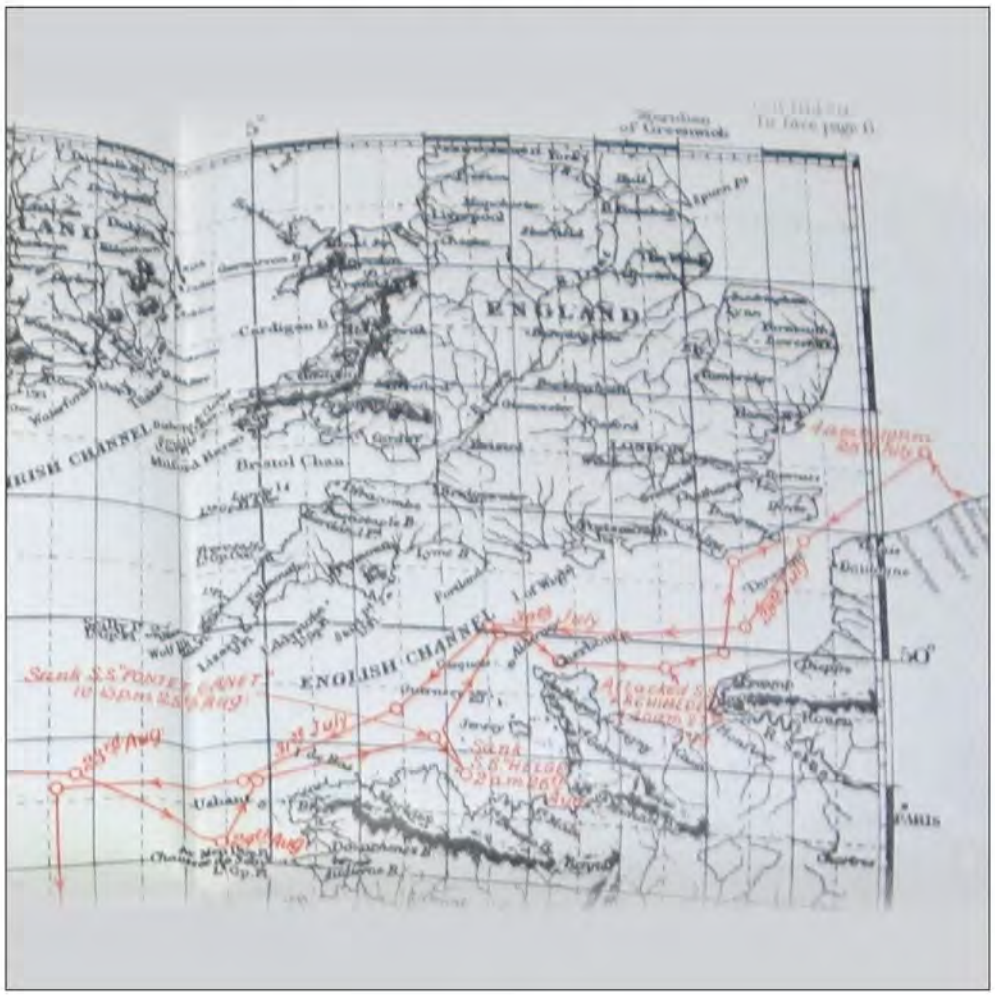
making sense of heritage

Archaeological Services in Relation to Marine Designation

UB 109, off Folkestone, Kent

Archaeological Report



Ref: 83803.34
January 2015

coastal&marine

ARCHAEOLOGICAL SERVICES IN RELATION TO MARINE DESIGNATION

UB-109, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

Prepared for:
English Heritage

Prepared by:
Wessex Archaeology
Portway House,
Old Sarum Park
Salisbury
WILTSHIRE
SP4 6EB

www.wessexarch.co.uk

January 2015

Ref: 83803.34

Quality Assurance

Project/Report Code	83803.34	**Accession Code**	n/a	**Client Ref.**	EH 6552
Planning Application Ref.	n/a	**Ordnance Survey (OS) national grid reference (NGR)**	WGS 84 Lat: 51° 3.731' N Long: 01° 14.146' E		

Version	Status*	Prepared by	Checked and Approved By	Approver's Signature	Date
v01	I	*G. Scott*	*T. Gane*		
File:	83803.34_UB109_draft_v2_GS (W:\Projects\PWA\Projects\83803\10 Reports\UB109\Internal Drafts)				
v02	E	*G. Scott*	*T. Gane*		12.01.2015
File:	83803.34_UB109_draft_v2_GS (W:\Projects\PWA\Projects\83803\10 Reports\UB109\External Drafts)				
v03	F	*G. Scott*	*T. Gane*		09.03.2015
File:	83803.34_UB109 (W:\Projects\PWA\Projects\83803\10 Reports\UB109\External Drafts)				

* I = Internal Draft; E = External Draft; F = Final

UB-109, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

Contents

1 INTRODUCTION 1
1.1 Assessment Background 1
2 ASSESSMENT OBJECTIVES AND PRODUCTS 1
3 METHODOLOGY 2
3.1 Diving Survey 2
3.2 Geophysical Survey 3
3.3 Data Audit 3
4 RESULTS 3
4.1 Progress against Objectives 3
4.2 Engagement 4
4.3 Data Audit Results 4
4.4 Geophysical Survey 12
4.5 Diving Inspection 12
4.6 pH Sampling 16
5 CONCLUSIONS AND DISCUSSION 16
5.1 Overall Characterisation 16
5.2 Assessment against the non-statutory criteria for scheduling 27
5.3 Risk assessment 29
5.4 The importance of submarine wrecks as monuments 29
6 ARCHIVE 30
7 REFERENCES 30
7.1 Bibliography 30
7.2 The National Archives 31
7.3 Other Sources 31
7.4 Admiralty and Other Charts 31
8 APPENDICES 32
Appendix 1: Dive Log (WA divers only) 32
Appendix 2: US Navy description of surrendered UB 88 33
Appendix 3: Site Risk Assessment 44

Tables

Table 1: Progress Against Objectives 4
Table 2: Site co-ordinates 12
Table 3: Characterisation Using BULSI 27

Figures

Figure 1: Site location
Figure 2: Geophysical survey anomalies of potential archaeological interest
Figure 3: Sidescan sonar mosaic, gridded magnetometer data and multibeam bathymetry
Figure 4: Multibeam swath bathymetry results
Figure 5: 7000 profile (bathymetry)
Figure 6: 7001 profile (bathymetry)
Figure 7: Diver survey results – 7000
Figure 8: Diver survey results - 7001
Figure 9: Mapping relevant to *UB-109*
Figure 10: Photomosaic of UB 88

Plates

Front Cover: Last cruise of *UB-109* (from TNA ADM 1373874)

UB-109, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

Summary

Wessex Archaeology was commissioned by English Heritage to undertake a condition survey of the wreck of *UB-109*, a First World War German type UB III submarine. It was lost late in the war in 1918 with the loss of twenty-eight men whilst trying to cross the Dover Barrage at the end of a war patrol.

The investigation comprised three parts: a limited desk-based audit of available primary and secondary sources; a geophysical survey; 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 and in conjunction with the survey of nearby *UB-78* (WA report no. 83803.40).

UB-109 lies within territorial waters off Folkestone, Kent at 51° 3.731' N, 01° 14.146' E. There are two NRHE records for the site, 901790 and 1388909. It is not currently designated. The site is well known to local divers.

The geophysical survey resulted in the acquisition of sidescan sonar, magnetometer and multibeam swath bathymetry data of the site. As expected from the data audit, the wreck was found to be in two sections, with the break aft of the conning tower of the main upright section resulting from the detonation of the shore controlled mine/s that sank the boat. The smaller stern section lies approximately 16m to the south-west and is upside down.

Although the propellers have been salvaged, some deck and casing is missing and fishing net is reported to have covered the wreck until recently, 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. *UB-109* 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, *UB-109* is part of the archaeology of the vital naval battlefield of the Dover Straits.

In addition to this Archaeological Report, the project is being followed up by an NAS Newsletter article and by a public talk in Folkestone in January 2015.

UB-109, off Folkestone, Kent

ARCHAEOLOGICAL REPORT

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 Simon Woolett, Brian Robinson, Kay Skinner, Robert Harrison and Deborah Phillips.

Local diving charter business Mutiny Divers participated in the data audit and thanks in particular are due to proprietor Chris Webb. 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:

- Stephanie Arnott (geophysical survey and interpretation);
- Kitty Brandon (illustration);
- Rachel Chester (geophysical survey and interpretation; report contributor);
- Paolo Croce (archaeological diver);
- Patrick Dresch (archaeological diver);
- Toby Gane (project management; QA);
- Andrea Hamel (archaeological diver);
- Peta Knott (archaeological diver);
- Richard Milwain (data management);
- Graham Scott (project officer; diving supervisor; report compiler);
- Louise Tizzard (geophysical survey management; geophysical survey QA); and
- Euan McNeill (QA).

UB-109, 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-109*, off Folkestone, Kent (NRHE 901790/1388909; **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 In addition to the above objectives, WA was also asked to carry out the following:

- Carry out multibeam swath bathymetry (multibeam) and sidescan sonar (SSS) surveys of the site;

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

2.1.3 The geophysical survey was carried out for EH as a separate operation and is reported upon separately (WA forthcoming). However, relevant data and interpretation has been integrated in this report.

2.1.4 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.

2.1.5 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.

2.1.6 Although not included in the original brief, EH requested a risk assessment of the wreck of the *UB-109* to be carried out in January 2015. This is included in **Appendix 3**.

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 surface supplied 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 and a bandmask-mounted umbilical camera. Sufficient natural light was available, although the diver also carried umbilical and video lights, together with a strobe.

3.1.6 Sampling of pH was carried out by hand. No methodology was provided by the client, so samples of seawater were 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 Geophysical Survey

3.2.1 Geophysical survey of the wreck of *UB-109* was carried out by WA on the 12th October 2014, during the survey of the nearby *Anglia* hospital ship wreck site. Sidescan sonar (SSS), multibeam swath bathymetry and magnetometer datasets were acquired using the MV *Neptune*. The geophysical survey is reported separately, although the results have been incorporated in this report (WA 2014).

3.3 Data Audit

3.3.1 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.

3.3.2 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.

3.3.3 Sources identified and used have been listed in Sections 4.3 and 7.

4 RESULTS

4.1 Progress against Objectives

Objectives	Progress
Contact the Receiver of Wreck to gain a list of droits relating to the site	Achieved. No relevant droits were identified.
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

Objectives	Progress
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. In addition BSAC 501Folkestone participated in the diving survey.

