 No attempt was made by the Admiralty Intelligence Division to locate and investigate the wreck in the aftermath of the loss due to the nearby presence of mines. The wreck was located in 1977 during hydrographic survey by HMS *Bulldog* and reported as a probable submarine wreck (UKHO wreck record no. 13449: Surveying Details).

4.3.18 The wreck was dived in 1982, the UKHO receiving confirmation that it was a submarine at this time. It was described as "sitting upright on the seabed". An additional dive report received from the UKHO described it as being "thought to be a WW1 German submarine" (UKHO wreck record no. 13449: Surveying Details).

4.3.19 In 1997 it was again surveyed, when it had sonar dimensions of 50 metres by 10 metres, with a height of 5 meters and an orientation of 070/250 degrees. It was described as being in one piece in a general depth of 22.5 metres, with no debris or scour (UKHO wreck record no. 13449: Surveying Details).

4.3.20 Kendall MacDonald described the wreck as upright, with its stern blown off. He stated that there were torpedoes in the bow tubes (McDonald 1994: 43).

4.3.21 The following undated description of the wreck is available on the Canterbury Divers website (http://www.canterburydivers.org.uk/wrecks.html#ub_78):

"The Wreck sits upright on the seabed in a max depth of 27m, the stern has been blown off by the mine and she lies along the current with the bows facing down channel. So the masts, cables and bow net cutter have all gone, there are holes in her outer hull. The gun and conning tower are still in place and she has a list of approximately 40 Degrees to Starboard. The stern is blown off in the area of the stern bulkhead. This is an interesting Sub dive and being a small coastal sub she can be well covered in 1 dive."

4.3.22 The wreck was subject to an inspection dive in April 2011, after which the following summary description was published after the completion of WA fieldwork (McCartney 2014: 71). Although the accompanying figure is not reproduced, the letter locations are marked on **Figure 3**:

"Forward section is upright. Aft section lies on its port side…A) A bronze reinforced platform, which is situated between the upper and lower pairs of torpedo tubes, can be seen at this point. Its exact purpose is unclear, but it seems to be part of the hinging mechanism for opening the forward torpedo doors. In either case it is in the author's experience unique to the UBIII-Class U-boat. B) The U-boat is fitted with the Krupp C14 30-calibre 88mm gun on the C16 mount as fitted to the UBIII-Class in 1916-17. It is known that this type of gun was fitted to *UB-78* (Gröner 1991, 26). C) The aft (torpedo) loading hatch is open, and the hatch door can be seen still attached at the top of the hatchway. Internally, the compartment below is full of sand. The conning tower hatch was also seen to be open, but the forward hatch was shut. D) The stern of the submarine is completely removed. Looking into the break, the doorway at the forward end of the aft torpedo room can be seen. The door has fallen off its hinges. E) The two propeller shafts are still attached to the wreck. F) The aft section of the wreck, which represents most of the aft torpedo room, has been blown off and pushed to the starboard side. The suspicion is that it has been salvaged and some of this damage aft has occurred in recent times, during this process. G) Both propellers have been removed, leaving just the shaft and an "A" bracket."

4.3.23 Prior to 1994 both propellers were salvaged. One of these came into the possession of Canterbury Divers and was donated to the German Maritime Museum in Wilhelmshaven in 2011 (http://www.canterburytimes.co.uk/World-War-relic-handed-Germany/story-18146776-detail/story.html). The whereabouts of the other propeller is unknown. Droit details have been requested from HM Receiver of Wreck as part of this investigation.

4.3.24 *UB-78* is recorded by the NRHE as 813225. The UKHO INSPIRE portal does not indicate the availability of multibeam bathymetry or other existing high resolution geophysical data for the location of the wreck.

Site Position

4.3.25 The following position was derived from the diving support vessel GPS on 5th October 2014 for the highest point of the wreck as defined by echo-sounder (the conning tower). Taking into account probable sources of error, the position is likely to be accurate to within ten metres:

Latitude (WGS 84)	Longitude (WGS84)
51° 1.034' N	01° 16.486' E

Table 3: Site co-ordinates

4.4 Diving Inspection

4.4.1 Diving inspection and survey was carried out on 5th October 2014. Statistics for the diving operation are given in **Appendix 1**.

Seabed

4.4.2 The wreck is lying on a gravel and cobble surface which may be the upper surface of the chalk bedrock. Very shallow waves of sand have built up along both sides of the hull, particularly on the starboard side and towards the bow. There is a small scour at the stern and bow ends of the main section, where the gravel surface is exposed.

Ecology

4.4.3 Ecological assessment was not set as an objective and therefore no survey was carried out. However, limited comment can be made based upon general observations during diving, supplemented by available literature.

4.4.4 Although strong currents are experienced, from a marine biological perspective the site can be characterised as a moderately low energy site. The site clearly acts as an artificial reef and the species observed are typical of such environments in the 20-30m depth range in the English Channel. Pouting (*Trisopterus Luscus*) and medium-large sized lobster (*Homarus Gammarus*) were observed.

General Description

4.4.5 The submarine lies in two sections in approximately 23m general depth. The main section comprises the hull forward of the tower and aft including the engine room and lies with its bow to the west-south-west. The stern of the submarine lies approximately 2m to starboard of the stern end of the main section and at 90 degrees to it. The small stern section, which comprises the casing aft of the rudders, is lying on its port side. The main section appears to be upright with an estimated list to port of about 40 degrees. The box keel is visible along most of the length of this side. No evidence of human remains were observed.

4.4.6 The following more detailed description should be considered with Figure 3, which integrates a contemporary plan of the *UB-78* batch with video stills from the inspection.

Main Section - Conning Tower/Bridge

4.4.7 The conning tower/bridge survives *in situ* (**Plate 1**), although the chariot casing forward and railings aft are gone, the former possibly salvaged as it may have been made of bronze (see **Appendix 2**). The structure is comprised of curved steel plates. The method

of fixing was obscured by concretion and marine growth but is assumed to be riveting. Contemporary photographs suggest that large pan or cup head rivets were used and arranged in chains (recessed features such as deadlights and navigation lights appear to have also been riveted).

4.4.8 Both periscopes, the rear navigation periscope and the forward attack periscope, are still *in situ*, as is their cutwater. Both appear to be retracted.

4.4.9 The circular watertight bridge/tower hatch is *in situ* and complete and the hatch lid is secure and open. This is covered in fragments of rope, either fishing gear or moorings. It is not known whether the locking screw and wheel are present. The conning tower was not penetrated and internal fixtures and fittings inside were not inspected. However it is apparent that the tower is partly filled with sand.

4.4.10 The combined steering wheel and binnacle mount is still attached to the forward end of the tower, although the binnacle itself is missing. This was removed by local diver Dave Batchelor in the 1980s, due to concerns that a salvage company was targeting U-boats in the area and it might have been removed and disposed of. It is still in his possession and is reported to be in good condition (Dave Batchelor, pers. comm.).

4.4.11 The forward pointing recesses for the port and starboard bridge navigation lights survive, together with deadlight slots aft. These were not examined. The diesel and boat air inlet masts appear to be *in situ* within the casing at the aft end of the tower. The possible short range radio mast base is bent over forward and rope fragments around it suggest that it has been subject to a bending force.

Main Section - Forward of the tower

4.4.12 Forward of the tower the deck casing is *in situ* (**Plate 3**), with only small sections of planking missing. The casing consists of thin wooden deck planks supported by longitudinal steel angle beams with free flooding slots on either side, with transverse angle beam supports. Heavy marine turf has colonised the planking, the surfaces of which appear to be moderately eroded. There is a small amount of unidentified debris lying on the deck. The deck railings are not present and may have been dismounted at the time of loss.

4.4.13 The deck gun is intact and *in situ* on its mountings. Both gun and mountings appear to be the types identified by McCartney. The gun is slightly elevated but otherwise in diving trim. There is a fragment of what may be the original low railings around the gun platform hanging over the starboard side of the deck.

4.4.14 Forward of the gun mounting is the circular watertight forward torpedo loading hatch. The hatch lid is closed. Both lid and hatch ring appear to be intact. The hatch is through the pressure hull and is below the level of the deck planking. Access is by means of a square opening in the planking. This would have been secured by a square steel cover plate, which is missing.

4.4.15 Forward of the hatch is what appears to be a partially buried toothed wheel. This is visible through a hole in the planking and may be part of the small windlass used for raising the radio mast.

4.4.16 Further forward there is a small base ring set into the deck with a squared central shaft that does not protrude (**Plate 3**, to the left). This appears to be the deck base plate of the capstan, together with the top of its spindle. The capstan head itself is missing. This motorised capstan is connected by a transmission arm to a windlass further forward which

would have been used for the anchor. This can be seen on the *UB-88* as the deck planking is missing at that point (**Figure 4**).

4.4.17 On the *UB-78* the deck planking is missing forward of the capstan and there is a considerable amount of debris lying on the deck. This includes what appears to be part of the windlass. Forward of this there is a transverse angle beam support which is directly above the forward transverse watertight boundary bulkhead of the pressure hull.

4.4.18 Forward of this most of the bow casing is missing, although part of the shallow riveted T-bar stem survives, giving the bow of the boat the appearance of a 'galleon beak'. A large section of the raking bow casing is lying on its side on the seabed below and to starboard of this. The surviving bow casing is confusing and appears to include a collapsed section of steel deck plating with bollards and access panel. Torpedo tubes survive on the port side and are reported to survive on the starboard side and there is a reinforced flat between upper and lower tubes which McCartney identified as brass (McCartney 2014: 71). The torpedo tube doors are closed.

4.4.19 Upper and lower hydroplanes survive on both sides. Both lower hydroplanes are complete with their fairings. Just forward, below and aft of the fairing on the port side are what are either inlet slots for the saddle tanks or drainage slots for the bow casing. The box keel is visible along the full length of the submarine with what appears to be drainage holes at the bow end. The keel plating is highly corroded with numerous holes, as is the plating of the bow and forward saddle tanks on the starboard side.

Main Section - Aft of the tower

4.4.20 Immediately aft of the tower, the deck planking is partly *in situ* on the casing. There is a raised egg-shaped feature of uncertain function in the centre of the deck. It is shown in contemporary plans and could be an access panel or conceivably a ready use locker. Below the decking at this point the air inlet trunking and HP cylinders are assumed to be *in situ*. The saddle tank on either side is intact.

4.4.21 Aft of the raised feature the deck planking is missing, although its longitudinal framing is still in place. Also *in situ* is the diesel and engine room air inlet trunking and lower valves, although this pipework is heavily corroded to the extent that the pipe walls have collapsed in places. A complete section of the saddle tank casing on the port side is missing at this point. Below is a large stubby cylinder with rounded ends attached to the pressure hull. This feature is unidentified but may be an oil fuel tank.

4.4.22 The aft torpedo hatch lid is open 180 degrees. The decking is missing from this point aft. It appears from the video evidence that the engine room below is partially filled with sand.

4.4.23 Aft of the torpedo loading hatch are the two exhaust outlets and silencer boxes, which appear to be *in situ* with the exhaust outlet control valves and pressure hull apertures. There are also sections of missing upper saddle tank casing. Aft of the exhausts is the raised circular aft torpedo room escape/access hatch. This opens forward but appears to be closed. Immediately aft of this is a full circumference fracture line running along the aft edge of a frame, at which point the structure of the wreck ends.

4.4.24 The forward end of the aft torpedo room survives, although the fixtures and fittings are largely missing and may be amongst the pile of debris on the *in situ* floor plates of the compartment. Amongst this debris is a large object that could be an auxiliary generator. The watertight transverse bulkhead between the engine room and the aft torpedo (possibly also motor) room survives and appears to be *in situ*. The watertight door is off its hinges, probably blown off by the explosion that sank the boat.

4.4.25 Both propeller shafts and their glands survive, although the propellers themselves are missing. The port shaft bracket is attached to the port shaft but is missing from the starboard shaft. The keel of the vessel can be seen below the pressure hull.

Stern section

4.4.26 About 2m starboard of the aft end of the main section is the small stern section (**Plate 2**). This comprises the casing aft of the rudders. The aft torpedo tube door is missing and the opening mechanism levers are damaged. The casing behind the door is distorted, with the plating pushed outwards. Within can be seen what appears to be part of the aft torpedo tube, although it is not clear whether the flanged end is present. The aft torpedo tube would have extended well forward of the surviving section and therefore only a small part of it can have survived.

4.4.27 Whether the torpedo tube has been salvaged, as tentatively suggested by McCartney (2014: 71) or the door has been blown off by the explosion that sank the *UB-78* is not clear.

4.4.28 The stern section appears to be smaller than comparison of the batch plans with the position of the fracture on the main section would suggest. It therefore appears that some of the aft torpedo room is missing, presumably destroyed by the explosion.

Debris

4.4.29 Astern of the wreck, just aft of the port shaft is one of the two rudders and its shaft, lying on the seabed. Small items of debris are scattered around the aft end of the main section and probably include displaced internal fittings.

4.4.30 Below and starboard of the surviving part of the stem is a large section of the bow casing. A few small pieces of debris are lying on either side of the hull.

4.5 Corrosion

4.5.1 Extensive evidence of corrosion was visually observed in all the above areas. This included thinning and some holes in the plating. Although no full condition survey could be undertaken and there is therefore no engineering assessment of the remaining strength of the hull, it does not appear to be in danger of short term collapse and it appears to be in a similar condition to other inshore FWW submarine wrecks in the Dover Straits and elsewhere.

4.6 pH Sampling

4.6.1 A sample was recovered from the base of the conning tower. A pH of 8.36 was measured after the dive. Temperature value during testing was 18.8 degrees centigrade. Seabed temperature recorded using a diver-held gauge was 15.3 degrees.

5 CONCLUSiONS AND DiSCUSSiON

5.1 Overall Characterisation

5.1.1 The results of the survey have been combined with the data audit to produce the following overall characterisation:

Build
The evidence found during the project has not added materially to our knowledge of the design and construction of the UB-78 or of UB III submarines generally; however, it represents a comprehensive summary of existing knowledge.

The design and features of the wreck are consistent with those of a UB III boat and nothing has been observed that is inconsistent with identification as the *UB-78*. Although WA has not seen material evidence of the propellor markings, all of the evidence points towards this wreck having been correctly identified.
The *UB-78* was a UB III coastal torpedo attack boat built by Blohm and Voss, Hamburg for the *Kaiserliche Deutsche Marine*, the German Imperial Navy, during the First World War. Ordered on 23 September 1916 as part of batch UB 103-117, the boat was laid down as hull number 315 and launched on 7th July, 1917 (Young 2006: 289; uboat.net website).
As a result of the German decision at the beginning of 1916 to attempt to blockade Britain and the Mediterranean and the subsequent renewal of unrestricted submarine warfare, the Germans realised that they lacked a medium-sized, torpedo-armed submarine that could be built quickly and that was capable of operating both all around the UK coast and in the Mediterranean. The UB II class was too lightly armed and its range limited it to the North Sea and the English Channel. Therefore the Germans modified the successful UC II minelaying class, principally by replacing the minelaying shafts with a torpedo compartment and by adding a more powerful engine and increased bunkerage (Rossler 2001: 56-7). The new type was designated UB III and the first contracts for the new boats were awarded in May 1916. Altogether more than 200 UB IIIs were ordered during the war, of which 96 were eventually commissioned (uboat.net website). The project results do not suggest that the technical specifications of the *UB-78* differed significantly from the standard specifications set out in **Table 2**.

Use

The project has not added materially to our knowledge of the service history of the UB-78 or of the UB III-type or the Flanders Flotillas; however, it represents a comprehensive summary of existing knowledge.

UB-78 was commissioned by Kapitänleutnant Woldemar Petri in Hamburg on 20th October 1917. From 2nd January 1918 until 15th February the boat was assigned to V U-Flotille (flotilla) based out of Bremerhaven. There it undertook one unsuccessful war patrol in the northern North Sea under Petri. Oberleutnant zur See Ulrich Pilzecker then replaced Petri and sailed *UB-78* to Bruges, where the boat became part of *Flandern I U-Flotille* (Young 2006: 289). Pilzecker then took the boat on an unsuccessful patrol off the east coast of England in late February, returning on 2nd March. He was then assigned to another newly commissioned UB boat, being replaced by Oberleutnant zur See Arthur Stoßberg. He took the *UB-78* on its only successful war patrol on 16th March. He damaged the armed trawler *Strathearn* south of May Island, before sinking the small merchant ship *Polleon* and the armed drifter *Border Lads*, as well damaging the larger merchant ship *British Star*, all off the Tyne. *UB-78* returned to Flanders on 28th March.
Following their failure to capture Calais and Dunkirk in 1914, the Germans decided to use captured Belgian ports as a base for attacks by submarines, destroyers and torpedo boats against Allied shipping. Unlike Ostend, the inland port of Bruges was immune to bombardment from the sea. With canals linking it with Zeebrugge and Ostend on the coast, it provided the Germans with an ideal base for gaining access to the English Channel and North Sea. Being nearer to the English Channel than bases in Germany, submarines based at Bruges consumed far less fuel and spent less time in transit to their patrol areas, allowing them more time to patrol Allied shipping lanes. As a result Bruges became their principal submarine base in 1915, with a workforce of 14,000 (Kendall 2009: 15-45). The U-boat force based there became known as the 'Flanders Flotillas'.
The British responded to the Flanders Flotillas by mining the approaches to Zeebrugge

and by a direct attack on the port. Although a number of U-boats were sunk by mines, the Germans were able to control their losses by sweeping channels. The direct attack, the famous Zeebrugge Raid in April 1918, was heroic but not completely successful and the Bruges base survived.
However, the British realised that the German resumption of unrestricted submarine warfare in 1917 and the urgent need in 1918 for the Germans to halt the flow of American troops and war supplies to Britain meant that the U-boats could be defeated by blocking their transit routes to the shipping lanes on the western side of the British Isles. The best place to do this was at choke points and, in the case of the English Channel, this was the Dover Straits. Whilst these had always been heavily defended, the increased German effort meant that the British had to revamp the defences.
Along with the depth charge, mines were the principal anti-submarine weapons of the First World War and by 1917 technical and manufacturing improvements to British mines had overcome their reputation for being unreliable. This allowed the Allies to build a formidable line of defences across the Straits in 1917. This consisted of two barrages. A net barrage stretched between the Goodwins and Dyck in Belgium. Behind this was a barrage patrol consisting of anti-submarine vessels. To the east, between Folkestone and Gris Nez on the French coast was the main deep mine barrage. This consisted of a deep belt of almost 3,500 mines laid in a ladder pattern at depths of 25, 22, 18 and 12m. This was augmented by anti-submarine nets, searchlights, flares and constant patrols. It was extremely difficult for a submarine to sneak through on the surface and once detected, it would have to dive, with a good chance of then running into a mine (**Figure 9**; Young 2006: 216-7; Grant 2002: 74-6). The boats of the Flanders Flotillas had to negotiate these defences twice each patrol or otherwise sail all the way around Scotland.

Loss

The evidence found during the project has added to our knowledge of the damage caused by the mine explosions that resulted in the loss of the boat and this report probably represents the best available synthesis of the loss.

Traditionally it was thought that *UB-78* was sunk by the cross channel transport ss *Queen Alexandra* on the morning of the 9th May, north of Cherbourg at 51°6' N, 1°28' W. After a lookout on the ship spotted a submerging U-boat, it turned and rammed the submarine at twenty knots, just as its conning tower was leaving surface. The steamer's escort P-35 dropped a depth charge at the location, followed by a marker buoy. Later that morning the escort returned to the location and found a seven mile slick of oil and debris. The *Queen Alexandra* was dry docked and its stem, rudder and screws were found to be badly damaged. The *UB-78*, which had been recorded as having been spotted mid-Channel on 7th May, was listed as 'Known Sunk' by the Admiralty (ADM 137/3917) subsequent post-war German study concluded that the ship had probably rammed and sunk the *UB-78* (Messimer 2002: 199).
However, this loss account was called into question by the recovery of the propellers from the wreck off Folkestone. These were stamped *UB-78* (Canterbury Divers website) and "B&V" for Blohm and Voss. WA has not come across any evidence to suggest that these propellers were not recovered from this wreck.
With the identity of the wreck as *UB-78* proven, the circumstances of loss were investigated by McCartney (2014: 71-3). He pointed out that the bow of the wreck is pointing south-west, suggesting that the *UB-78* was outbound, rather than returning damaged. Furthermore, British naval records indicate that the detonation of a mine was detected in the vicinity of the wreck at 00:30 on 19th April, which is consistent with when Stoßberg's departure suggests he would have been attempting to breach the Barrage. The British concluded that a U-boat had been destroyed by that explosion but were unable to confirm this by diving or sweeping because of the presence of mines (ADM

137/2097). Furthermore, the missing stern of the wreck reported by divers is only likely to have occurred as a result of a large explosion or impact, such as a mine. It therefore seems overwhelmingly likely that the *UB-78* was sunk by a mine whilst trying to penetrate the Dover Barrage outbound on the night of 19-20th April 1918.
McCartney has suggested that the aft and conning tower hatches were opened by the blast. Whilst this is not certain, it is the case that there were no survivors from the thirty-five onboard. The dead were as follows (Young 2006: 303). Where known their Royal Navy equivalent ranks are given:

- Bauer (Stoker)
- Bloss (Seaman)
- Borgmann (Stoker)
- Brandenburg (Sub-Lieutenant)
- Böhler (Stoker)
- Dengler (Stoker)
- Doerfert (Navigating Petty Officer 1st Class)
- Ducke (Telegraphist)
- Feyertag (Engine Room Petty Officer 1st Class)
- Hale (Seaman)
- Heimbech (Stoker)
- Helmer (Leading Seaman)
- Herchenroder (Engine Room Petty Officer 2nd Class)
- Knöfler (Telegraphist Petty Officer 1st Class)
- Koch (Stoker)
- Kressmann (Engine Room Petty Officer 2nd Class)
- Kundschaft (Seaman)
- Kübler (Navigating Petty Officer 2nd Class)
- Künnert (Ob.Masch.Anw)
- Morgenstern (Seaman)
- Nahrstedt (Stoker)
- Nix (Stoker)
- Przibylla (Engine Room Petty Officer 2nd Class)
- Reckmann (Masch.Anw)
- Rusp (Seaman)
- Schramm (Engine Room Petty Officer 2nd Class)
- Schulz (Mn.Ing.Asp.)
- Schück (Seaman)
- Specht (Engine Room Petty Officer 2nd Class)
- Steen (Engine Room Petty Officer 2nd Class)
- Stoßberg (Lieutenant-Commander)
- Weinrich (Seaman)
- Wolf (Seaman)
- Zickoll (Seaman)

Survival

The project has added considerable detail to published knowledge of what survives and its condition and to our understanding of how this has changed since the UB-78 sank.

The survival and current condition of the *UB-78* can be summarised as follows.
The submarine lies in two sections in approximately 23m general depth. The main section comprises the hull forward of the tower and aft including the engine room and lies with its bow to the west-south-west. The stern of the submarine lies approximately 2m to starboard of the stern end of the main section and at 90 degrees to it. The small

stern section, which comprises the casing aft of the rudders, is lying on its port side. The main section appears to be upright with an estimated list to port of about 40 degrees. The corroded box keel is visible along most of the length of this side. No evidence of human remains has been observed.