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

4.2.3 *UB-109* has been adopted by Canterbury Divers under the Nautical Archaeology Society *Adopt a Wreck* scheme, although a report has not yet been submitted. It is anticipated that WA will be assisting the club to file a report. In addition WA will be presenting the results of the survey to the Folkestone and Canterbury clubs and their invited guests on 14th January 2015.

4.2.4 A short article on the results of the survey has been submitted to the NAS Newsletter. It is likely to be published in the forthcoming issue. WA will assist Canterbury Divers to submit their own report under the NAS *Adopt a Wreck* scheme as required.

4.2.5 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.

4.3 Data Audit Results

Build

4.3.1 *UB-109* 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).

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 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-109* 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 / 9,040 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-109* specifications

4.3.4 No plans specific to the UB 103-117 batch have been traced. **Figures 5 and 6** therefore incorporate what are believed to be (or based upon) contemporary deck plans of the UB 75-79 (U-Boot-Archiv), an earlier UB III batch. Another set of UB III plans and frame lines for the UB III class are shown in Rössler (2001: 56). A photograph of a slipway launch of an unnamed UB III boat at Blohm & Voss survives (Rössler 2001: 58).

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 *UB-88*, showing the upper deck minus deck casing and fittings.

4.3.6 The British interrogation report refers to a special report being written on the technical details of *UB-109*, based upon a captured notebook (ADM 137/3874). This report has not yet been traced.

Use

4.3.7 *UB-109* was commissioned into the Imperial German Navy by Oberleutnant zur S. Kurt Ramien in Hamburg on 31 December 1917. Already a highly successful U-boat captain who had sunk over 100,000 tons of Allied shipping, *UB-109* was Ramien's third command.

Leaving Hamburg on its first patrol on 25th March 1918, it arrived at Zeebrugge on 30th March, where the next day it officially joined *Flandern I.U-Flotille* (Young 2006: 289).

4.3.8 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'.

4.3.9 *UB-109* left Zeebrugge on 6th April 1918 to begin its first full war patrol. After patrolling in the English Channel and Irish Sea, the boat arrived back at Zeebrugge on 25 April, having accounted for three British and one French ship, a total of 7,739 tons (**Figure 9**; Young 2006: 289-290; uboat.net website).

4.3.10 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.

4.3.11 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.

4.3.12 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.

4.3.13 At the end of July 1918 the Flanders Flotillas made their last major attempt to interdict the flow of American troops to Europe. The six boats involved, including Ramien's *UB-109* were ordered to pass through the Straits close to Folkestone and operate in the Channel or off the French coast. The reason why they were ordered to skirt the English coast is because the British swept a channel in the barrage for coastal shipping at that end, known as the 'Folkestone Gate', and which the U-boats could potentially use (Grant 2002: 91).

4.3.14 *UB-109* left Zeebrugge at 01:00 on 28th July, having successfully negotiated the British blockships sunk during the famous raid earlier in the year. After lying on the bottom off Bligh Bank during daylight hours, the boat used the westward flow of the tide to successfully penetrate the Dover Barrage, surviving an attack by the three patrol vessels, including the drifter *Monarda*, near Buoy No.5 of the Folkestone to Griz Nez Barrage. Immediately before or during the action *UB-109* broke surface as a result of a short-circuiting of the hydroplane motor. Ramien saved the boat by the simple expedient of ordering the crew forward, thus altering the trim and causing the submarine to dive (ADM 137/3874).

4.3.15 Ramien had received orders to go as far as the Azores to reconnoitre convoy routes. Although the Flanders boats had not previously operated that far from their base, this was now being considered (ADM 137/3784). After completing that task *UB-109* began its return voyage on 16th August. It encountered and sank the unescorted British steamship *Zinal* north-north-east of the islands (**Figure 9**). Approaching Guernsey the boat was bombed but no damage was sustained. Thereafter it sank the French steamship *Pontet Canet* and the Swedish steamer *Helge* in the September Iles area between Cherbourg and Brest, making a total of 6375 tons sunk during the patrol (**Figure 9**; Grant 2003: 80; Young 2006: 290; ADM 137/3784). Two further attacks were unsuccessful.

4.3.16 The only modification to *UB-109* reported by secondary sources appears to be the removal of the radio masts. These were taken down because Ramien thought that they affected the trim of the boat. No contemporary source is cited for this (Young 2006: 291).

Loss

4.3.17 Ramien decided to return to Bruges through the Folkestone Gate. However, whilst *UB-109* had been on patrol, the British had mined the gap, publishing a notice to shipping to this effect in the *Times*. The returning *UC-71* struck one of these mines but survived. As a result the Germans issued a radio warning.

4.3.18 Making for Dungeness, Ramien found that the strong current had pushed the boat to westward, so he followed a course parallel to the shore about three miles out to reach Dungeness at 02:00 on 29th August. Ramien passed inshore of a vessel stationed there. Further east he saw two light vessels, which he took to be the gate-ships guarding the swept channel. According to interrogation reports, the Acting Navigation Officer proposed that they pass through the gate, however a patrol vessel was spotted between them and Ramien decided to pass to the south (ADM 137/3874).

4.3.19 At 03:12 the radio log recorded that the boat had dived. Thereafter sources differ about exactly what happened. However, it appears that the boat must have gone inshore of the swept channel, in other words to the north of the light vessels. In doing so, the boat entered a shore-controlled minefield equipped with hydrophones and a 'Bragg Loop', a cable on the seabed that acted as an indicator (induction) loop and alerted a shore-based controller if a ship or submarine passed over it (Grant 2003: 291; Walding 2009)). It was detected by hydrophones when proceeding at 15 metres and five knots and seventeen minutes later the boat was detected again over a Bragg Loop, just as the boat was rising to periscope depth (12 metres). At least one and possibly as many as three or four mines were then detonated (Grant 2003: 80; ADM 137/3874). This is recorded as happening at 04:20 on 29th August (ADM 137/3874).

4.3.20 Bragg Loops were used extensively around harbours and headlands during the First World War. However, the only other U-boat known to have been lost as a result of their use by the British was *UB-116*, which was detected and destroyed outside Scapa Flow (McCartney 2014: 62).

4.3.21 At least one of the mines must have detonated under or in the very close vicinity of the engine room. The boat is reported to have sunk to the bottom at twelve fathoms (*c.* 21m) almost immediately, so it is likely that the boat broke in two as a direct result of the explosion/s (ADM 137/3874). Ramien, who was in the conning tower and is reported to have been thrown down the periscope well by the force of the blast, gave the following account to his interrogators (Messimer 2002: 220-1). Words in brackets are added:

"I heard loud shouting in the boat and then everything was still. The explosion had thrown me against the periscope and it took a while for me to regain my senses. I had fallen into the periscope well, and I crawled back into the conning tower where I found the navigator [Göderich] and the helmsman. I tried to talk to them but the noise of released compressed air drowned out our voices. Even shouting was impossible [the British noted that the survivors had been suffering from deafness due to excessive air pressure, presumably because the boat filled with water so quickly].

The boat was flooded up to the conning tower. I climbed up the ladder to the hatch and the navigator stood on the rungs right below me. When I tried to open the hatch it blew open and the navigator and I were blown into the opening where we became wedged together [the British interrogators drily noted that the three men competed with each other for the honour of leaving the boat first]. It took thirty seconds of hard struggle to free ourselves, but the navigator was able to pull himself back into the conning tower. That freed me and I rose to the surface.

I rose quickly and at no time did I have any feeling that I was running out of air. The compressed air in my lungs flowed out naturally and in large amounts. I reached the surface and right behind me came the helmsman, the navigator and the radioman (Keitel) who was unable to explain how he had reached the conning tower.

I was astounded to find five other men on the surface. The torpedomen [probably Eggert, Dömpke, Irle and possibly Janssen] had opened the forward hatch immediately following the explosion and these five men were by chance blown through the hatch. Included in those five men was a machinist [Bader] who had been carried through all the compartments on the crest of the rising water and shoved out the forward hatch.

I shed my heavy leather boots. We were swimming for about three quarters of an hour before a British patrol boat that had been attracted by the explosion arrived and picked us up [the British interrogators record that this was just a quarter of an hour]."

4.3.22 One of the men who made the surface does not appear to have survived, although it is not clear who this was. Grant and Young state that although only eight men survived, about twenty men were able to get out of the submarine (Young 2006: 291; Grant 2003: 80). WA has not traced any contemporary account to support this number.

4.3.23 The survivors were as follows (ADM 137/3874). Their German rank or rating with British equivalent is given in brackets:

- Ramien, Kurt (Kapitänleutnant/Lieutenant-Commander)
- Göderich, Hermann (Diensttuender Steuermann/Acting Navigation Warrant Officer)
- Bader, Fritz (Maschinistenmaat/Engine Room Petty Officer, 2nd Class)
- Janssen, Otto (Obermatrose/Leading Seaman)
- Eggert, Kurt (Matrose/Seaman)
- Dömpke, Franz (Heizer/Stoker)
- Irle, Ernst (Heizer/Stoker)

- Keitel, Karl (F.T.Mast/Telegraphist Petty Officer, 2nd Class)

4.3.24 The dead were (ADM 137/3874):

- von Schubert (Leutnant/Sub-Lieutenant)
- Voss (Marine Ingenieur/Engineer Sub-Lieutenant)
- Grath (Maschinist/Engine Room Warrant Officer)
- Koch (Obersteuermannsmaat/Navigating Petty Officer 1st Class)
- Krug (Obermaschinistenmaat/Engine Room Petty Officer 1st Class)
- Angerstein (Bootsmannsmaat/Petty Officer 2nd Class)
- Reinhold (Bootsmannsmaat/Petty Officer 2nd Class)
- Dood (Maschinistenmaat/Engine Room Petty Officer 2nd Class)
- Dribusch (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Edelmann (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Grotmann (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Schulz (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Winterhof (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Westkamp (Obermaschinistenwärter/Senior Engine Room Probationer)
- Schillig (Obermatrose/Leading Seaman)
- Höfle (Oberheizer/Leading Stoker)
- Kronenburg (Oberheizer/Leading Stoker)
- Luhmann (Oberheizer/Leading Stoker)
- Seiler (Oberheizer/Leading Stoker)
- Bohn (Matrose/Seaman)
- Dade (Matrose/Seaman)
- Gepp (Matrose/Seaman)
- Hennemann (Matrose/Seaman)
- Jakobsen (Matrose/Seaman)
- Sonnabend (Matrose/Seaman)
- Diehl (Heizer/Stoker)
- Keidel (Heizer/Stoker)
- Jäger (F.T.Gast/Telegraphist)

Survival and Investigation

4.3.25 A team of divers led by the famous Royal Navy diver Lt. Cdr. Guybon Chesney Castell Damant C.B.E. had found and buoyed the wreck of *UB-109* by 10:30 the next morning. The job of this secret team, nicknamed 'The Tin Openers', was to search for intelligence material such as code books, minefield and boat plans and new equipment in newly sunk U-boats.

4.3.26 The initial report submitted by Damant's superiors following this first dive said (italics added; Grant 2003: 81):

"Diver got down through fore hatch cleared bedding and body from man quarters and got through bulkhead into forepart of officers' quarters expect to be able to search them thoroughly. There is no damage to this part of boat but she is cut *nearly* in half at a point about 25 feet abaft conning tower."

4.3.27 This account suggests that *UB-109* may still have been technically in one piece (although severely compromised). However, it was written second-hand and Damant subsequently gave these accounts in his own reports, which are not so clear (italics added):

"Severe damage abaft engine room, no damage seen on fore side of conning tower, depth about 12 fathoms. Am sending notebook recovered from coat pocket" (Grant 2003: 81; the notebook may be that referred to as having technical specifications).

"She is lying in 14 fathoms on a sandy bottom, heading NE, 30 degree list to starboard. Fore hatch and conning tower open, no buoyancy remaining, *about twenty feet abaft conning tower the damage begins and from there aft the vessel is shapeless wreckage*. The damage is far more severe than that generally met with in deep minefield cases. The forepart of the boat is quite intact, for instance the large mirror on door of captain's wardrobe is not even cracked. For this reason and because the depth was moderate I decided to work aft from the fore hatch without cutting any plates by explosives....To get to their objective, divers had to negotiate a chain of five narrow apertures: (1) fore hatch, (2) watertight door in fore bulkhead of officers' quarters, (3) partition between officers and captain's quarters, (4) watertight door in fore pressure bulkhead of control room, (5) door of watertight cabinet. Between 4 and 5 are awkward obstacles formed by the compass and steering pedestals in the control room. Afternoon on day of sinking, fore hatch was cleared of bodies, bedding, etc. and some personal material sent to the Admiralty" (Grant 2002: 96).

4.3.28 Damant and his men stayed on site into September. After recovering a very valuable cache of intelligence material, they focussed on recovering ammunition. McCartney has suggested that this was because little was known about German submarine guns (McCartney 2014: 64; ADM 116/1851).

4.3.29 The wreck next appears in UKHO records as having been surveyed by HMS *Bulldog* in 1978. The wreck is recorded as being "in two halves lying close together. Lies 020/200 degrees". The wreck was identified as "probably *UB-109*" (UKHO 13533, Surveying Details). It was subsequently reported as having had "extensive exploration" and the aft seven metres of the hull missing by P.G. Weatherly in 1982. T.W. Bennetto (see 4.4.25 below) reported it to be in two parts "about 30ft apart" in 1983, when the periscope was reported to be extended twelve feet and the deck gun aft of the conning tower; the latter is presumably a typo. In 1997 routine hydrographic survey reported scattered debris.

4.3.30 In 1998 the propellers of the submarine were reported to have been salvaged, with one bearing the mark *UB-109* and the other *UB-104*. The wreck was reported to be blown in two, with the stern section thirty feet to the west, the hatches open and the periscope extended (Diver Magazine, October 1998).

4.3.31 The wreck was identified as being *UB-109* on the basis of the propeller markings, *UB-104* being known to have been lost elsewhere. This is a unique characteristic of First World War German submarines and has enabled researchers to identify other boats in the past (McCartney 2014: 144). The fact that the boat was fitted with a propellor from another boat probably reflects the increasing shortage of spare parts that affected the Flanders Flotillas in 1918.

4.3.32 Recent published and web site observations of the condition of the wreck are as follows.

"The wreck has been dived frequently since (the Tin Openers). She is in 22m and the damaged stern has now parted from the forepart. They lie about 30ft apart and even so part of the stern appears to have disappeared entirely....the experienced Channel diver

Tim Bennetto tells me that when he first saw her in 1983 she had her periscope extended some 12ft above the conning tower hatch, which was open. The gun and her props were still in position. Later diving showed that on the shank of one prop was the number *UB-109* and on the other *UB-104*." (McDonald 1994: 55-6)

"The wreck of the UB 109 lies on a seabed of sand, shell and shingle, in a general; depth of 29m (LAT). It is broken open and lying in two halves, with the engine area smashed up, but very intact from just aft of the conning tower to the bow. The hatches are open, offering glimpses down into the dark interior. The prism is still present in the periscope standard, while the deadeyes in the conning tower are very impressive as they reflect in the torchlight. The conning tower hatch where the captain and navigator escaped is said to be incredibly small, but you can see down the height of the tower, until you get to the sand-filled hull. It is heavily silted in places but, surprisingly, the large bore 105mm deck gun is still in place and points menacingly off the starboard bow. The torpedo loading hatch forward of the gun is open – evidence of the escape attempt.

The 'jackstaff' socket on the bow also remains intact. The wreck is absolutely smothered in rope, fishing line and netting, and some of this floats around and could easily wrap itself around an unwary diver. The wreck provides a home for a large variety of wrasse and crabs and is encrusted with life of all kinds. The propellers, one of which was stamped UB 109 and the other UB 104, have both been removed." (Young 2006: 293)

"The Seabed generally at 25m, the bow has a bit of a scour under it and you can get 28m there, the deck is at 20m with the conning tower rising up to about 17m. The periscope rises above that to about 15m or so. The stern is blown off and it is a short swim to its rear, both props have been salvaged. The pressure hull is intact, however, the tip of the bow has broken off and you have a large empty box like area open there. You can see 4 bow torpedo tubes just before that. The hatches are open, where the crew bailed out and the Tin Openers (RN Divers) went in." (www.canterburydivers.org.uk/109).

4.3.33 McDonald's account is interesting because it implies that the boat may not have broken completely in two until after the sinking, and therefore was the result of a subsequent impact. However, it is not clear how an impact large enough to move such a heavy section of hull could have occurred.

4.3.34 Recent dive videos of *UB-109* are available online, for example at https://www.youtube.com/watch?v=kLsBxX5gXcA.

4.3.35 McCartney's newly published study of U-boat wreck sites was received at a very late stage during this project. He dived the wreck in April 2011 and has published a brief summary of the inspection, as follows (McCartney 2014: 62-4):

"The extreme point of the bow has lost its tip, which lies on the seabed and, from the overall condition of the wreck, can only have fallen off recently. The forward torpedo hatch is open…Looking down, it can be seen that the entire submarine at this point is full of sand. The gun is in place on the foredeck and looks, from the single recoil cylinder above the barrel to be a late-war 88mm type. The attack periscope is partially extended and remarkably still intact. It may well have been used to negotiate the Straits at the time the U-boat was sunk. The aft section is blown off in front of the engine room. It is possible to swim over the crushed bottom of the hull and peer into the officer's space beyond. The stern portion of the wreck lies at least 10 metres away from the forward part. Remarkably it is completely upside down. The force of the explosion that blew it off had to have been very heavy and very close to have blown it off completely, so that it capsized in a different way from the forward section. The aft torpedo door is shut, showing that the mine did not

detonate the tube. The upside down nature of the stern section is obvious from this position. Both rudders and hydroplanes are still present, but the propellers are gone. The wreck is in very good condition for one so close to shore and in such shallow water."

4.3.36 It is understood that the wreck was subject to a short filmed inspection for the purposes of a television documentary on the 'Tin Openers' in 2014 (Chris Webb, pers. comm.). As of the end of 2014, this documentary does not appear to have been screened.

4.3.37 Two NRHE records exist for *UB-109*, Monument Numbers 901790 and 1388909. The latter is a loss record. There is some uncertainty expressed within 901790 with regard to both location and identification.

4.4 Geophysical Survey

4.4.1 The geophysical survey identified a total of nine features of archaeological potential, including the two sections of the wreck, two items of debris and five magnetic anomalies (WA 2014; **Figure 2**). The geophysical survey results are reported on separately but have been incorporated in this report (WA 2014). **Figures 3-4** summarises the geophysical survey results.

Site Position

4.4.2 The positions of the two sections of the wreck (7000 and 7001; **Figures 1-2**) are as follows. The positions have been calculated from the multibeam survey data.

Wreck section	Latitude (WGS 84)	Longitude (WGS84)
7000	51° 3.731' N	01° 14.146' E
7001	51° 3.711' N	01° 14.134' E

Table 3: Site co-ordinates

4.5 Diving Inspection

4.5.1 Diving inspection and survey was carried out on 2-3rd October 2014. Statistics for the diving operation are given in **Appendix 1**.

Seabed

4.5.2 The seabed is irregular with some areas of sediment build-up and scatterings of rocky patches, probably bedrock. Build-up of sediment can be observed surrounding both sections of wreck, except at the north end of the main section, where the port side of the bow is scoured and there is a depositional feature running to the north east from the starboard side of the bow. These features are clearly linked with the way the wreck lies across the dominant south-west to north-east (and vice-versa) tidal current flow. Although not confirmed by direct observation, the wreck appears to be resting on bedrock.

Ecology

4.5.3 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.

4.5.4 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

4.5.5 The submarine lies in two sections in approximately 22m LAT water depth, a short distance to the south-east of the UKHO position (**Figure 3**). The main section (7000), which is orientated 25/205° or approximately NNE/SSW, comprises the tower, the hull forward of the tower and the hull aft of the tower to the engine room lies on its keel. It is 36m long by approximately6.6m wide at its maximum. It has an average height above the seabed of 3.5m (**Figure 5**).

4.5.6 The smaller section (7001), comprising the hull aft of and including part of the engine room lies approximately 16m to the south-west at an orientation of 10/185°, approximately N/S (**Figure 3**). It is inverted, with the props pointing towards the main section. This section is 16m long and has a maximum width of approximately 5m. Maximum height above the seabed is 4.5m (**Figure 6**).

4.5.7 The two sections have a combined length of 52m and a maximum width of approximately 6m. Taking into account the missing casing of the bow (see below), this length is consistent with *UB-109*.

4.5.8 The following detailed description of the results of the diving inspection should be read in conjunction with **Figures 7** (7000) **and 8** (7001).

Main Section - Conning Tower/Bridge

4.5.9 The watertight section of the conning tower/bridge survives *in situ*, together with fragments of the bridge deck plates. However, the bridge casing and the aft casing are missing, although the stubs of the trailing edge of the bridge casing framing survive. Part of the bridge casing of UB 88 was probably made of bronze (**Appendix 2**) and the bridge casing of *UB-109* may therefore have been salvaged.