The conning tower/bridge survives *in situ*, although the chariot casing forward and railings aft are gone, the former possibly salvaged as it may have been made of bronze (see Appendix 2). The structure is comprised of curved steel plates. The method of fixing was obscured by concretion and marine growth but is assumed to be riveting. Contemporary photographs suggest that large pan or cup head rivets were used and arranged in chains (recessed features such as deadlights and navigation lights appear to have also been riveted).

Both periscopes, the rear navigation periscope and the forward attack periscope, are still *in situ*, as is their cutwater. Both appear to be retracted.

The circular watertight bridge/tower hatch is *in situ* and complete and the hatch lid is secure and open. This is covered in fragments of rope, either fishing gear or moorings. It is not known whether the locking screw and wheel are present. The conning tower was not penetrated and internal fixtures and fittings inside were not inspected. However it is apparent that the tower is partly filled with sand.

The combined steering wheel and binnacle mount is still attached to the forward end of the tower, although the binnacle itself is missing. This was removed by local diver Dave Batchelor in the 1980s, due to concerns that a salvage company was targeting U-boats in the area and it might have been removed and disposed of. It is still in his possession and is reported to be in good condition (Dave Batchelor, pers.comm.).

The forward pointing recesses for the port and starboard bridge navigation lights survive, together with deadlight slots aft. These were not examined. The diesel and boat air inlet masts appear to be *in situ* within the casing at the aft end of the tower. The possible short range radio mast base is bent over forward and rope fragments around it suggest that it has been subject to a bending force.

Forward of the tower the deck casing is *in situ*, with only small sections of planking missing. The casing consists of thin wooden deck planks supported by longitudinal steel angle beams with free flooding slots on either side, with transverse angle beam supports. Heavy marine turf has colonised the planking, the surfaces of which appear to be moderately eroded. There is a small amount of unidentified debris lying on the deck. The deck railings are not present and may have been dismounted at the time of loss.

The deck gun is intact and *in situ* on its mountings. Both gun and mountings appear to be the types identified by McCartney. The gun is slightly elevated but otherwise in diving trim. There is a fragment of what may be the original low railings around the gun platform hanging over the starboard side of the deck.

Forward of the gun mounting and is the circular watertight forward torpedo loading hatch. The hatch lid is closed. Both lid and hatch ring appear to be intact. The hatch is through the pressure hull and is below the level of the deck planking. Access is by means of a square opening in the planking. This would have been secured by a square steel cover plate, which is missing.

Forward of the hatch is what appears to be a partially buried toothed wheel. This is visible through a hole in the planking and may be part of the small windlass used for raising the radio mast.

Further forward there is a small base ring set into the deck with a squared central shaft that does not protrude. This appears to be the deck base plate of the capstan, together with the top of its spindle. The capstan head itself is missing. This motorised capstan is connected by a transmission arm to a windlass further forward which would have been used for the anchor. This can be seen on the *UB-88* as the deck planking is missing at that point.

On the *UB-78* wreck the deck planking is missing forward of the capstan and there is a

considerable amount of debris lying on the deck. This includes what appears to be part of the windlass. Forward of this there is a transverse angle beam support which is directly above the forward transverse watertight boundary bulkhead of the pressure hull. Forward of this most of the bow casing is missing, although part of the shallow riveted T-bar stem survives, giving the bow of the boat the appearance of a 'galleon beak'. A large section of the raking bow casing is lying on its side on the seabed below and to starboard of this. The surviving bow casing is confusing and appears to include a collapsed section of steel deck plating with bollards and access panel. Torpedo tubes survive on the port side and are reported to survive on the starboard side and there is a reinforced flat between upper and lower tubes which McCartney identified as brass (McCartney 2014: 71). The torpedo tube doors are closed.

Upper and lower hydroplanes survive on both sides. Both lower hydroplanes are complete with their fairings. Just forward, below and aft of the fairing on the port side are what are either inlet slots for the saddle tanks or drainage slots for the bow casing. The box keel is visible along the full length of the submarine with what appears to be drainage holes at the bow end. The keel plating is highly corroded with numerous holes, as is the plating of the bow and forward saddle tanks on the starboard side.

Immediately aft of the tower, the deck planking is partly *in situ* on the casing. There is a razed egg-shaped feature of uncertain function in the centre of the deck. It is shown in contemporary plans and could be an access panel or conceivably a ready use locker. Below the decking at this point the air inlet trunking and HP cylinders are assumed to be *in situ*. The saddle tank on either side is intact.

Aft of the raised feature the deck planking is missing, although its longitudinal framing is still in place. Also *in situ* is the diesel and engine room air inlet trunking and lower valves, although this pipework is heavily corroded to the extent that the pipe walls have collapsed in places. A complete section of the saddle tank casing on the port side is missing at this point. Below is a large stubby cylinder with rounded ends attached to the pressure hull. This feature is unidentified but may be an oil fuel tank.

The aft torpedo hatch lid is open 180 degrees. The decking is missing from this point aft. It appears from the video evidence that the engine room below is partially filled with sand.

Aft of the torpedo loading hatch are the two exhaust outlets and silencer boxes, which appear to be *in situ* with the exhaust outlet control valves and pressure hull apertures. There are also sections of missing upper saddle tank casing. Aft of the exhausts is the raised circular aft torpedo room escape/access hatch. This opens forward but appears to be closed. Immediately aft of this is a full circumference fracture line running along the aft edge of a frame, at which point the structure of the wreck ends.

The forward end of the aft torpedo room survives, although the fixtures and fittings are largely missing and may be amongst the pile of debris on the *in situ* floor plates of the compartment. Amongst this debris is a large object that could be an auxiliary generator. The watertight transverse bulkhead between the engine room and the aft torpedo (possibly also motor) room survives and appears to be *in situ*. The watertight door is off its hinges, probably blown off by the explosion that sank the boat.

Both propeller shafts and their glands survive, although the propellers themselves are missing. The port shaft bracket is attached to the port shaft but is missing from the starboard shaft. The keel of the vessel can be seen below the pressure hull.

About 2m starboard of the aft end of the main section is the small stern section. This comprises the casing aft of the rudders. The aft torpedo tube door is missing and the opening mechanism levers are damaged. The casing behind the door is distorted, with the plating pushed outwards. Within can be seen what appears to be part of the aft torpedo tube, although it is not clear whether the flanged end is present. The aft torpedo tube would have extended well forward of the surviving section and therefore only a small part of it can have survived.

Whether the torpedo tube has been salvaged, as tentatively suggested by McCartney (2014: 71) or the door has been blown off by the explosion that sank the *UB-78* is not clear.
The stern section appears to be smaller than comparison of the batch plans with the position of the fracture on the main section would suggest. It therefore appears that some of the aft torpedo room is missing, presumably destroyed by the explosion.
Astern of the wreck, just aft of the port shaft is one of the two rudders and its shaft, lying on the seabed. Small items of debris are scattered around the aft end of the main section and probably include displaced internal fittings.
Below and starboard of the surviving part of the stem is a large section of the bow casing. A very few small pieces of debris are lying on either side of the hull.

Investigation

The project appears to be the first systematic archaeological assessment of the UB-78 on any scale.

No attempt was made by the Admiralty Intelligence Division to locate and investigate the wreck in the aftermath of the loss due to the nearby presence of mines. The wreck was located in 1977 during hydrographic survey by HMS Bulldog and reported as a probable submarine wreck (UKHO wreck record no. 13449: Surveying Details).
The wreck was dived in 1982, the UKHO receiving confirmation that it was a submarine at this time. It was described as "sitting upright on the seabed". An additional dive report received from the UKHO described it as being "thought to be a WW1 German submarine" (UKHO wreck record no. 13449: Surveying Details).
In 1997 it was again surveyed, when it had sonar dimensions of 50 metres by 10 metres, with a height of 5 meters and an orientation of 070/250 degrees. It was described as being in one piece in a general depth of 22.5 metres, with no debris or scour (UKHO wreck record no. 13449: Surveying Details).
Kendall MacDonald described the wreck as upright, with its stern blown off. He stated that there were torpedoes in the bow tubes (McDonald 1994:43).
The following undated description of the wreck is available on the Canterbury Divers website (http://www.canterburydivers.org.uk/wrecks.html#ub_78):
"The Wreck sits upright on the seabed in a max depth of 27m, the stern has been blown off by the mine and she lies along the current with the bows facing down channel. So the masts, cables and bow net cutter have all gone, there are holes in her outer hull. The gun and conning tower are still in place and she has a list of approximately 40 Degrees to Starboard. The stern is blown off in the area of the stern bulkhead. This is an interesting Sub dive and being a small coastal sub she can be well covered in 1 dive."
The wreck was subject to an inspection dive in April 2011, following which the following summary description was published following WA fieldwork (McCartney 2014: 71):
"Forward section is upright. Aft section lies on its port side…A) A bronze reinforced platform, which is situated between the upper and lower pairs of torpedo tubes, can be seen at this point. Its exact purpose is unclear, but it seems to be part of the hinging mechanism for opening the forward torpedo doors. In either case it is in the author's experience unique to the UBIII-Class U-boat. B) The U-boat is fitted with the Krupp C14 30-calibre 88mm gun on the C16 mount as fitted to the UBIII-Class in 1916-17. It is known that this type of gun was fitted to *UB-78* (Gröner 1991, 26). C) The aft (torpedo) loading hatch is open, and the hatch door can be seen still attached at the top of the hatchway. Internally, the compartment below is full of sand. The conning tower hatch was also seen to be open, but the forward hatch was shut. D) The stern of the submarine is completely removed. Looking into the break, the doorway at the forward end of the aft torpedo room can be seen. The door has fallen off its hinges. E) The two propeller shafts are still attached to the wreck. F) The aft section of the wreck, which

represents most of the aft torpedo room, has been blown off and pushed to the starboard side. The suspicion is that it has been salvaged and some of this damage aft has occurred in recent times, during this process. G) Both propellers have been removed, leaving just the shaft and an "A" bracket." Prior to 1994 both propellers were salvaged. One of these came into the possession of Canterbury Divers and was donated to the German Maritime Museum in Wilhelmshaven in 2011 (http://www.canterburytimes.co.uk/World-War-relic-handed-Germany/story-18146776-detail/story.html). The whereabouts of the other propeller is unknown. Droit details have been requested from HM Receiver of Wreck as part of this investigation. *UB-78* is recorded by the NRHE as 813225. The UKHO INSPIRE portal does not indicate the availability of multibeam bathymetry or other existing high resolution geophysical data for the location of the wreck.

Table 4: Characterisation Using BULSI

5.2 Assessment against the non-statutory criteria for scheduling

5.2.1 The Site has been assessed against the key non-statutory criteria for scheduling under the 1979 Ancient Monuments and Archaeological Areas Act ('the 1979 Act'), as set out in the relevant EH Designation Selection Guide (EH 2012: 9-10). The wording used and given below in italics is derived from the Guide. Regard has also been paid to the recent EH-funded *Strategic Assessment of Submarines in English Waters* desk-based assessment (Cotswold Archaeology 2014).

Assessment Scale

5.2.2 For each criterion, one of the following grades has been selected. This has been done in order to help assess the relative importance of the criteria as they apply to the site. The 'scoring' system is as follows:

- Uncertain – insufficient evidence to comment;
- Variable – the importance of the wreck may change, subject to the context in which it is viewed;
- Not Valuable – this category does not give the site any special importance;
- Moderately Valuable – this category makes the site more important than the average wreck site;
- Highly Valuable – this category gives the site a high degree of importance. A site that is designated is likely to have at least two criteria graded as highly valuable;
- Extremely Valuable – this category makes the site exceptionally important. The site could be designated on the grounds of this category alone.