4.5.10 The surviving tower 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).

4.5.11 Both periscopes, the rear navigation periscope and the forward attack periscope, are still *in situ*, as is their cutwater. The navigating periscope, with surviving prism, is extended. The attack periscope was reported by the diver to be retracted, although the possibility that it has been broken off cannot be entirely discounted from the inspection video. There is a considerable amount of modern rope around the navigation periscope. It is not clear whether this is the result of commercial fishing, use of the conning tower to provide a mooring for dive boats, or perhaps just drifting debris.

4.5.12 The narrow circular watertight bridge/tower hatch through which Ramien escaped is complete. The forward opening hatch lid with its locking screw and wheel is fully open and is still securely attached by the hinge. The deck around the hatch has small, regularly spaced indentations. It is not clear what function these fulfilled, although they may have been there to improve footing for crewmen on the bridge. The conning tower was not penetrated and internal fixtures and fittings were not inspected.

4.5.13 No trace of the combined steering wheel and binnacle that are likely to have been mounted at the forward end of the bridge were observed. It is very likely to have been removed by Damant's divers, but otherwise by divers in the later 20th century.

4.5.14 The forward pointing recesses for the port and starboard bridge navigation lights survive, together with deadlight slots aft. These were not closely examined. No trace of either the diesel or boat air inlet masts or their fittings were found aft of the tower.

Main Section - Forward of the tower

4.5.15 Although the deck gun is missing, part of its seating survives *in situ* forward of the conning tower. It consists of a horizontal partially webbed rectangular steel base plate at deck level. Through this is bolted the circular gun mounting base, which is attached to the pressure hull and reinforced by triangular stiffening brackets also attached to the pressure hull. The lower end of the base survives but only a fragment of the cylindrical upper section survives. The edge is ragged and deformed and either the result of a heavy impact that carried away the gun or crushing forces from the weight of the gun as the mounting collapsed due to corrosion.

4.5.16 The deck gun and its main mounting body are reported to have fallen to the seabed and become buried (Dr Innes McCartney, Facebook web page; accessed 26/09/2014). Visual searches did not locate it on the port side of the vessel. The gun is variously reported to have been either a late war 88mm or a 105mm. It is described in a contemporary British account as a 22 pounder, which is equivalent to an 88mm and this ties in with McCartney's opinion of it based upon his identification of a single recoil cylinder above the barrel (ADM 137/3784; McCartney 2014: 64).

4.5.17 Although most of the deck casing bulge around the gun mounting is missing, some of it survives. As elsewhere on the boat 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.

4.5.18 Forward of the gun mounting is the circular watertight forward torpedo loading hatch. This is the hatch through which the torpedo men and stoker escaped. The hatch lid is fully open forwards. The ring frame is partially buried in sand and the hatch opening is blocked with sand, which suggests that the lower ratings and forward torpedo compartments into which it opens are at least partially full of sand. It is not entirely clear how this hatch was secured, but it is assumed to have had a similar locking screw to the bridge/tower hatch, in which case part of the mechanism is missing.

4.5.19 On the port side between the longitudinal deck casing and the hatch is a double ended (?) HP air cylinder with associated pipework. The cylinder would have been mounted aft of the hatch and has therefore been displaced. Forward of the hatch on the starboard side is a similar HP cylinder. It is not clear whether this has been displaced as it is in approximately the correct position shown on contemporary plans.

4.5.20 Forward of the torpedo loading hatch there is another area of surviving deck casing. There is a considerable amount of lose debris in and around the hatch, including fragments of the steel angle and a cogged spindle, which may be part of a small windlass for raising the forward long range radio mast. No trace of the radio mast or its mounting was observed.

4.5.21 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 *UB-88* as the deck planking is missing at that point (**Figure 10**).

4.5.22 Further forward the wooden deck is replaced by steel plating. There is a fragment of curved steel coaming around the outline of a flush circular feature in the deck which appears in UB III plans but is unidentified. It is possible that it could be a ready use canister. Immediately forward of this there is an open rectangular hole in the deck next to the pair of bow bollards. The hole in the deck is regular in shape and alignment, has rounded corners and appears to be a bow casing access panel. The inside was not examined, although pipework can be seen in the dive video.

4.5.23 Just forward of the panel on both sides of the deck are the stubs of what were flat bars bolted to the deck via a bracket. These lean aft and could be the leading edges of the fixed deck rails. However, there is a detached fixed rail with bracket just aft of the open panel and they could therefore be part of the aft frame of the missing net cutter, as the bracket would have allowed them to swivel forwards. Immediately forward of this is a centreline fairlead-like attachment. This is of uncertain function, although it could be the bow attachment for the forward aerial.

4.5.24 Immediately forward of this the upper bow casing is missing. This section of the hull is not part of the pressure hull. This may have become detached at the same time as the net cutter as a result of an impact. The flat that is flush with the top of the pressure hull and which protrudes forward below the missing casing has possibly survived because it is secured to the raking stem below by strong transverse web frames. Most of the exposed stem and the foremost part of the bow casing have not survived and what can be seen internally is the forward face of two webbed transverse frames that are riveted together.

4.5.25 A combination of limited bottom time and additional depth required meant that the hull along the mudline forward of the break in the hull aft was not inspected, except in one place. As far as can be ascertained from the deck, the saddle tanks and pressure hull are intact forward of the gun mounting. However on the port side between the gun mounting and the mid-point of the conning tower, the saddle tank casing is missing, leaving only the transverse and longitudinal framing in places. One small fragment of shell plate was observed to be lying on the seabed. The reason for this is unclear; it may be damage related to the original loss, collapse due to corrosion of the plates or a heavy impact or, conceivably, damage caused by the falling deck gun. On the starboard side just forward of the deck gun mount there is similar but less extensive damage, with the shell plating of the top of the starboard saddle tank having partially collapsed. Again, it is not clear how this has been caused, although plate thinning and general corrosion appears to have been taking place.

Main Section - Aft of the tower

4.5.26 The full width break in the hull occurs approximately 4.75m aft of the conning tower (**Figures 3 and 5**). It is not a straight fracture and approximately a third to half of the lower pressure hull and bases of the saddle tanks extend for approximately another 5-6m. Unless there was subsequent damage, the shape of the fracture line that split the hull was therefore z-shaped. The position of the fracture suggests that it occurred at the transverse watertight bulkhead at the forward end of the engine room.

4.5.27 The deck and deck casing aft of the conning tower is missing. The pressure hull is intact aft of tower up to the break. The port saddle tank is also *in situ* until just forward of the break, although there are large holes due to plate thinning. Below are two high pressure air cylinders. Parts of the air inlet trunking survive below the missing deck on either side, although the masts are missing. There is some debris lying on the pressure hull.

4.5.28 A wide cylinder, what may be a section of the large diesel air inlet trunking (or alternatively the exhaust silencer) is lying at an angle over the edge of the fracture. Aft of the fracture

the interpretation is unclear, although video looking into the surviving pressure hull at this point suggests that the transverse engine room bulkhead has been displaced. Whilst interpretation is again difficult and there is clearly displaced plating and debris, the Vulcan diesels appear to be present, although it is not clear from the video whether they remain on their mounts. It is also unclear whether either of the electric motors, positioned aft of the diesels, were observed. There is a small amount of debris on the seabed at the southern end.

Stern Section

4.5.29 The following description of the stern section (7001) is based only upon the post-fieldwork interpretation of diver video. The stern section has been reported by divers to be turned around so that the stern is in fact facing towards the main section of the wreck. However, the video and the shape of 7001, which narrows to the south (**Figures 3 and 4**), strongly suggest that this is not the case.

4.5.30 The stern section is however upside down. The starboard propellor shaft is *in situ*, together with its shaft bracket and gland and housing. However, the propellor itself has been deliberately removed, presumably salvaged. The starboard aft hydroplane, mounting arm and fairing are *in situ*, as appears to be the starboard rudder (minus its plates), support post and arm. Other sources indicate that the port rudder and hydroplane also survive. The after casing is partially intact and what appear to be drainage slots can be seen. The single stern torpedo tube door and its frame are *in situ* and the door is closed.

4.5.31 The forward end of the port propellor shaft is *in situ* in its housing. Between the shafts in the casing is what is either an open access panel or, more likely a large drainage slot. Forward of this, interpretation is more difficult. The stern section ends in an irregular fracture line consistent with the shape of 7001 and there is some displacement of the hull, as well as some debris.

Debris

4.5.32 Seabed searching for debris was limited to the area between the two sections and the seabed to the port and forward of the conning tower. There is a small amount of debris around the southern end of 7000 and also port forward, including small fragments of corroded plate. No evidence of the deck gun previously reported to have fallen onto the seabed was seen.

4.5.33 Very little abandoned fishing gear was observed and that was in the form of small fragments. No floating gear was seen.

4.6 pH Sampling

4.6.1 A sample was recovered from the base of the conning tower. A pH of 8.23 was measured after the dive. Temperature value during testing was 18.8 degrees centigrade. Seabed temperature recorded using a diver-held gauge was 15.1 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 UB-109 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 *UB-109*. Although WA has not seen material evidence of the propellor markings, all of the evidence points towards this wreck having been correctly identified.

UB-109 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 (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). The project results do not suggest that the technical specifications of *UB-109* 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 UB-109 or of the UB III type or the Flanders Flotillas; however, it represents a comprehensive summary of existing knowledge.

UB-109 was commissioned by Oberleutnant zur S. Kurt Ramien in Hamburg on 31 December 1917. Already a highly successful U-boat captain who had sunk over 100,000 tons of Allied shipping, *UB-109* was Ramien's third command. Leaving Hamburg on its first patrol on 25th March 1918, it arrived at Zeebrugge on 30th March, where the next day it officially joined Flander I.U-Flotille. (Young 2006: 289).

Following their failure to capture Calais and Dunkirk in 1914, the Germans decided to use capture 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'.

UB-109 left Zeebrugge on 6th April 1918 to begin its first full war patrol. After patrolling in the English Channel and Irish Sea, the boat arrived back at Zeebrugge on 25 April,

having accounted for three British and one French ship, a total of 7,739 tons (Young 2006: 289-290; uboat.net website).

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 (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.

At the end of July 1918 the Flanders Flotillas made their last major attempt to interdict the flow of American troops to Europe. The six boats involved, including Ramien's *UB-109* were ordered to pass through the Straits close to Folkestone and operate in the Channel or off the French coast. The reason why they were ordered to skirt the English coast is because the British swept a channel in the barrage for coastal shipping at that end, known as the 'Folkestone Gate', and which the U-boats could potentially use (Grant 2002: 91).

UB-109 left Zeebrugge at 01:00 on 28th July 1918, having successfully negotiated the British blockships sunk during the famous Zeebrugge Raid earlier in the year. After lying on the bottom off Bligh Bank during daylight hours, the boat used the westward flow of the tide to successfully penetrate the Dover Barrage, surviving an attack by the three patrol vessels, including the drifter Monarda, near Buoy No.5 of the Folkestone to Griz Nez Barrage. Immediately before or during the action *UB-109* broke surface as a result of a short-circuiting of the hydroplane motor. Ramien saved the boat by the simple expedient of ordering the crew forward, thus altering the trim and causing the

submarine to dive (ADM 137/3874).

Ramien had received orders to go as far as the Azores to reconnoitre convoy routes. Although the Flanders boats had not operated previously operated that far from their base, this was now being considered (ADM 137/3784). After completing that task *UB-109* began its return voyage on 16th August. It encountered and sank the unescorted British steamship Zinal north-north-east of the islands (**Figure 9c**). Approaching Guernsey the boat was bombed but no damage was sustained. Thereafter it sank the French steamship Pontet Canet and the Swedish steamer Helge in the September Iles area between Cherbourg and Brest, making a total of 6375 tons sunk during the patrol (**Figure 9b**; Grant 2003: 80; Young 2006: 290; ADM 137/3784). Two further attacks were unsuccessful.

The only modification to *UB-109* reported by secondary sources appears to be the removal of the radio masts. These were taken down because Ramien thought that they affected the trim of the boat. No contemporary source is cited for this (Young 2006: 291).

Ramien decided to return to Bruges through the Folkestone Gate. However, whilst *UB-109* had been on patrol, the British had mined the gap, publishing a notice to shipping to this effect in the Times. The returning UC 71 struck one of these mines but survived. As a result the Germans issued a radio warning.

Making for Dungeness, Ramien found that the strong current had pushed the boat to westward, so he followed a course parallel to the shore about three miles out to reach Dungeness at 02:00 on 29th August. Ramien passed inshore of a vessel stationed there. Further east he saw two light vessels, which he took to be the gate-ships guarding the swept channel. According to interrogation reports, the Acting Navigation Officer proposed that they pass through the gate, however a patrol vessel was spotted between them and Ramien decided to pass to the south (ADM 137/3874).

At 03:12 the radio log recorded that the boat had dived. Thereafter sources differ about exactly what happened. However, it appears that the boat must have gone inshore of the swept channel, in other words to the north of the light vessels. In doing so, the boat entered a shore-controlled minefield equipped with hydrophones and a 'Bragg Loop', a cable on the seabed that acted as an induction loop and alerted a shore-based controller if a ship or submarine passed over it (Grant 2003: 291). It was detected by hydrophones when proceeding at 15 metres and five knots and seventeen minutes later the boat was detected again over a Bragg Loop, just as the boat was rising to periscope depth (12 metres). At least one and possibly three or four mines were then detonated (Grant 2003: 80; ADM 137/3874). This is recorded as happening at 04:20 on 29th August (ADM 137/3874).

Bragg Loops were used extensively around harbours and headlands during the First World War. However, the only other U-boat known to have been lost as a result of their use by the British was UB 116, which was detected and destroyed outside Scapa Flow (McCartney 2014: 62).

At least one of the mines must have detonated under or in the very close vicinity of the engine room. The boat is reported to have sunk to the bottom at twelve fathoms (c.21m) almost immediately, so it is likely that the boat broke in two as a direct result of the explosion/s (ADM 137/3874). The full width break in the hull caused occurs approximately 4.75m aft of the conning tower. It is not a straight fracture and

approximately a third to half of the lower pressure hull and bases of the saddle tanks extend for approximately another 5-6m. Unless there was subsequent damage, the shape of the fracture line that split the hull was therefore z-shaped. The position of the fracture suggests that it occurred at the transverse watertight bulkhead at the forward end of the engine room.

Ramien, who was in the conning tower and is reported to have been thrown down the periscope well by the force of the blast, gave the following account to his interrogators (Messimer 2002: 220-1). Words in brackets are added:

"I heard loud shouting in the boat and then everything was still. The explosion had thrown me against the periscope and it took a while for me to regain my senses. I had fallen into the periscope well, and I crawled back into the conning tower where I found the navigator [Göderich] and the helmsman. I tried to talk to them but the noise of released compressed air drowned out our voices. Even shouting was impossible [the British noted that the survivors had been suffering from deafness due to excessive air pressure, presumably because the boat filled with water so quickly].

The boat was flooded up to the conning tower. I climbed up the ladder to the hatch and the navigator stood on the rungs right below me. When I tried to open the hatch it blew open and the navigator and I were blown into the opening where we became wedged together [the British interrogators drily noted that the three men competed with each other for the honour of leaving the boat first]. It took thirty seconds of hard struggle to free ourselves, but the navigator was able to pull himself back into the conning tower. That freed me and I rose to the surface.

I rose quickly and at no time did I have any feeling that I was running out of air. The compressed air in my lungs flowed out naturally and in large amounts. I reached the surface and right behind me came the helmsman, the navigator and the radioman [Keitel] who was unable to explain how he had reached the conning tower.

I was astounded to find five other men on the surface. The torpedomen [probably Eggert, Dömpke, Irle and possibly Janssen] had opened the forward hatch immediately following the explosion and these five men were by chance blown through the hatch. Included in those five men was a machinist [Bader] who had been carried through all the compartments on the crest of the rising water and shoved out the forward hatch. I shed my heavy leather boots. We were swimming for about three quarters of an hour before a British patrol boat that had been attracted by the explosion arrived and picked us up [the British interrogators record that this was just a quarter of an hour]."

One of the men who made the surface does not appear to have survived, although it is not clear who this was. Grant and Young state that although only eight men survived, about twenty men were able to get out of the submarine (Young 2006: 291; Grant 2003: 80). WA has not traced any contemporary account to support this number.

The survivors were as follows (ADM 137/3874). Their German rank or rating with British equivalent is given in brackets:

- Ramien, Kurt (Kapitänleutnant/Lieutenant-Commander)
- Göderich, Hermann (Diensttuender Steuermann/Acting Navigation Warrant Officer)
- Bader, Fritz (Maschinistenmaat/Engine Room Petty Officer, 2nd Class)
- Janssen, Otto (Obermatrose/Leading Seaman)
- Eggert, Kurt (Matrose/Seaman)
- Dömpke, Franz (Heizer/Stoker)

- Irle, Ernst (Heizer/Stoker)
- Keitel, Karl (F.T.Mast/Telegraphist Petty Officer, 2nd Class)

The dead were (ADM 137/3874):

- von Schubert (Leutnant/Sub-Lieutenant)
- Voss (Marine Ingenieur/Engineer Sub-Lieutenant)
- Grath (Maschinist/Engine Room Warrant Officer)
- Koch (Obersteuermannsmaat/Navigating Petty Officer 1st Class)
- Krug (Obermaschinistenmaat/Engine Room Petty Officer 1st Class)
- Angerstein (Bootsmannsmaat/Petty Officer 2nd Class)
- Reinhold (Bootsmannsmaat/Petty Officer 2nd Class)
- Dood (Maschinistenmaat/Engine Room Petty Officer 2nd Class)
- Dribusch (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Edelmann (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Grotmann (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Schulz (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Winterhof (Bootsmannsmaat/Engine Room Petty Officer 2nd Class)
- Westkamp (Obermaschinistenwärter/Senior Engine Room Probationer)
- Schillig (Obermatrose/Leading Seaman)
- Höfle (Oberheizer/Leading Stoker)
- Kronenburg (Oberheizer/Leading Stoker)
- Luhmann (Oberheizer/Leading Stoker)
- Seiler (Oberheizer/Leading Stoker)
- Bohn (Matrose/Seaman)
- Dade (Matrose/Seaman)
- Gepp (Matrose/Seaman)
- Hennemann (Matrose/Seaman)
- Jakobsen (Matrose/Seaman)
- Sonnabend (Matrose/Seaman)
- Diehl (Heizer/Stoker)
- Keidel (Heizer/Stoker)
- Jäger (F.T.Gast/Telegraphist)

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 UB-109 sank.

The survival and current condition of *UB-109* can be summarised as follows.
The submarine lies in two sections in approximately 22m LAT water depth, a short distance to the south-east of the UKHO position. The main section, which is orientated 25/205° or approximately NNE/SSW, comprises the tower, the hull forward of the tower and the hull aft of the tower to the engine room lies on its keel. It is 36m long by approximately 6.6m wide at its maximum. It has an average height above the seabed of 3.5m.

Although there is some ambiguity in contemporary accounts, it seems overwhelmingly likely that the separation of the boat into two sections occurred during the loss rather than subsequently.

The smaller section (7001), comprising the hull aft of and including part of the engine room lies approximately 16m to the south-west at an orientation of 10/185°, approximately N/S. It is inverted, with the props pointing towards the main section. This

section is 16m long and has a maximum width of approximately 5m. Maximum height above the seabed is 4.5m.

The two sections have a combined length of 52m and a maximum width of approximately 6m. Taking into account the missing casing of the bow (see below), this is consistent with *UB-109*.

The watertight section of the conning tower/bridge survives *in situ*, together with fragments of the bridge deck plates. However, the bridge casing and the aft casing are missing, although the stubs of the trailing edge of the bridge casing framing survive. Part of the bridge casing of UB 88 was made of bronze and the bridge casing of *UB-109* may therefore have been salvaged.

The surviving tower 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. The navigating periscope, with surviving prism, is extended. The attack periscope was reported by the diver to be retracted, although the possibility that it has been broken off cannot be entirely discounted from the inspection video. There is a considerable amount of modern rope around the navigation periscope. It is not clear whether this is the result of commercial fishing, use of the conning tower to provide a mooring for dive boats, or perhaps just drifting debris.

The narrow circular watertight bridge/tower hatch through which Ramien escaped is complete. The forward opening hatch lid with its locking screw and wheel is fully open and is still securely attached by the hinge. The deck around the hatch has small, regularly spaced indentations. It is not clear what function these fulfilled, although they may have been there to improve footing for crewmen on the bridge. The conning tower was not penetrated and internal fixtures and fittings were not inspected.

No trace of the combined steering wheel and binnacle that are likely to have been mounted at the forward end of the bridge were observed. It is very likely to have been removed by Damant's divers; otherwise by divers in the late 20th century.
The forward pointing recesses for the port and starboard bridge navigation lights survive, together with deadlight slots aft. These were not closely examined. No trace of either the diesel or boat air inlet masts or their fittings were found aft of the tower Although the deck gun is missing, part of its seating survives *in situ* forward of the conning tower. It consists of a horizontal partially webbed rectangular steel base plate at deck level. Through this is bolted the circular gun mounting base, which is attached to the pressure hull and reinforced by triangular stiffening brackets also attached to the pressure hull. The lower end of the base survives but only a fragment of the cylindrical upper section survives. The edge is ragged and deformed and either the result of a heavy impact that carried away the gun or crushing forces from the weight of the gun as the mounting collapsed due to corrosion.