Assessment

5.2.3 ***Period*** *– Vessels from all periods are important in reflecting technological advances in boat construction and materials, and providing evidence of trade networks, industry, and transport. Those vessels which best illustrate or epitomise this development can have strong claims to national importance.*

5.2.4 Moderately valuable. The First World War saw the emergence of the submarine as a potentially decisive strategic weapon. In order to become this it had to evolve rapidly in terms of design and equipment. Nothing better epitomises this than the development of the various types of U-boat, of which the UB III represents perhaps the ultimate operational development of the medium size torpedo armed diesel-electric submarine. Whilst there is nothing to suggest that *UB-78* is technologically exceptional as an individual vessel, it is a representative example of its type. In addition, the damage evident

to the *UB-78* indirectly provides evidence of another maritime weapon that came of age in the First World War, the sea mine.

5.2.5 ***Rarity*** *– The remains of vessels for periods before 1700 are so rare that any firmly dated vessels from this period are likely to be of national importance and may merit scheduling. For vessels of later date, particularly those types for which examples survive today, scheduling will always be exceptional.*

5.2.6 Not Valuable. U-boat wrecks of the First World War are not uncommon and there are a number of UB III class vessels in English territorial waters.

5.2.7 ***Documentation*** *– Our understanding of shipbuilding, transport, trade and industry can be greatly enhanced by the survival of historical documentation relating to particular vessels and their service. Where modern analytic documentation can provide evidence for especially strong historical claims, for example confirming a ship to be the last of its type, this may be a key factor in establishing its importance.*

5.2.8 Moderately Valuable. Documentary evidence for this submarine exists in some quantity. Documentation traced for this project is largely related to the building of *UB-78* and its modern investigation by authors and recreational divers. In addition there is substantial linked documentation available related to its the wider historical and maritime landscape context, including records of the Dover Patrol and Barrage, records relating to the ships it sank, (possibly) additional German records relating to both boat and crew and secondary works. There is currently no indication that this documentation will revolutionise our archaeological understanding of this type of vessel or their activities.

5.2.9 ***Group Value*** *– In some instances, a vessel's importance may be strengthened by an association with other vessels of a similar type, for example the Scottish fishing boats at Kilspindie or the group of gunpowder boats at Waltham Abbey Gunpowder works, which allows for comparative study. Association within a wider context which reflects their use can also be a consideration. In the case of hulks, as well as having intrinsic interest, they can contribute to the story of a landscape, and its long-term evolution and management.*

5.2.10 Highly Valuable. The activities of the Flanders Flotillas and the barrage built to defeat them have created an associated multi-national marine archaeological landscape of wrecks within the Dover Straits and further afield that includes other U-boat wrecks such as *UB-78* and their Allied merchant ship victims (**Figure 9**). Such landscapes are commemorative as well as archaeological and their importance is easily communicated during the ongoing 1914-18 Centenary commemorations.

5.2.11 ***Survival/Condition*** *– Given the range of materials used in boat-building, survival of vessels can be highly varied, from the sand-imprint of the ship at Sutton Hoo or fragment of the log boat at Shardlow (Derbyshire) to the concrete boats of Second World War date at Purton. Given the rarity of surviving vessels of pre-1700 date, even fragmentary survivals are likely to be of national importance although a judgment must be reached as to the degree of survival and intactness. For vessels of later date, increasingly complete survival, allied to strong archaeological and historical importance, will be expected before scheduling would be considered.*

5.2.12 Not Valuable. Although the pressure hull is not intact, this appears to be due to the damage sustained from the mine that sank the boat. As such it can be plausibly argued as an original and integral part of the wreck rather than evidence of subsequent deterioration. Seen in this context the wreck is visually largely intact. However, no close examination of its condition has been carried out and issues such as plate thinning and structural integrity

remain uncertain or unknown. Parts of the boat that are missing, including the propellers are commonly absent from submarines of this period and it can therefore be argued that this wreck is therefore in a fairly average condition.

5.2.13 ***Potential*** *– England's maritime past is one of its most defining characteristics throughout all periods. Evidence for the construction and use of vessels gives us great insight into not only the exploitation of our immediate marine environment, but also into the development of wider trade and transport networks. This is especially true of earlier periods which are lacking in the rich literature and documentation of later times. Surviving vessels may also provide evidence of their use and construction, reflecting technological developments which in some instances may be all but lost. For the prehistoric period, in particular, the remains of vessels may be some of the largest artefacts discovered which demonstrate the technology of woodworking and management of woodland resources. Similarly, where vessels are found in situ, associated deposits may be rich in palaeoenvironmental remains. The potential which a vessel has for answering questions about our maritime past will be a consideration in establishing its importance. If remains of a cargo survive it is likely to add very considerably to the vessel's significance, for its evidence of trade and material culture at a particular point in time.*

5.2.14 Moderately valuable. Although *UB-78* clearly has some potential for further study as a representative example, its main potential appears to lie in its potential contribution to the wider battlefield environment of the Dover Barrage. Within this battlefield lie the wrecks of a significant number of U-boats (**Figure 9**) and patrol vessels and possibly evidence of the barrages themselves. Research for this study suggests that the vital defence of the Dover Straits during the First World War has not been the subject of the thematic archaeological study that it surely deserves, so the potential of *UB-78* in this respect is clearly fairly high.

Summary

5.2.15 Measured against current EH guidance on the criteria, the *UB-78* scores fairly highly and is perhaps a borderline candidate for scheduling. Whether the protection such scheduling would bring would have a practical impact upon the monument is uncertain.

5.2.16 Group value has been rated as 'Highly Valuable'. However, it is arguable in the context of the marine heritage assets of such an important First World War battlefield as the Straits of Dover that this should in fact be 'Extremely Valuable'.

5.3 Risk assessment

5.3.1 Risk is assessed as being low (**Appendix 3**). However, it should be understood that there are two caveats to this:

- It has been assumed that no intrusive activity is currently taking place because none was observed by or reported to WA; and
- The is currently no agreed definition of what individual or groups of features constitutes 'features of special interest' in relation to First World War submarines.

5.4 The importance of submarine wrecks as monuments

5.4.1 Archaeological assessment of the significance of submarine wrecks has tended to be primarily typological, with most attention paid in the past to rare examples of very early pre-1914 submarine design. In strategic terms importance has therefore tended to be argued by archaeologists in terms of how representative of particular types and models of submarine individual wrecks are and whether they are of pre-1914 design.

5.4.2 However, it is arguable that the significance of submarines as monuments should be argued in terms of their association with events. It would therefore follow that the *UB-78*'s principal interest lies not in its design, but in its status – like the *UB-109* - as part of the vital Dover Barrage battlefield during the First World War.

5.4.3 That battlefield, in the context of a wider project, has been explored in recently published PhD research (McCartney 2014). It has also been discussed in relation to the *UB-109* assessment (Wessex Archaeology 2015).

6 ARCHIVE

6.1.1 The project archive consists of a hard copy file and computer records and is currently stored at WA under project code 83803. The archive will be transferred to an accredited repository to be agreed.

6.1.2 Shapefiles generated for the project comply with Marine Environment Data and Information Network (MEDIN) standards for metadata.

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Deutsches U-Boot-Museum (U-Boot-Archiv)

7.4 Admiralty and Other Charts

Admiralty Chart 2449 (2014)

8 APPENDiCES

Appendix 1: Dive Log (WA divers only)

Dive	Date	Start Time	Duration*	Max Depth (m)	Divers	Work
01	05/10/2014	13:11	23	24	Croce & Dresch	Initial inspection

*** Bottom time in minutes (time from diver left surface to diver left bottom; actual working time will be shorter)**

Appendix 2: US Navy description of surrendered *UB-88*

The UB-88 lay moored in the "Trot," Harwich Harbor, from the date of her surrender, November 27, 1918, until March 13, 1919. On the latter date the UB-88, UB-148, UC-97, U-117, U-140, and the U-111 were allocated to the United States by the British Admiralty. The first five named were at Harwich; the U-111 was at Plymouth. On March 11, 1919, six officers and 100 men from the Submarine Base at New London, Conn., and about thirty other men detailed from the various U.S. naval stations in the British Isles, arrived in Harwich to take over these boats. Several officers were already in Harwich, having been sent there from the U.S. Naval Headquarters in London.

About fifty percent of the men had had previous submarine duty, while all the officers were experienced in submarine work. The problem before us was to learn the boats, train the crew and sail under our own power for the United States at the earliest possible date. As these vessels were to be used in connection with the Victory Loan campaign, it was desired to hasten their arrival in New York. With the above problem in mind, we set about to solve the task allotted to us.

The German submarine is, naturally, a distinctive type. True, all submarines are built upon the same general principles, in that they have ballast and trimming tanks, diving rudders, motors, engines, etc. Still the arrangements and installation of all this material may be such as to present to a person who has had experience operating one type, a vessel in which everything will appear entirely different. Our previous experience was to be sure, of great value to us, but on account of the design of the German submarine it was necessary "to learn" these boats in every particular. For example: it is a very simple matter to blow tanks on a U. S. Submarine - but the problem was, how to blow them on the UB-88. First it was necessary to learn the operation of the German type of air compressor. Next to learn the air distribution system to the different parts of the ship, then the leads to the air flasks or accumulators, then the leads from the flasks to the manifolds and from the manifolds to the tanks. This would put air into the tanks but it was further necessary to learn the operation of the ballast Kingston and the ballast vents. Then if you had been successful in following out the leads and valves, the problem was solved. This appears, no doubt, simple, and under ordinary conditions it would be, but the German arrangement of piping has not that beautiful symmetry found in our boats and a pipe may wind in and out among its fellows in such a way as to present a veritable Chinese puzzle. Blue prints and drawings were luxuries we did not enjoy, for all these had been very carefully removed.

The cleaning, repairing where necessary, tracing out fuel oil lines, lubricating oil leads, air lines, water lines, ventilating pipes, battery leads, lighting circuits, took up a great deal of time allotted before the moving parts could be tried. All the name plates, naturally, were in German. We found that the German phraseology used in engineering was not the same we had learned in school. The amount of work necessary was apparent and the conditions under which we worked can be imagined.

The UB-88 was in a filthy condition. Food had been left aboard after she had surrendered. The remnants of the last meals had been thrown in the bilges. The stench from the galley was unbearable. Rust covered all the piping. The engines were one mass of corrosion. The torpedoes had been pulled from the tubes and thrown on the torpedo room deck. The air flasks and after-bodies were coated with rust and badly pitted. The storage battery was almost run down, not having had a charge for over four months. The bilges were full of oil and water. Many parts of the boat had been taken by souvenir hunters while she lay moored in Harwich. The eye-piece on the forward periscope had been broken off and the reflecting prism and lens removed. The stabilizer had been taken from the gyro compass, as had also the azimuth motor. The magnetic compass had disappeared. Out of the dozen cooking utensils on hand, only one would cook, the rest had been smashed or the coils burned out. There were no mess gear, mattresses or blankets. There were no spare parts for the engines. Parts of the radio set had been stolen and the rest smashed

in with a hammer. The repeaters for the gyro compass now decorated the homes of the British as souvenirs of the war.

So many parts of the equipment were out of commission that it was decided to find out first what would work, then go after the parts that would not. This system was followed out. Everything was tested and report made whether or not it was in running order. If not, what was wrong, and what was needed to fix it. In a very short time we had a good estimate on just what we had to do.

To illustrate our method; The radio set, as stated, had been demolished. The motor generator was there and would work, but sending and receiving sets were almost completely wrecked. By rummaging through about a dozen of the submarines still remaining in the "Trot," which were going to be sold for junk, we collected enough material to complete a sending set. We were unable to find a detector, however, so that had to be purchased in London, and with parts of a receiving set "stubbed out" from the U. S. S. Chester, the radio outfit was complete, but not efficient. Probably it was the lack of harmony, due to the combination of English, German and American parts. Who knows? It was impossible to improve on the set until the arrival of the U. S. S. Bushnell. She had on board six complete out fits. By the addition of a quench gap and an audion bulb to what we already had, the outfit from one of these sets was connected up and tested. Our reward was a set with a hundred miles radius, which was sufficient for our needs.