The deck gun and its main mounting body are reported to have fallen to the seabed and become buried (Dr Innes McCartney, Facebook web page). Visual searches did not locate it on the port side of the vessel. The gun is variously reported to have been either an 88mm or a 105mm but is described in contemporary British records as a 22

pounder, equivalent to an 88mm.
Although most of the deck casing bulge around the gun mounting is missing, some of it survives. As elsewhere on the boat 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.

Forward of the gun mounting is the circular watertight forward torpedo loading hatch. This is the hatch through which the torpedo men and stoker escaped. The hatch lid is fully open forwards. The ring frame is partially buried in sand and the hatch opening is blocked with sand, which suggests that the lower ratings and forward torpedo compartments into which it opens are at least partially full of sand. It is not entirely clear how this hatch was secured, but it is assumed to have had a similar locking screw to the bridge/tower hatch, in which case part of the mechanism is missing.

On the port side between the longitudinal deck casing and the hatch is a double ended (?) HP air cylinder with associated pipework. The cylinder would have been mounted aft of the hatch and has therefore been displaced. Forward of the hatch on the starboard side is a similar HP cylinder. It is not clear whether this has been displaced as it is in approximately the correct position shown on contemporary plans.

Forward of the torpedo loading hatch there is another area of surviving deck casing. There is a considerable amount of lose debris in and around the hatch, including fragments of the steel angle and a cogged spindle, which may be part of a small windlass for raising the forward long range radio mast. No trace of the radio mast or its mounting was observed.

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 UB 88 as the deck planking is missing at that point.

Further forward the wooden deck is replaced by steel plating. There is a fragment of curved steel coaming around the outline of a flush circular feature in the deck which appears in UB III plans but is unidentified. It is possible that it could be a ready use canister. Immediately forward of this there is an open rectangular hole in the deck next to the pair of bow bollards. The hole in the deck is regular in shape and alignment, has rounded corners and appears to be a bow casing access panel. The inside was not examined, although pipework can be seen in the dive video.

Just forward of the panel on both sides of the deck are the stubs of what were flat bars bolted to the deck via a bracket. These lean aft and could be the leading edges of the fixed deck rails. However, there is a detached fixed rail with bracket just aft of the open panel and they could therefore be part of the aft frame of the missing net cutter, as the bracket would have allowed them to swivel forwards. Immediately forward of this is a centreline fairlead-like attachment. This is of uncertain function, although it could be the bow attachment for the forward aerial.

Immediately forward of this the upper bow casing is missing. This section of the hull is not part of the pressure hull. This may have become detached at the same time as the net cutter as a result of an impact. The flat that is flush with the top of the pressure hull and which protrudes forward below the missing casing has possibly survived because it

is secured to the raking stem below by strong transverse web frames. Most of the exposed stem and the foremost part of the bow casing has not survived and what can be seen internally is the forward face of two webbed transverse frames that are riveted together.

As far as can be ascertained from the deck, the saddle tanks and pressure hull are intact forward of the gun mounting. However on the port side between the gun mounting and the mid-point of the conning tower, the saddle tank casing is missing, leaving only the transverse and longitudinal framing in places. One small fragment of shell plate was observed to be lying on the seabed. The reason for this is unclear; it may be damage related to the original loss, collapse due to corrosion of the plates or a heavy impact or, conceivably, damage caused by the falling deck gun. On the starboard side just forward of the deck gun mount there is similar but less extensive damage, with the shell plating of the top of the starboard saddle tank having partially collapsed. Again, it is not clear how this has been caused, although plate thinning and general corrosion appears to have been taking place.

The full width break in the hull occurs approximately 4.75m aft of the conning tower. It is not a straight fracture and approximately a third to half of the lower pressure hull and bases of the saddle tanks extend for approximately another 5-6m. Unless there was subsequent damage, the shape of the fracture line that split the hull was therefore z-shaped. The position of the fracture suggests that it occurred at the transverse watertight bulkhead at the forward end of the engine room.

The deck and deck casing aft of the conning tower is missing. The pressure hull is intact aft of tower up to the break. The port saddle tank is also *in situ* until just forward of the break, although there are large holes due to plate thinning. Below are two high pressure air cylinders. Parts of the air inlet trunking survive below the missing deck on either side, although the masts are missing. There is some debris lying on the pressure hull.

A wide cylinder, what may be a section of the large diesel air inlet trunking (or alternatively the exhaust silencer) is lying at an angle over the edge of the fracture. Aft of the fracture the interpretation is unclear, although video looking into the surviving pressure hull at this point suggests that the transverse engine room bulkhead has been displaced. Whilst interpretation is again difficult and there is clearly displaced plating and debris, the Vulcan diesels appear to be present, although it is not clear from the video whether they remain on their mounts. It is also unclear whether either of the electric motors, positioned aft of the diesels, were observed. There is a small amount of debris on the seabed at the southern end.

The stern section is upside down. This is probably due to the force of the explosion/s. The starboard propellor shaft is *in situ*, together with its shaft bracket and gland and housing. However, the propellor itself has been deliberately removed, presumably salvaged. The starboard aft hydroplane, mounting arm and fairing are *in situ*, as appears to be the starboard rudder (minus its plates), support post and arm. The after casing is partially intact and what appear to be drainage slots can be seen. The single stern torpedo tube door and its frame are *in situ* and the door is closed.

The forward end of the port propellor is *in situ* in its housing. Between the shafts in the casing is what is either an open access panel or, more likely a large drainage slot. Forward of this, interpretation is more difficult. The stern section ends in an irregular fracture line consistent with the shape of the main section and there is some displacement of the hull, as well as some debris.

There is a small amount of debris around the southern end of 7000 and also port forward, including small fragments of corroded plate. No evidence of the deck gun previously reported to have fallen onto the seabed was seen.

Investigation

The project appears to be the first systematic archaeological assessment of UB-109 on any scale.

A team of divers led by the famous Royal Navy diver Lt. Cdr. Guybon Chesney Castell Damant C.B.E. had found and buoyed the wreck of *UB-109* the following morning. The job of this secret team, nicknamed 'The Tin Openers', was to search for intelligence material such as code books, minefield and boat plans and new equipment in newly sunk U-boats. The initial report submitted by Damant's superior following this first dive said:

"Diver got down through fore hatch cleared bedding and body from man quarters and got through bulkhead into forepart of officers' quarters expect to be able to search them thoroughly. There is no damage to this part of boat but she is cut *nearly* in half at a point about 25 feet abaft conning tower."

Damant himself subsequently gave the following accounts in his own reports:

"Severe damage abaft engine room, no damage seen on fore side of conning tower, depth about 12 fathoms. Am sending notebook recovered from coat pocket."

"She is lying in 14 fathoms on a sandy bottom, heading NE, 30 degree list to starboard. Fore hatch and conning tower open, no buoyancy remaining, about twenty feet abaft conning tower the damage begins and from there aft the vessel is shapeless wreckage (it is not clear whether Damant knew that the wreck was in two parts or investigated the stern section). The damage is far more severe than that generally met with in deep minefield cases. The forepart of the boat is quite intact, for instance the large mirror on door of captain's wardrobe is not even cracked. For this reason and because the depth was moderate I decided to work aft from the fore hatch without cutting any plates by explosives....To get to their objective, divers had to negotiate a chain of five narrow apertures: (1) fore hatch, (2) watertight door in fore bulkhead of officers' quarters, (3) partition between officers and captain's quarters, (4) watertight door in fore pressure bulkhead of control room, (5) door of watertight cabinet. Between 4 and 5 are awkward obstacles formed by the compass and steering pedestals in the control room. Afternoon on day of sinking, fore hatch was cleared of bodies, bedding, etc. and some personal material sent to the Admiralty".

The wreck next appears in UKHO records as having been surveyed by HMS *Bulldog* in 1978. The wreck is recorded as being "in two halves lying close together. Lies 020/200 degrees". The wreck was identified as "probably *UB-109*" (UKHO 13533, Surveying Details). It was subsequently reported as having had "extensive exploration" and the aft seven metres of the hull missing by P.G. Weatherly in 1982. T.W Bennetto (see 4.4.25 below) reported it to be in two parts "about 30ft apart" in 1983, when the periscope was reported to be extended twelve feet and the deck gun aft of the conning tower; the latter is presumably a typo. In 1997 routine hydrographic survey reported scattered debris. In 1998 the propellers of the submarine were reported to have been salvaged, with one bearing the mark *UB-109* and the other UB 104. The wreck was reported to be blown in two, with the stern section thirty feet to the west, the hatches open and the periscope

extended (Diver Magazine, October 1998).
Recent published and web site observations of the condition of the wreck are as follows:

"The wreck has been dived frequently since (the Tin Openers). She is in 22m and the damaged stern has now parted from the forepart. They lie about 30ft apart and even so part of the stern appears to have disappeared entirely….the experienced Channel diver Tim Bennetto tells me that when he first saw her in 1983 she had her periscope extended some 12ft above the conning tower hatch, which was open. The gun and her props were still in position. Later diving showed that on the shank of one prop was the number *UB-109* and on the other *UB-104*." (McDonald 1994: 55-6)

"The wreck of the *UB-109* lies on a seabed of sand, shell and shingle, in a general; depth of 29m (LAT). It is broken open and lying in two halves, with the engine area smashed up, but very intact from just aft of the conning tower to the bow. The hatches are open, offering glimpses down into the dark interior. The prism is still present in the periscope standard, while the deadeyes in the conning tower are very impressive as they reflect in the torchlight. The conning tower hatch where the captain and navigator escaped is said to be incredibly small, but you can see down the height of the tower, until you get to the sand-filled hull. It is heavily silted in places but, surprisingly, the large bore 105mm deck gun is still in place and points menacingly off the starboard bow. The torpedo loading hatch forward of the gun is open – evidence of the escape attempt. The 'jackstaff' socket on the bow also remains intact. The wreck is absolutely smothered in rope, fishing line and netting, and some of this floats around and could easily wrap itself around an unwary diver. The wreck provides a home for a large variety of wrasse and crabs and is encrusted with life of all kinds. The propellers, one of which was stamped *UB-109* and the other *UB-104*, have both been removed." (Young 2006: 293)

"The Seabed generally at 25m, the bow has a bit of a scour under it and you can get 28m there, the deck is at 20m with the conning tower rising up to about 17m. The periscope rises above that to about 15m or so. The stern is blown off and it is a short swim to its rear, both props have been salvaged. The pressure hull is intact, however, the tip of the bow has broken off and you have a large empty box like area open there. You can see 4 bow torpedo tubes just before that. The hatches are open, where the crew bailed out and the Tin Openers (RN Divers) went in."
(www.canterburydivers.org.uk/109)

McDonald's account is interesting because it implies that the boat may not have broken completely in two until after the sinking, and therefore was the result of a subsequent impact. However, it is not clear how an impact large enough to have moved such a large section of hull could have occurred.