I stated before that the magnetic compass had been removed. Search was made through all the German submarines lying in the "Trot" and none could be found. A U.S. Naval Vessel donated one, but it had been lying idle for so long in one position without any liquid in the bowl that the magnets had lost practically all their directive force. There was not much hope in getting good results from this compass, but nevertheless it was installed, and after filling the bowl, an attempt was made at compensation on one heading. That night before turning in I looked at the compass and it showed the heading NNW 1/4" W, which was about correct on magnetic North. I looked at the compass the next morning with the ship headed in the opposite direction (having swung with the tide) and it still showed us headed NNW 1/4" W. All the compensating magnets were removed but true to her straight forward aim in life, the compass never moved a fraction of a degree and for aught I know she still heads NNW 1/4" W. A call was made on the Senior Submarine Officer at the British Submarine Base, and after a "search" he supplied us with a compass which had been taken from one of the German submarines. This was installed but on account of the binnacle being placed inside the chariot bridge, its operation was slow and sluggish. A make-shift stand was then installed between the periscopes on the periscope sheer. A block of wood placed directly under the center of the compass and bored with several holes at right angles, served admirably as a compensating rack and in this "rig," we placed our hopes. True the steering wheel was about ten feet from the compass, but I don't think we worried much about that at the time.

The German (Anshutz) type of gyro compass was a source of mystery. The stabilizer had been removed as had also the azimuth motor. By again visiting several of the boats up the "Trot," an azimuth motor was found and connected up. Also on the same trip we were fortunate in getting three repeaters in good condition. A stabilizer, however, could not be found. There was no one aboard who knew the interior construction of this type of gyro and in consequence no one knew how to operate it. By tracing up the leads from the compass, we found the motor generator and the power leads from the switch boards. That much settled, we went after the compass and by a process of trial and error, it was finally started, and much to the surprise of everyone, it worked satisfactorily. A four degree easterly deviation was removed by balancing the rotors with sealing wax placed in the compass levels to compensate for the loss of alcohol from the levels, which had been broken. The compass is still running perfectly. It has never shown any tendency to "get off" the Meridian even in the roughest weather.

The drainage system was of course, a vital problem, although a simple one. Trouble was

experienced with the after trimming line pump and it has never been in good condition. The adjusting pump, just abaft the central control room, was working and as it could be connected up to all the bilges through the manifolds, full confidence was placed in this pump. If it had broken down completely the novel situation of bailing out a submarine with buckets or the use of a handy-billy would have resulted. Nothing else could have been done.
As the safety of the boat on the trip from England to the United States was a paramount factor, it was thought advisable to dock the boats at Harwich before sailing. The underwater hull and all tanks were minutely examined. New Kingston gaskets were installed where necessary. The trustworthiness of our late enemies was never mentioned, still I do not doubt that it was in everyone's mind during the period of preparation. However, let credit be given them where it can, for we found no tampering of any kind. The boat was in dock two days, during which time very little opportunity was had for any progressive preparation. After undocking, however, we again turned to.

The engines were the most important part of the equipment to prepare for operation. I think that everyone who worked on the engines did so with the determination to make them run as well or even better than the Germans had done. It was this or admit that the German crew was the better of the two. Looking at it in that light, the determination to succeed in the preparation of them was to everyone a matter which touched the most delicate spot in the human make-up - Pride.

In beginning to learn the engines and auxiliaries, we were in the dark, except for our general experience with Diesel engines and the intimate knowledge of a few types which are used in our own service. As all engines of this type operate upon the same principle it was chiefly necessary to locate the supply, the discharge, if any, and the power of delivery of the circulating water, the air, and the lubricating oil. In the case of the fuel oil, the tanks were first located, then the leads, to the gravity feed tanks, and then the valves and pumps controlling the delivery to the engines. At the same time the fuel compensating system was traced out. The lubricating oil system was followed out and tested in the same way as was also the cooling water. In order not to forget the thousand and one valves with their German names, shipping tags were placed on each valve and gauge. On these were written the use of the valve and how to operate it. The explanation of this procedure is brief and to the point and one would judge that we were occupied probably one or two days in this work of tracing out lines and tagging them. But so complicated and intricate was the German system of piping and valve arrangement that the time consumed before we were ready to start the engines was fourteen working days. When everybody had been properly prepared for our first trials of the engines, they were jacked over by hand to insure that everything was clear. The engine clutches were then thrown in and they were turned over slowly with the motors. All looked well. A signal was given to the electrician at the switch board to "speed her up."

Slowly the lubricating oil built up the required pressure and the discharge pipes into the sight box on the side of the engine showed abundant supply to the piston heads. The circulating water pressure started to climb and was soon up to the required mark on the gauge. The spray air pressure was slow in building up but finally arrived at the proper mark. The oil supply was then opened and the cylinder try-cocks closed, and as the engines had run under the care of the Germans who had built them and studied their operation, so they ran then. There was not a hitch, nor had anything been forgotten. That day we charged batteries for four hours without stopping the engines, in order to be assured there would be enough power in the battery to turn the engines over the next time they were needed.

After the crew had demonstrated their ability to run the engines, all hands "turned to" to provide the necessities of life and what few comforts we could gather. The subs up the "Trot" were ransacked for cooking utensils. We found plenty; terribly dirty and rusty. These we took, and after cleaning them and forgetting the condition in which they were found, the food prepared in them tasted very good. Plates, knives, forks and spoons, and the thousand and one things needed in the

preparation and serving of food were purchased in London. Blankets, mattresses, pillows, life belts, sheets, etc., etc., were obtained from the Naval Depot, London. The Red Cross, always on the job when needed, provided us with woollen goods, pajamas, under wear, candy, chocolate, cigarettes, etc.

Fuel, lubricating oil, provisions and water were taken from the U.S.S Bushnell and the UB-88 was ready.

April 4 was the date set for sailing.

Following is a more complete **general description** of the important features of the UB-88:

German submarines were divided into several classes, depending upon the work they were to perform. One type was wholly used for torpedo work, another was a combined type which carried both torpedoes and mines, and a third consisted of the mine-layers, which carried mines only. These vessels were again divided into classes according to their sizes and dates of construction.

The UB-88 was a small straight torpedo type of submarine (UB-III class), carrying ten torpedoes, one 8.8 cm. gun, and bombs which were used for destroying surrendered merchant vessels. She was propelled by two six-cylinder, four cycle, 450 revolution, 550 H.P. reversing Diesel engines. Connected to the engine shaft by means of friction clutches are four electric motors, (two on each shaft) which are used to propel the vessel in confined waters and when submerged. They are of about 325 H.P. apiece. The power for these motors is obtained from a 124 cell storage battery, divided into two groups of 62 cells each.

Torpedo Tubes

The vessel has five torpedo tubes, four of which are located in the bow and one in the stern. These are constructed of bronze. Length from door to door 24' 8". Length from door to No. 6 ballast tank bulkhead 9' 1". Diameter 20". The bottom of the tubes are fitted with pockets to receive zincs. There are three of these pockets holding two zincs each. There are two drains in each tube, one forward and one aft about 2-1/2" in diameter. The upper tube bow doors work on the same principal as do the doors on our Holland "L" and "N" class. The lower tubes have only a bow door, there are no outer shutters. The rear door seats on a knife edge against a leather gasket and is operated by a lever with a worm that engaged a rack on the locking ring. There are three safety devices, one locking inner door while outer door is open, one locking outer door while inner door is open, and one to prevent stop bolt from lifting while impulse valve is lifted. The tube is so fitted that the torpedo can be boosted while in the tube, and depth and curve fire can be changed while torpedo is in the tube. The rear door is fitted with a small plug that can be removed to insert impulse gauge.

Impulse Tanks

Located in torpedo rooms, eight forward, two aft. There are two impulse tanks to each tube. Each set having its own reducer from a high pressure line and can be fired electrically or by hand. There are two valves, one between the impulse tanks separating the high from the low pressure tanks and the other forward of the firing or impulse valve, preventing same from functioning until stop is lifted. The capacity of these tanks is about 6 cubic feet per set. These tanks were used also as volume tanks to supply air for blowing tubes. The blow line has its own reducer leading to the tanks.

Periscopes

There were two periscopes of the walk-around type, of zero and six power. They were fitted with two small shifting levers, one to shift high and low power, and one to shift the objective prisms to elevate or depress. Both are housing periscopes. The after periscope well contained an elevator. This periscope could be raised and lowered by motor or hand.

Air Flasks

There are ten air flasks located between inner and outer hull, above the water line, with exception of Nos. 1 and 2 groups, which are located in central control room and pump room. These flasks can be charged from the engine air compressor or from the auxiliary compressor, also in engine room, and were usually charged to 160 atmospheres. Each flask group has a separate line to the high pressure manifold.

Oxygen

There are ten oxygen flasks, seven forward and three aft. These can be charged from ashore while in the boat. They are connected to manifolds fitted with charging caps used for charging small bottles on escape helmets.

Bunking Arrangement

The boat has bunking facilities for a crew of twenty-seven men and three officers. There are four bunks for chief petty officers in a separate compartment, and a cook's bunk near the galley. Due to very poor ventilation the latter bunk was considered unfit for use at sea. The crew's bunks are located partly in the torpedo compartment and partly in the after battery compartment.

Radio Set

The 1/2 K.W. Radio set as installed at present is almost completely of American make. The Motor Generator is German. The other apparatus was found to be broken or stolen when the boats were taken over and a new set (received from the U.S.S. BUSHNELL) was installed.

The antenna is T-type. The rat-tail enters the boat through a porcelain tube. This tube is heated with an electrical coil which keeps the outside dry, so that the set can be used immediately upon coming to surface.

There are places for two masts, one forward and one aft, but these were never installed. Arrangements were made to raise and lower these masts by compressed air from the Radio room.

Signals

No methods of signalling (except recognition) were found on the boat. Forward of the gun on deck, there is a sheet iron semi-circle. When in one position it shows only the iron surface, when turned over it makes a complete white circle. This is thought to have been used for aeroplane recognition.

Ground Tackle

There is a patent anchor housed in the superstructure, starboard side, weighing about 100 lbs. It is fitted with 120 fathoms of 3/4" stud link chain and it can be controlled from the deck or torpedo room. This anchor gear is similar in construction to that of our Holland boats of the "L" type with the exception of the housing. A capstan connected to the anchor control shaft can be operated independent of the anchor by disengaging a clutch fitted to the shaft. The anchor is fitted with a compressor and a controller that can be operated from the deck or from below. There is a small

compartment built in No. 6 ballast tank to receive the chain.

Deck Arrangement

The deck is fitted with lockers, that serve as stowage space for lines, and ready ammunition for deck gun. Forward of the torpedo hatch there is a large locker that served for boat stowage. The ammunition lockers are constructed of very light material and were intended to be water-tight. The mooring arrangements consist of cleats and bits that can be housed in the superstructure while underway. There is a tripod fitted on the forecastle to which is fitted a saw tooth net cutter. This tripod also serves as a guide and brace for the clearing lines. These clearing lines run from the bow up and over the tripod, over the braces on the wings of the bridge, to the stern and are there fitted with turnbuckles. They also serve as an antenna support for the radio. There are two cradles or beds, one forward and one aft, on deck that served as housing for large Radio Masts that could be raised and lowered. These were not installed. There are four hatches, the forward or torpedo hatch, the conning tower hatch, the engine room hatch (which is on an angle to receive torpedoes), and the galley hatch.

Bridge

The bridge is of the open chariot type, constructed of a light bronze extending 3/4 way around, the after end being enclosed by a rail. A small periscope cut-water comes up through the center, standing about two and one-half feet in height. On the after end of the bridge there is an insulator for the radio and a telescopic flagstaff. In the center, forward and on either wing of chariot there are fitted permanent pelorus dials with a portable sight for same. The running lights are permanent fixtures on either wing of the bridge.

Holds

There are three holds in the forward torpedo room and two in the central control room. The one on the starboard side of torpedo room is for fresh stores, one on the port-side for dry stores and one for miscellaneous stores. One vegetable locker and one reserve ammunition locker are located in central control room. The torpedo room bilge is fitted with brackets to carry spare torpedoes.

Main Ballast Tanks and Vents

These are six in number. No. 1 is located in extreme after end of ship, capacity about 5 tons; Nos. 2 and 3 located in engine room, capacity about 15 tons each; No. 4 located in central control room, and extends into cabin; No. 5 in torpedo room, and No. 6 forward. Nos. 1 and 6 have one flood valve or Kingston, while Nos. 2, 3, 4 and 5, are fitted with two. There are two blow lines to each tank, one from high and low pressure and one from the turbo blower. Vents are installed at four parts of superstructure. Nos. 1 and 6 ballast tanks have single pipe to the vent dome. Tanks Nos. 2 and 3 (main ballast) vent to one dome aft of conning tower fairwater. Tanks Nos. 4 and 5 (main ballast) vent to a single forward of the torpedo hatch. Tanks Nos. 2, 3, 4 and 5 can be vented independently or in tandem by master vent controlling shafts in the central control room. There are no inboard vents on these tanks. The only way of determining whether or not these tanks are full is by trying the pet-cocks in vent lines.

Batteries

There are two batteries, No. 1 (after) and No. 2 (forward) composed of sixty-two (62) lead, acid cells each. The cells are about the same size and dimensions as American Gould and Exide inclosed type cell. Gravity has been brought up to 1.230 or 1.235 on full charge. None of the cells have been disassembled or cell covers taken off and exact number of plates is unknown. Capacity

of battery according to ampere hour meter is 8,000 A.H.S. It is not known whether there is a lead lining around sides of battery tank as none can be seen.

These batteries have no advantage over ours unless it is in locating, which is such as will not allow entry of salt water, as there are no hatches over battery. The batteries are difficult of access for instead of the whole battery deck being removed, there are installed steel doors in a steel deck. Through the center line of the boat these steel doors are about 2' by 4' in size, the outboard doors are about 18". For example, if an outboard cell had to be pulled, the center cells would have to be pulled first; then by moving the outboard cell to the center line it could be lifted. This arrangement is very poor.

The outboard rows on port and starboard sides of each battery set about a foot higher than the rest of the battery and the only way to see inside cells in outside rows in by means of a mirror, which is very awkward and slow when watering. It is not known whether there is lead lining in bottom of battery tank to prevent acid from leaky cells from eating holes in the hull.

Main Motors

Seimens Schuckert made. There are four (4) motors, ten pole, interpole, shunt, two inside same case on each shaft, controlled by same switches, so one motor can be cut out only by pulling fuses for same. Horse power about 225 each. Reversing or rotation is done by reversing field. Speed variation is obtained by using batteries is series or parallel or by switching the two motors on same shaft in either series or parallel. Starboard and port motors cannot be put in series. They also have control by field rheostat in shunt field.

There are no advances over American motors except that they have greater speed variation in that the batteries can be hooked up to the motors on either shaft and may operate off batteries in series while the other side uses batteries in parallel or vice versa, and the two motors on the same side can be operated in series or parallel regardless of the other side.

The motors are located low in the boat, near bilges and under switchboards and the other gear is installed so close to them that they cannot be gotten at to repair without removing all parts abaft the engines. The motor case and brush rigging of the two after motors must be removed in order to reach after motor bearing.

There is one ventilating blower to starboard motors and one to port motors, operated by an intermittent duty motor at each end, one or both motors may run at the same time.

Blower Motors and Ventilating System

There are two (2) two pole, interpole, shunt, blower motors, 3 to 4.6 H.P. run on 24 amperes, 110 to 170 volts. They are situated one on the port and one on the starboard side of the forward end of engine room.

The ventilating system is so installed that one or both motors may take suction from battery or compartments, or both at the same time. The system is also arranged so that starboard motor may take suction from outside of boat and discharge fresh air inside boat and battery, while port motor takes from boat and battery and discharges overboard, this method gives best results.

The only advantage over American systems are that one blower may take foul air out of the boat while the other feeds fresh air in, and both blowers may take suction from battery while charging.

These motors have only one speed which is so high that they will not stand continuous running.

The ventilating system is fitted with numerous valves located in places that are hard to get at to overhaul when froze from action of acid from batteries.

Lighting System

There are two distribution boards for lighting, one in motor space and one near central control room. One board feeds lights on starboard side and the other feeds port side. One or both distribution boards may feed from either battery. Branch distribution boxes are located in each compartment protected by plug fuses. Lamp bases are about the same as American and fit standard screw base lamp.

If one board or one battery is out of commission half the lights in each compartment remain in commission. (This is a decided advantage over our system). All fuses are enclosed in a porcelain cap and cannot be shorted when working near a fuse box.
Connections in junction boxes are easy to work on as the wires do not have to be bent around the securing screws. Rotary snapswitches are installed but contain too many parts. These get out of order very easily. Fuses are hard to reload, everything being enclosed, making repair work slow. The system takes an excessive amount of wire cable.

Heating System

Each compartment is fitted with a receptacle to plug in a portable electric heater. These heaters are about the same as American, except in shape, these being about 12" x 12" x 16". Current is obtained from power circuit.

A steam radiator is fitted in each compartment hooked up to a pipe leading to outside of boat, supposedly for getting steam heat from Tender. This has never been tried out.

Cooking System

The galley is fitted with an electric cooking system. Current is obtained from after distribution board, fused for 60 amperes. Current may be taken from either battery by turning a four-way rotary switch on the line to each receptacle. Large portable pots varying in size from about one to twenty gallons are used. Each contains its own heating coil between the inside and outside shell of the pot. Each pot heating coil is divided into two or three parts. Different degrees of heat may be obtained by changing hook-up of the coils, this is done by shifting position of the plug on pot, which may be plugged in four positions.

Battery Charging Data

No German charging data is available. Charging is done similar to charging American submarine batteries, starting at not exceeding 1200 amperes in series, charging until voltage reaches about 295 or 300 volts, then cutting down load gradually, keeping voltage constant at 295 or 300 till gravity reaches 1.225 or 1.230 or until temperature of pilot cell reaches 105 degrees F.

A chemical ampere hour meter is installed, but does not give a good indication of charge as gravity, so ampere hour meter is only used to get a rough estimate.

Gyro Compass

The gyro compass consists of three A.C. 90 volt induction motors 120 degrees apart, suspended on an inner gimble ring, which floats in a mercury bowl. The main voltage, 125 D.C. comes from ship's mains to motor generator set, which converts and steps it down to 90 volts A.C. The rotors

are about four inches in diameter and weigh about ten pounds each. They spin in the air as there is no vacuum chamber on the compass. The repeater system is operated by a three-phase motor, turning a shaft with a row of contacts, which cut in simultaneously the field poles in the step by step motors in the repeaters. The three-phase motor is operated back and forth by having one phase split with each side connected to contacts on the inner compass standard. When the compass finds its course the hunting motor on bottom of compass moves the two contacts so that the motor contact will be between them and keep the repeater in stop. All the repeaters are D.C. The lights are dimmed in the repeaters by cutting in resistance.

Arrangement

The interior arrangement is very poor. Repairs at sea are almost out of the question. This is due to the inaccessibility of the parts which are most likely to get out of running order; for example; the main motors and fields are directly below the switchboards in heavy casings. In order to remove a motor or field coil it is necessary to remove a section of the hull. The pumps are located behind or under a network of piping and cables.

The UB-88, although of only about 750 tons displacement, is an excellent sea boat. This may be accounted for by the fact that the boat is of the saddle tank type, which gives larger beam dimensions for small tonnage.

Engines

Engine Builder: Vulcan Works, Hamburg & Stettin, Germany Number of engines installed: Two (2) R.P.M.: 450 Horsepower: 550 Number of cylinders: Six (6) Cycle: Four (4) Bore: 13-3/4" Stroke: 13-3/4"

There are two sets of cams shifted by hand from forward end of engine, by means of hand lever and worm gears.

The engines may be started by air or electric motors.
The pistons are of high grade cast iron, and the top of pistons are concave. The pistons are oil cooled.

Wrist pin is keyed into piston by taper pins.
Wrist pin bearings are of white metal keyed into connecting rod.
Engine base and bed plates are of cast iron.
Crank shaft is of high grade carbon steel and disc friction clutch acts as fly wheel to engine.

The rocker arms are of cast iron, located on the upper inboard side of the engine above and outboard of camshaft on a sectional eccentric rocker arm shaft. A two piece collar holds each arm in place so that in renewing or overhauling any valve the rocker arm can be easily shifted so as not to interfere with the lifting out of the valve.

If necessary to remove cylinder head, the section of rocker arm shaft can be removed by lifting off boxing on each side of the cylinder.

The rocker arms are operated on the forward end of engine by means of two levers; each lever controlling three sections of shaft by three cylinders.

The fuel pump, lubricating pump, and circulating water pump of each engine are also at forward end of engine, forward of air compressor. The fuel pump and circulating water pumps are driven by a horizontal crank driven off the main crank by worm gears.

The fuel pumps are similar to the Nelseco.

The circulating water pumps are plunger type.

The lubricating and circulating pumps may be cross connected for either engine.

Engine Air compressors

The engine air compressors are similar to the Nelseco, except that they are four stage and are located at the forward end of engine. There are two trunk type pistons with the 1st stage in the middle, the 2nd at the bottom, and 3rd and 4th tops of pistons. The air suction to compressor is governed by small throttle connected to a piston valve allowing the required amount of air to 1st stage of compressor. The first stage compresses the air from 2 to 3 atmospheres and discharges it through the cooler to the 2nd stage. The 2nd stage compresses the air from 9 to 10 atmospheres discharging through the cooler to the 3rd stage. The third stage compresses from 32 to 44 atmospheres and discharges through the cooler to 4th stage. The 4th stage compresses from 60 to 90 atmospheres, (relief valve set at 160 atmospheres) and discharges through cooler to restrictor where the air is distributed, the required amount for the engine to the spray bottle and the amount over can be sent to the ship's air flasks.

Pumps

1 - Auxiliary lubricating oil pump, centrifugal.
1 - Auxiliary circulating water pump, centrifugal.
1 - Fuel pump, centrifugal for loading oil to tanks.
1 - Bilge pump, centrifugal.
1 - Adjusting pump, plunger type, for pumping to or from trims, regulating tanks, fresh water tanks and bilges.

Opinion

It is the opinion of the Commanding Officer that the German type of submarine is superior to the American type (both Holland and Lake) in the following particulars only:

1. Easier riding in heavy seas, with seas ahead, astern, or on the beam. This is attributed to the fact that all German boats are of saddle tank construction and therefore have larger dimensions for the same tonnage than our submarines. There is very little tendency for the boat to bury itself in a sea way. The bridge, in any kind of weather is comfortable. Seas have never broken over the bridge since the trip was started, and only occasionally does spray come over.

2. Wooden deck. This feature is far superior to our steel decks in that it gives a firm foothold, does not require constant attention to keep in good condition; it is easier to repair or remove for getting in inaccessible parts of the hull; it is lighter, and is much cheaper.

3. Gyro compass. The Aushulz type of gyro compass is an almost perfect working instrument. During the entire trip of 15,361 miles, mostly in rough water, this compass was never over three degrees off the meridian. Trouble has been experienced with the repeaters.

4. Bunking arrangements are excellent but the accessibility of the batteries has been sacrificed to obtain this condition. Would not recommend any change from our system.