Recent dive videos of *UB-109* are available online, for example at https://www.youtube.com/watch?v=kLsBxX5gXcA.

The most recent description of the wreck appears to come from McCartney, who investigated the wreck in the context of PhD research on German submarine wrecks. In its published summary format it appears to represent the first archaeological inspection of *UB-109* (McCartney 2014: 64):

"The extreme point of the bow has lost its tip, which lies on the seabed and, from the overall condition of the wreck, can only have fallen off recently. The forward torpedo hatch is open…Looking down, it can be seen that the entire submarine at this point is

full of sand. The gun is in place on the foredeck and looks, from the single recoil cylinder above the barrel to be a late-war 88mm type. The attack periscope is partially extended and remarkably still intact. It may well have been used to negotiate the Straits at the time the U-boat was sunk. The aft section is blown off in front of the engine room.

It is possible to swim over the crushed bottom of the hull and peer into the officer's space beyond. The stern portion of the wreck lies at least 10 metres away from the forward part. Remarkably it is completely upside down. The force of the explosion that blew it off had to have been very heavy and very close to have blown it off completely, so that it capsized in a different way from the forward section. The aft torpedo door is shut, showing that the mine did not detonate the tube. The upside down nature of the stern section is obvious from this position. Both rudders and hydroplanes are still present, but the propellers are gone. The wreck is in very good condition for one so close to shore and in such shallow water."

It is understood that the wreck was subject to a short filmed inspection for the purposes of a television documentary on the 'Tin Openers' in 2014 (Chris Webb, pers. comm.).

UB-109 appears to have been subject to its first published archaeological survey of any scale in October 2014. This was carried out for EH by WA, working with avocational divers from Canterbury Divers and Folkestone 501 BSAC clubs. The wreck appears to have been almost completely clear of abandoned fishing gear at this time.

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.

Period

5.2.3 **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-109* is technologically exceptional as an individual vessel, it is a representative example of its type. In addition, the damage evident to *UB-109* indirectly provides evidence of another maritime weapon that came of age in the First World War, the sea mine.

Rarity

5.2.4 **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

Documentation

5.2.5 **Highly Valuable**. Documentary evidence for this submarine exists in some quantity. Documentation traced for this project is largely related to the interrogation of its crew, its investigation by the 'Tin Openers' following its loss 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. However, it does, for example, provide evidence that *UB-109* was probably the last victim of the Dover Barrage and with regard to the important work of the 'Tin Openers'.

Group Value

5.2.6 **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.

Survival/Condition

5.2.7 **Not Valuable**. Although it is in two parts, 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 deck gun, the deck casing, parts of the saddle tanks, the tower casing and 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.

Potential

5.2.8 **Moderately valuable**. Although *UB-109* 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-109* in this respect is clearly fairly high.

Summary

5.2.9 Measured against current EH guidance on the criteria, *UB-109* scores fairly highly and is perhaps a borderline candidate for scheduling. Whether the protection such scheduling provides would have a practical impact upon the vulnerability of the monument is uncertain.

5.2.10 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
- There is currently no agreed definition of what individual or group 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. As a result it has been suggested that *UB-109* might be considered important as a representative example of a UB III boat.

5.4.2 By way of contrast, the wider public focus tends to be more commemorative in nature, with the principal interest of submarines as monuments lying in their association with the events and people of the First and Second World Wars. There is therefore a case to be made that assessment of the value of individual submarine wrecks should be more event and personality driven. Examined in that context, the significance of *UB-109* lies in its possible status as the last U-boat to be sunk in the Straits of Dover and therefore as the last victim of the Dover Barrage. It would therefore follow that its principal interest lies not in its design, but in its status as part of an important battlefield and as a more general symbol of the vital and bloody defeat of the U-boat menace in 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 can be seen in **Figure 9** which shows some of the marine heritage assets linked to *UB-109*, either because they were its victims or because they are also First World War U-boats lost in the Dover Straits area. This battlefield was arguably just as important in terms of the eventual outcome of the war as any of those on land on the Western Front or further afield and is worthy of further study.

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.

7 REFERENCES

7.1 Bibliography

Cotswold Archaeology marine, 2014, *NHPP 3A1: Unknown Marine Assets & Landscapes. Strategic Assessment of Submarines in English Waters*, Cotswold Archaeology Report No. 6655.

Grant, R., 2002a, *U-Boats Destroyed*, Periscope Publishing Ltd.

Grant, R., 2002b, *U-Boat Intelligence*, Periscope Publishing Ltd.

Grant, R., 2003, *U-Boat Hunters*, Periscope Publishing Ltd.

Kendall, P., 2009, *The Zeebrugge Raid 1918, 'The Finest Feat of Arms'*, Spellmount.

McCartney, I., 2002, *Lost Patrols: Submarine Wrecks of the English Channel*, Periscope Publishing Ltd.

McCartney, I., 2014, *The maritime archaeology of a modern conflict: comparing the archaeology of German submarine wrecks to the historical text*, Routledge.

McDonald, K., 1994, *Dive Kent*, Underwater World Publications Ltd.

Williamson, G., I., 2002, *U-boats of the Kaiser's Navy* , New Vanguard Series 5, Osprey Publishing Ltd.

Messimer, D., 2002, *Verschollen, World War I U-boat Losses*, Naval Institute Press, Annapolis.

Rössler, E., 1997, *Die Unterseeboote der Kaiserlichen Marine*, Bernard & Graefe Verlag.

Rössler, E., 2001, *The U-Boat. The evolution and technical history of German submarines*, Cassel & Co.

Walding, Dr R., 2009, 'Bragg and Mitchell's Antisubmarine Loop' in *Australian Physics*, Volume 46 (5): 140-145

(http://www.academia.edu/6720520/Bragg_and_Mitchell_s_Antisubmarine_Loop)

Wessex Archaeology, 2014, *Archaeological Services in Relation to Marine Designation. UB-109: Marine Geophysical Survey Report*, Wessex Archaeology Ltd Report No. 83803.35.

Young, R., & Armstrong, P., 2006, *Silent Warriors: Submarine Wrecks of the United Kingdom, Vol 1*, Tempus.

7.2 The National Archives

ADM 137/3874

7.3 Other Sources

English Heritage, 2012, *Designation Selection Guide: Ships and Boats: Prehistory to Present*, English Heritage.

EH Brief and supporting documents.

EH NRHE Complete Monument Reports 901790 and 1388909 (accessed via PastScape).

http://www.uboat.net/ (comprehensive U-boat website)

http://www.canterburydivers.org.uk/109.html (Canterbury Divers)

http://ub88.org/ (UB 88 project website)

https://www.youtube.com/watch?v=kLsBxX5qXcA (White Wolf Diving, YouTube)

https://www.youtube.com/watch?v=BhajVfMtB7U (Luke Wyndam, YouTube)

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	02/10/2014	08:57	36	23	Croce	Initial inspection
02	02/10/2014	09:52	23	21.5	Hamel	Continuation of 1
03	02/10/2014	15:26	29	23	Knott	Survey of foredeck
04	02/10/2014	16:21	7	21.5	Hamel	Aborted due to loss of slack; survey gear recovered
05	03/10/2014	10:46	45	21.5	Croce	Survey of tower and foredeck
06	03/10/2014	17:23	14	21.5	Hamel	pH sampling; survey gear recovered; short slack

*** 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-109***		
NRHE /UKHO No.	EH Region	Restricted Area	Principal Land Use
901777/13482	South East	N/A	Coastland 1: Marine
Latitude (WGS84)	51° 3.731' N (7000)		
Longitude (WGS84)	01° 14.146' E (7000)		
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	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-109* lies at one location in two sections within territorial waters off Folkestone, Kent. It is almost fully exposed. *UB-109* 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 geophysical and 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 deck, conning tower and some other casing and deck fittings. Both of its propellers were salvaged in the late 20th century and other items may have been removed as souvenirs. The whereabouts of items removed is unknown. The submarine appears to be at least partly filled with sand and access within the pressure hull is restricted, although not impossible. There is some evidence from sources that the wreck has been impacted by fishing gear and it was reportedly covered in fishing net until recently, although during WA inspection work on the site in October 2014, no significant trace of fishing gear was found. 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.

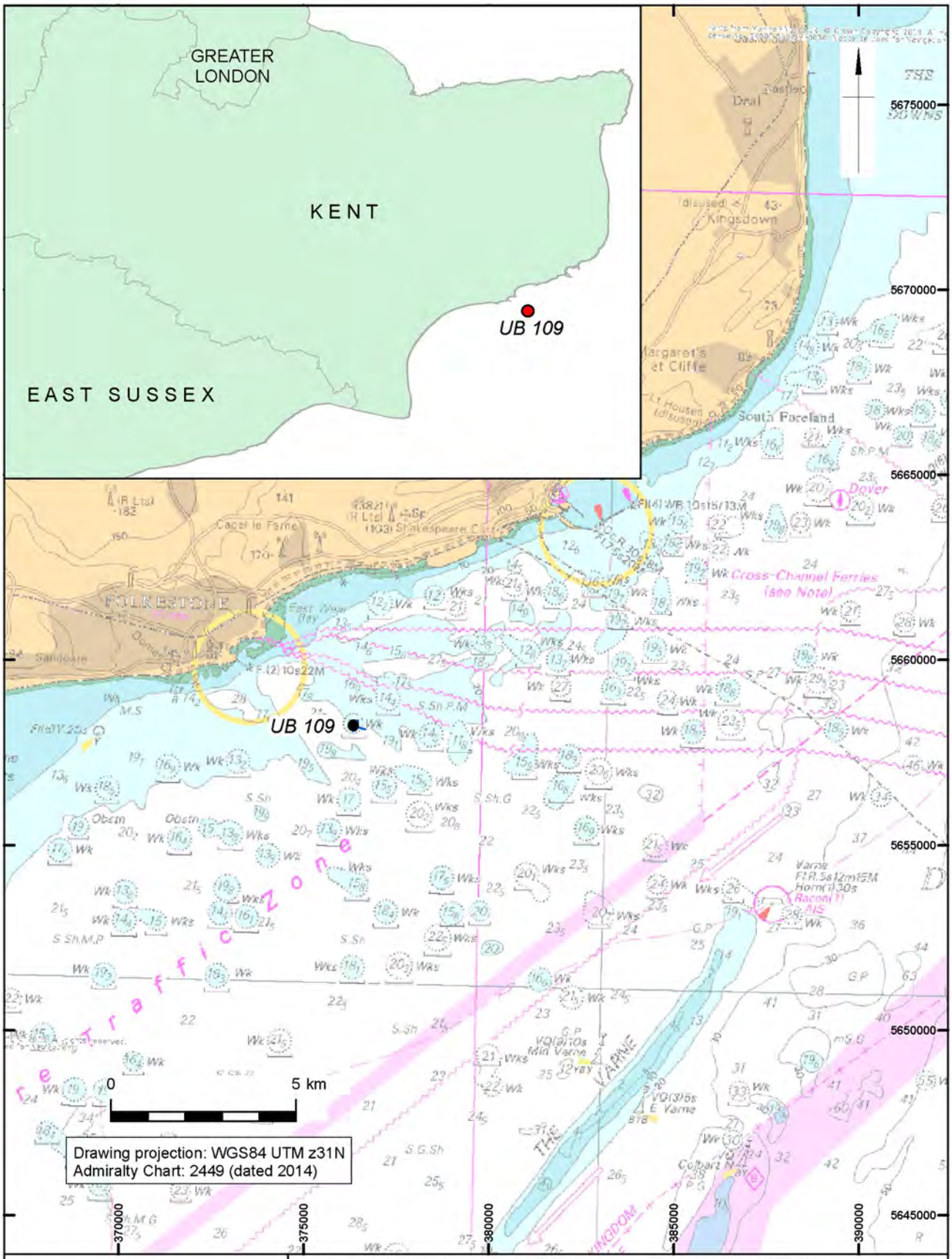
No formal management prescription appears to be appropriate, although EH has the opportunity to benefit from the strong encouragement to local engagement provided by the investigation of this and other local FWW sites in 2014 by undertaking further related fieldwork and/or engagement in the region.