5. Sounding machine. This machine is installed in the central operating room and should be an

indispensable feature of our submarines.

6. Periscopes. From observations and comparisons the German type of periscope is superior, due to greater light transmission of the reflecting prisms and lenses.

7. Turbo blower. This blower greatly facilitates the blowing of tanks. It saves all the high-pressure air which is ordinarily used for that purpose and which should be kept available for emergency or torpedo use. Only air tanks of sufficient capacity for torpedo work or emergency use need be installed.

8. The propellers on the UB-88 are under the fan tail and are more deeply submerged than ours. This of course reduces the propeller losses and ensures complete propeller submergence in all weather.

9. Hull paint. While in dry-dock the underwater hull was found to be absolutely free from all rust and growth. The hull paint used by the Germans should be tried out, as it appears to be superior to that used by our service. It is, from a superficial examination, made from an asphalt or coal tar base.

10. Diving rudders. The forward diving rudders are placed about two and a half feet above the keel. This ensures full rudder effect at any depth. The forward diving rudders on U.S. submarines are placed so high on the bow that they lose a great deal of their power when near the surface due to lack of weight of water above them. I think this change would cut down the crash dive time an appreciable amount.

The interior arrangement of the UB-88 is exceedingly poor. This is probably accounted for by the fact that these boats were built in a hurry and were only intended for the duration of the war. The lack of copper and brass is apparent and much of the piping is rapidly going to pieces. This is especially true of the circulating water piping on the main engines and the high pressure air lines.

Except as noted above the UB-88 presents nothing new in submarine construction or anything which is superior to our boats.

Appendix 3: Site Risk Assessment

Wreck/Site Name	***UB-78***		
NRHE /UKHO No.	EH Region	Restricted Area	Principal Land Use
1388897/13449	South East	N/A	Coastland 1: Marine
Latitude (WGS84)	51° 1.034' N		
Longitude (WGS84)	01° 16.486' E		
Class Listing	Period	Status	
Submarine	FWW	Non-designated site	
Licensee	Nominated Archaeologist	Principal Ownership Category	
N/A	N/A	C: MoD	
Seabed Owner	Navigational Administrative Responsibility		
Crown Estate	Dover MRCC		
Environmental Designations			
G: NONE			
Seabed Sediment	Energy		
sG sandy gravel and G gravel	Medium		
Survival			
Very Good			
Overall Condition	Condition Trend	Principal Vulnerability	
E: Extensive significant problems	B: Declining	NAT	
Amenity Value: visibility			
A			
Amenity Value: physical accessibility		Amenity Value: intellectual accessibility	
A: Full		C: no interpretation	
Management Action	A: no action required		
Management Prescription	M: no management prescription required		
Notes:			

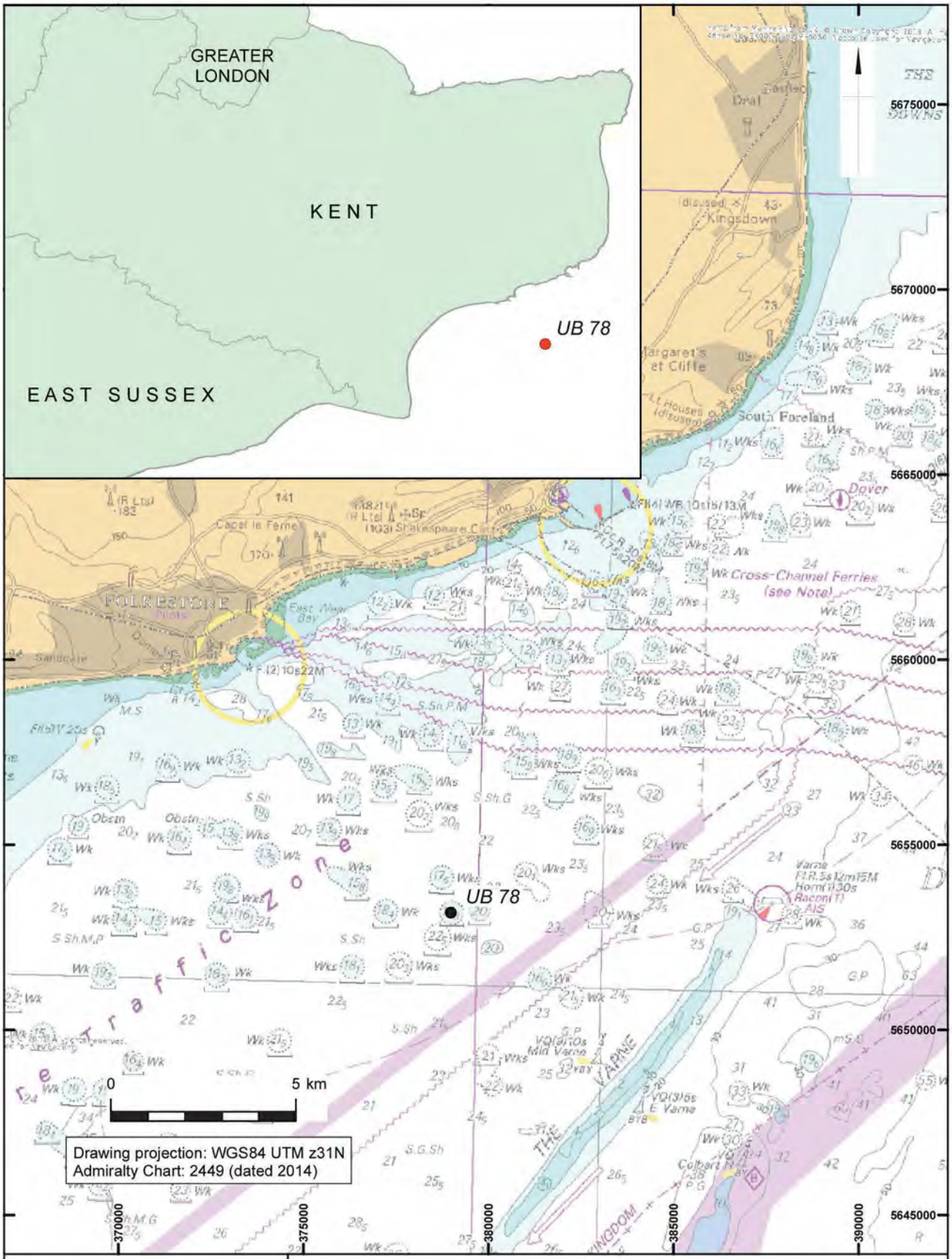
The wreck of the FWW German submarine *UB-78* lies at one location in two sections within territorial waters off Folkestone, Kent. It is almost fully exposed. The *UB-78* was lost in 1918 whilst attempting to pass through the Dover Barrage and the separation of the hull into two pieces is thought to have occurred at the time of loss and as a result of the explosion of one or more mines.

The site is well known to the local diving community and is occasionally dived. Although the propellers have been salvaged, WA has not come across any evidence to suggest that the submarine is unusually vulnerable to salvage. Although limited surveys have now been carried out, including a diving survey by Wessex Archaeology in 2014, it has not been fully recorded.

The submarine is in a reasonably good condition considering the circumstances of loss and the ongoing effects of corrosion. It has lost some deck, conning tower and other casing and deck fittings. Both of its propellers were salvaged in the late 20th century and other items have been removed. No human remains were observed during this survey, although they are likely to be present within the main section of the wreck.

The principal long term vulnerability of this site is likely to be the ongoing process of corrosion, which will inevitably result in the eventual collapse and destruction of the wreck. Although our understanding of its impact on both this and other submarines would benefit from further corrosion-specific survey, halting or

slowing its progress is not currently practicable. There may be some risk to external fittings if they are used for moorings. No formal management prescription appears to be appropriate, although EH has the opportunity to benefit from the strong encouragement to local engagement provided by the investigation of this and other local FWW sites in 2014 by undertaking further related fieldwork and/or engagement in the region. Using the 'decision tree' method of risk assessment, risk is assessed as LOW. Data source for this risk assessment is: Wessex Archaeology, 2015, *Archaeological Services in Relation to Marine Designation. UB-78, off Folkestone, Kent. Archaeological Report*, Wessex Archaeology Ltd Report No. 83803.40.			
Risk is assessed as:	**LOW**		
Data Source	CON	Date & Initials	Wessex Archaeology. January 2015



● Wreck location

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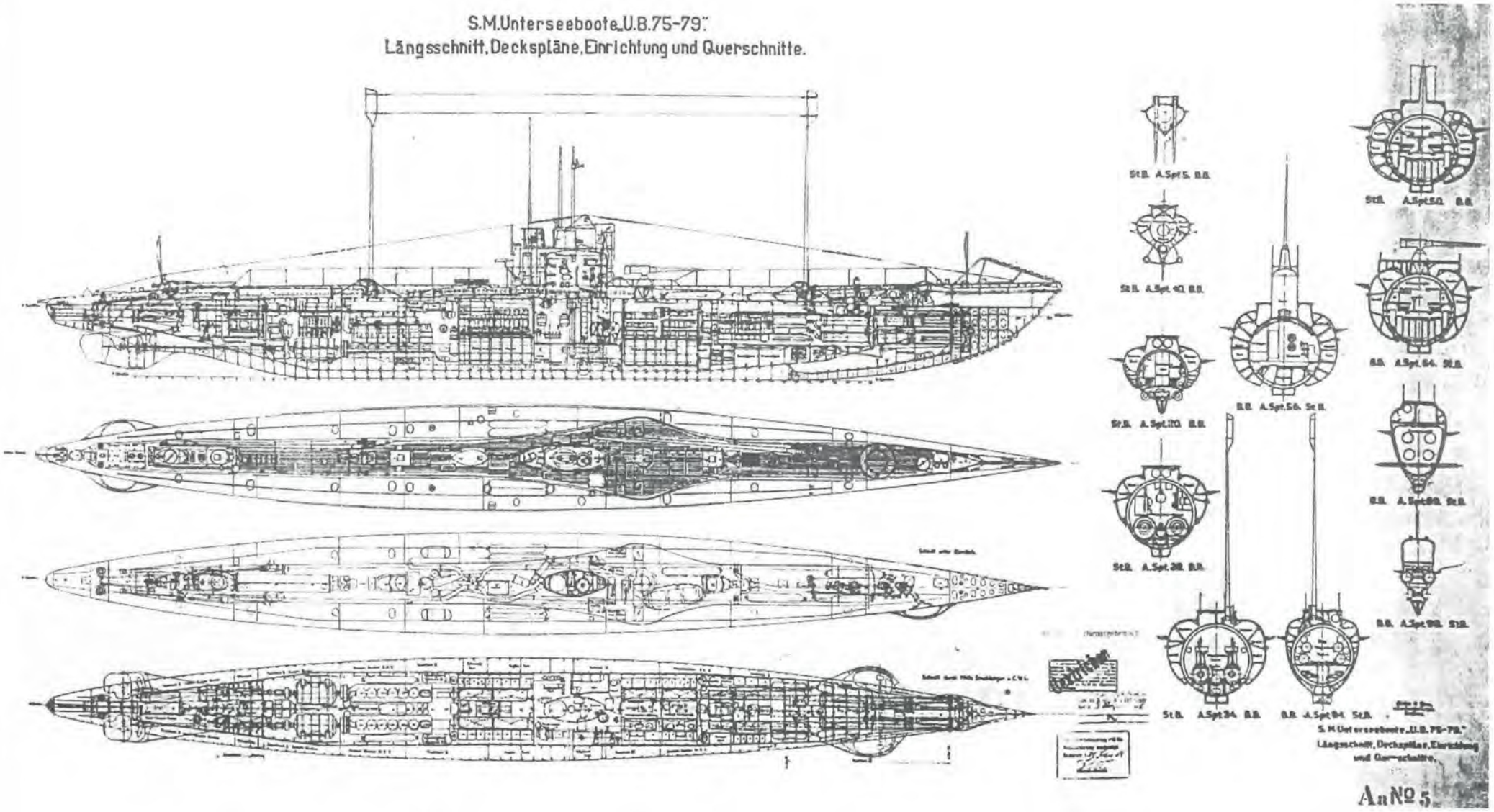
Site location

Figure 1



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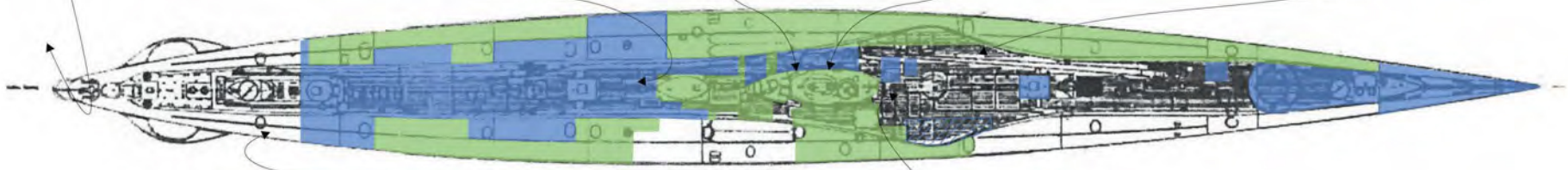
Rudder

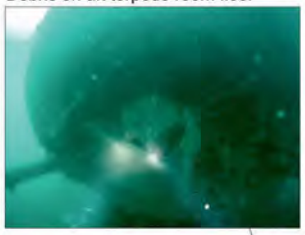
Aft torpedo loading hatch

Periscope cutwater with binnacle mount beyond; looking forward

Fragments of abandoned fishing gear on tower

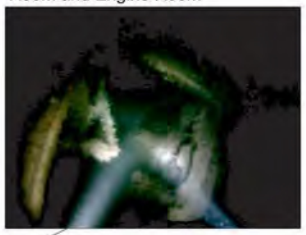
88mm deck gun, looking aft





Debris on aft torpedo room floor

Looking forward at damaged stern; port shaft on right

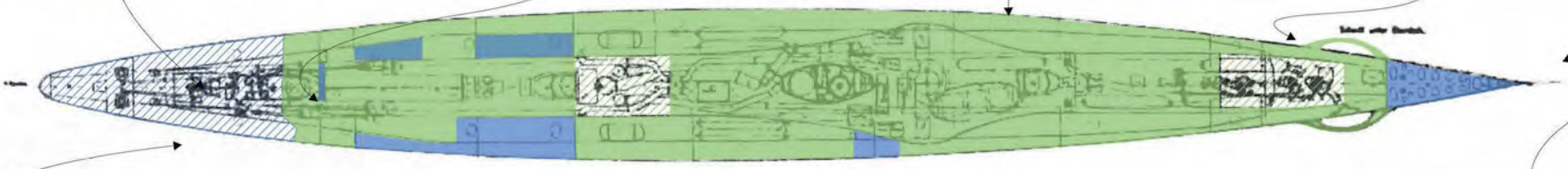


Open doorway between Aft Torpedo Room and Engine Room

88mm deck gun, looking forward

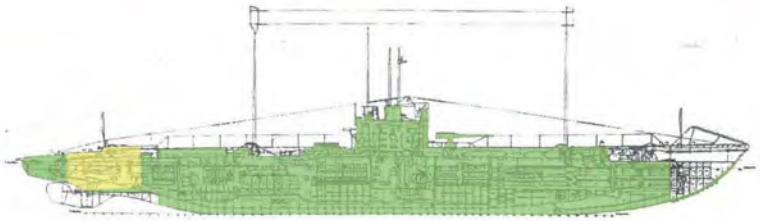
Keel, port side

Forward port hydroplane



Damaged Aft Torpedo Room with detached stern section to right

Detached stern section with possible torpedo tube section



Stem, looking aft

Surviving
Missing
Uncertain

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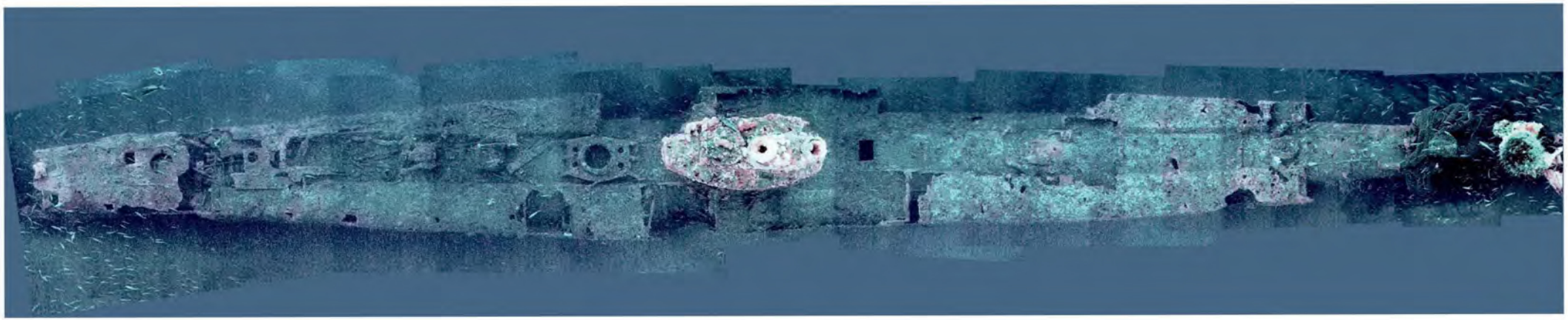

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Photomosaic of *UB 88*

Figure 4

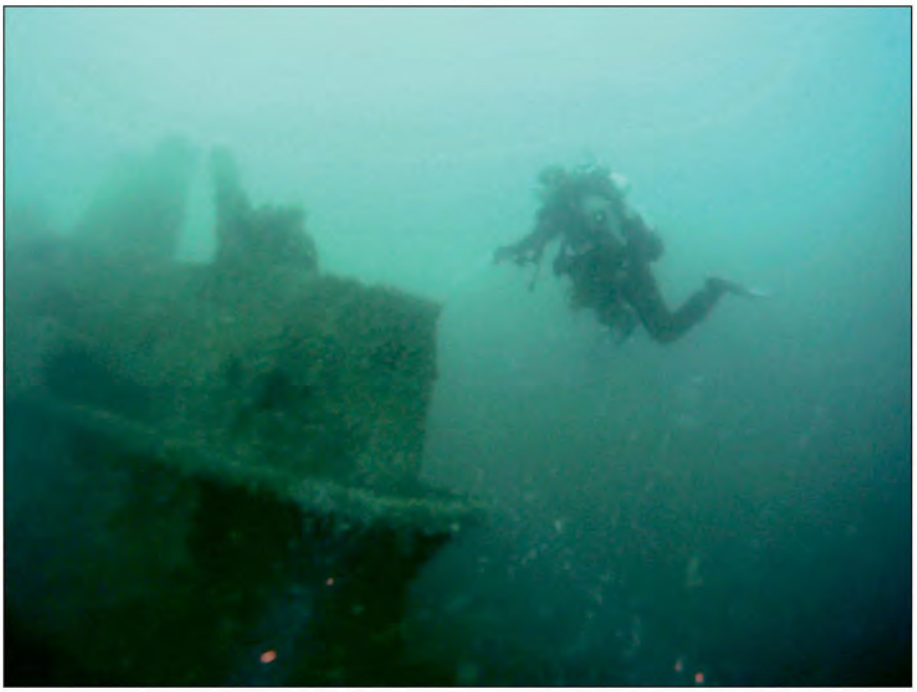

Plate 1: Video still of aft end of conning tower

Plate 2: Video still of detached stern section looking aft (main section to the right)

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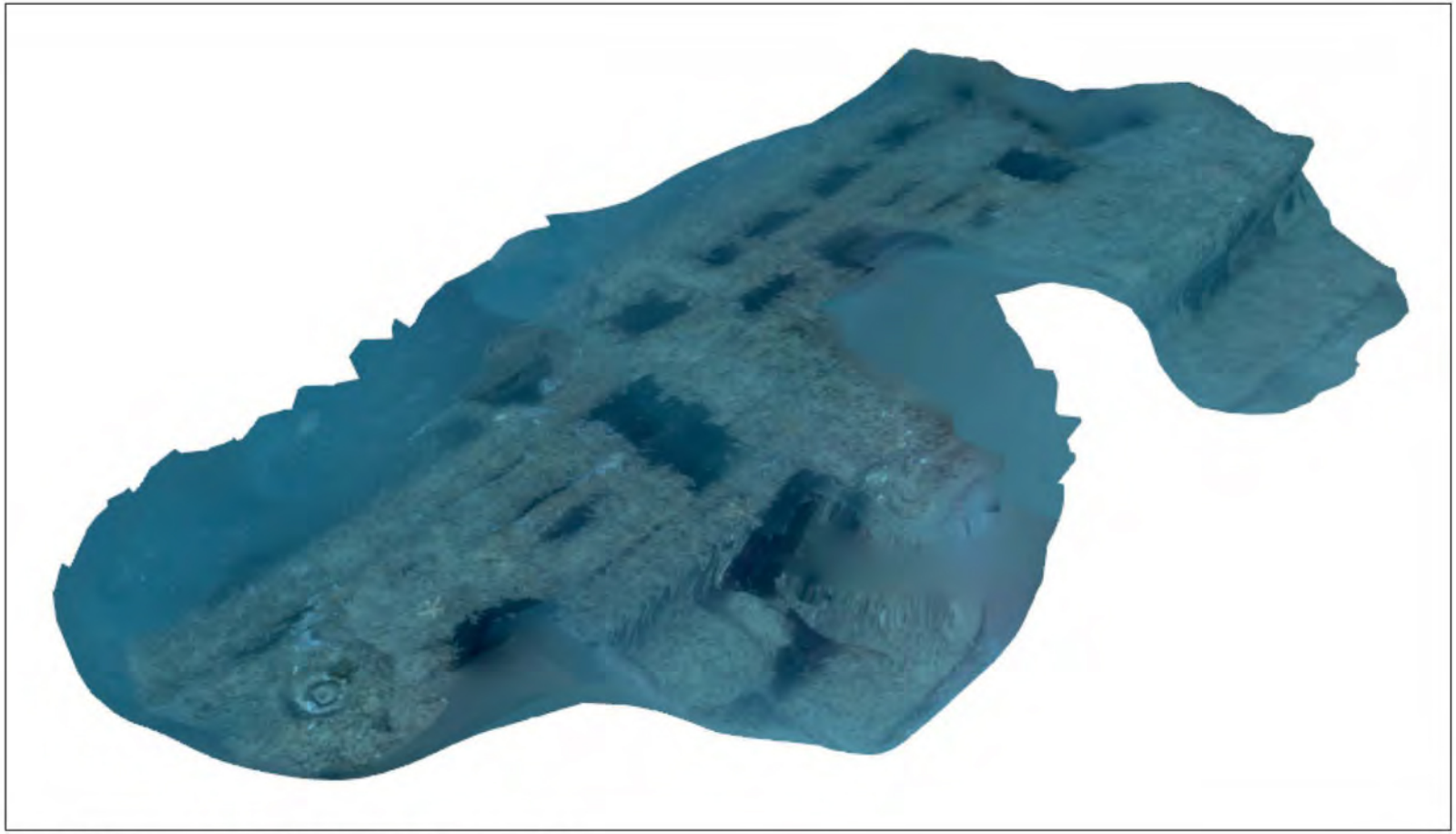

Plate 3: Photogrammetry model of part of *UB 78*'s foredeck

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