Using the 'decision tree' method of risk assessment, risk is assessed as LOW.

Data source for this risk assessment is:

Wessex Archaeology, 2014, *Archaeological Services in Relation to Marine Designation. UB-109, off Folkestone, Kent. Archaeological Report*, Wessex Archaeology Ltd Report No. 83803.34.

Risk is assessed as:	**LOW**		
Data Source	CON	Date & Initials	Wessex Archaeology, January 2015

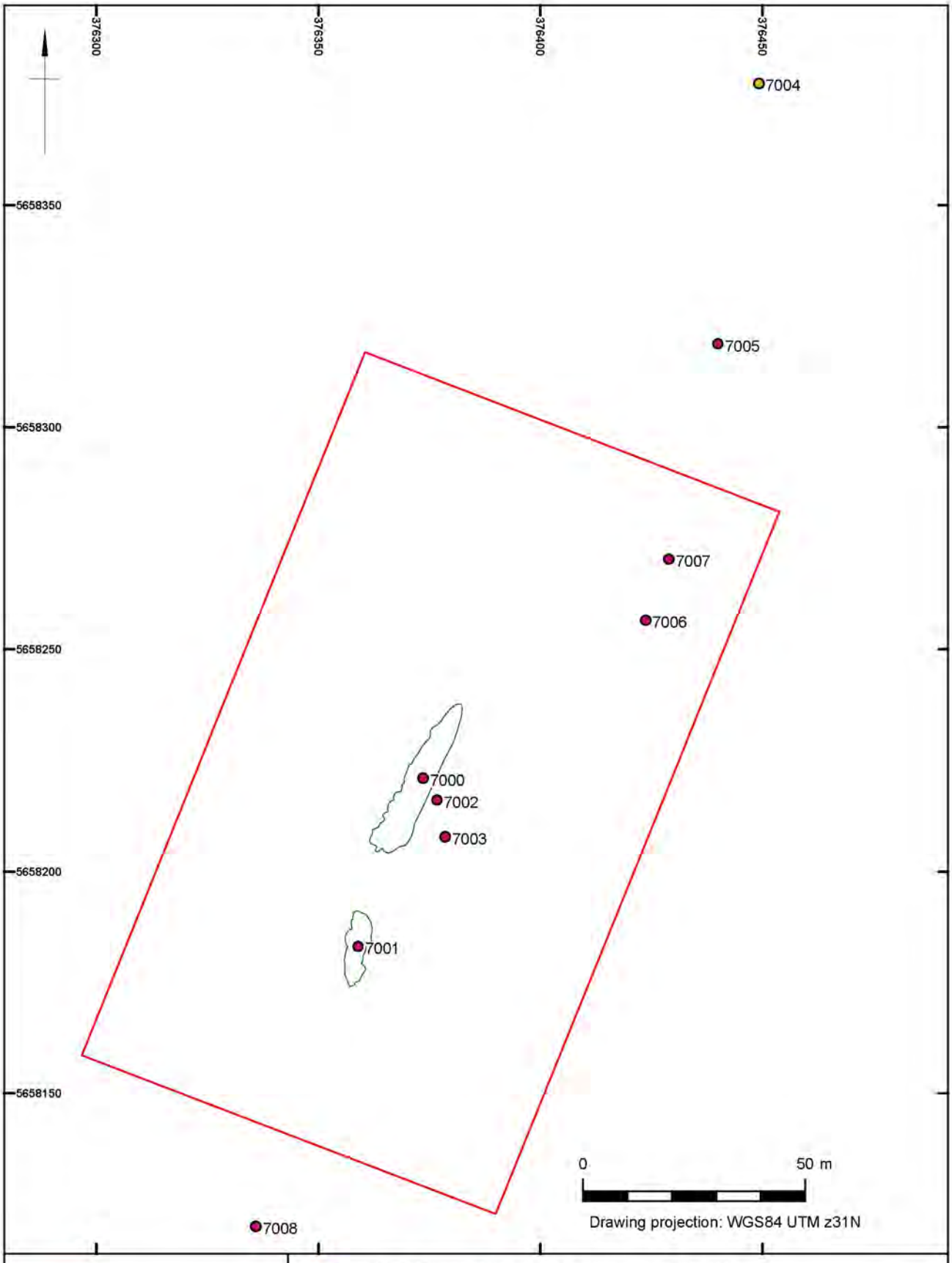


● Wreck location

Date:	07/01/2015	Revision Number:	0
Scale:	1:150,000 at A4	Illustrator:	KL/KJF
Path:	W:\Projects\PWA\Projects\83803\7 DO\UB 109\Arch report\2015_01_17		

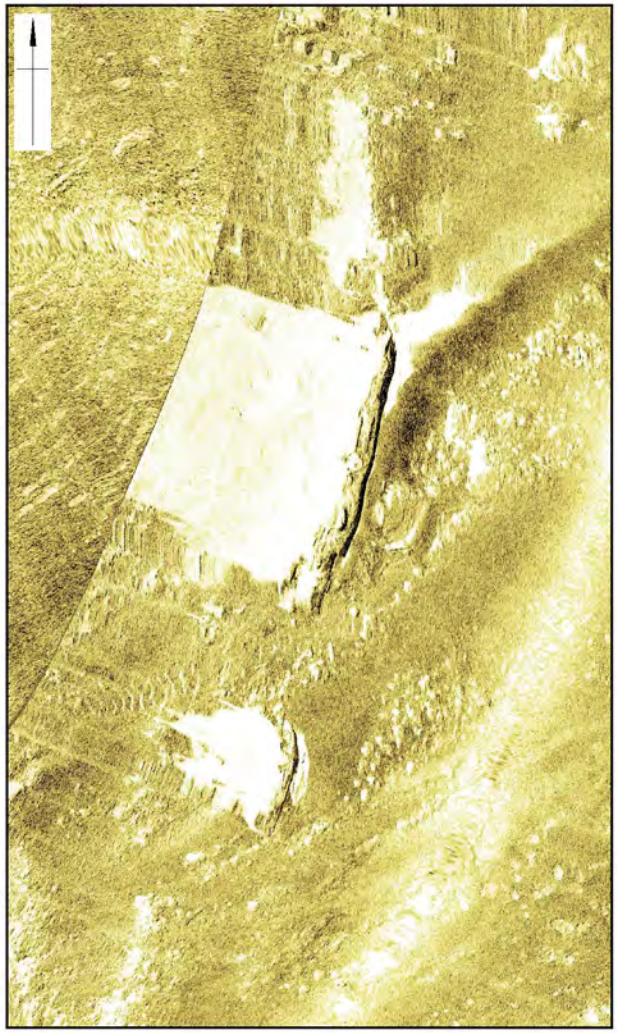
Site location

Figure 1

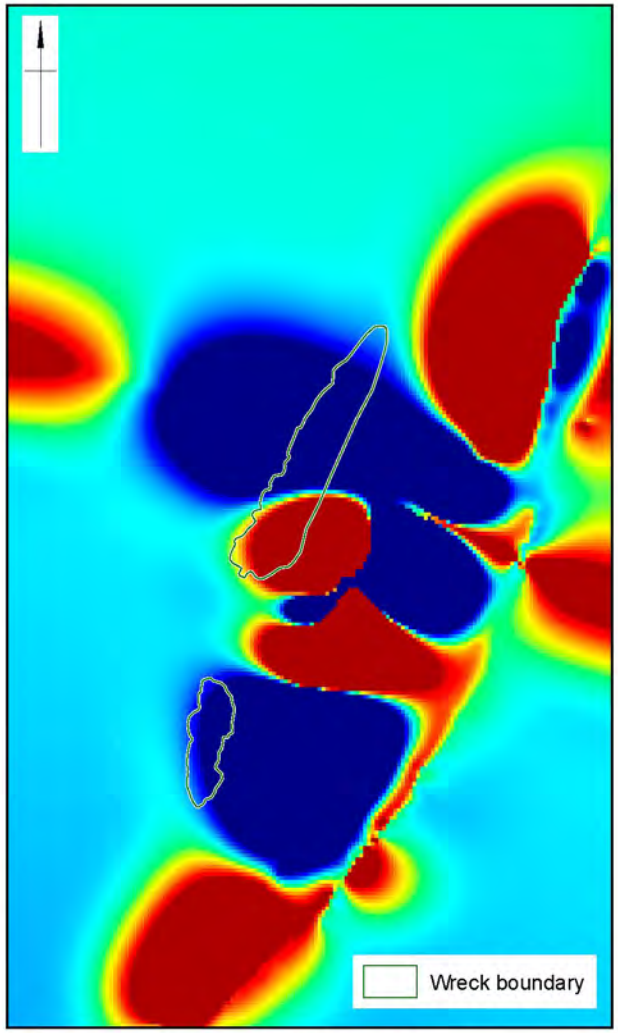


Geophysical survey anomalies of potential archaeological interest

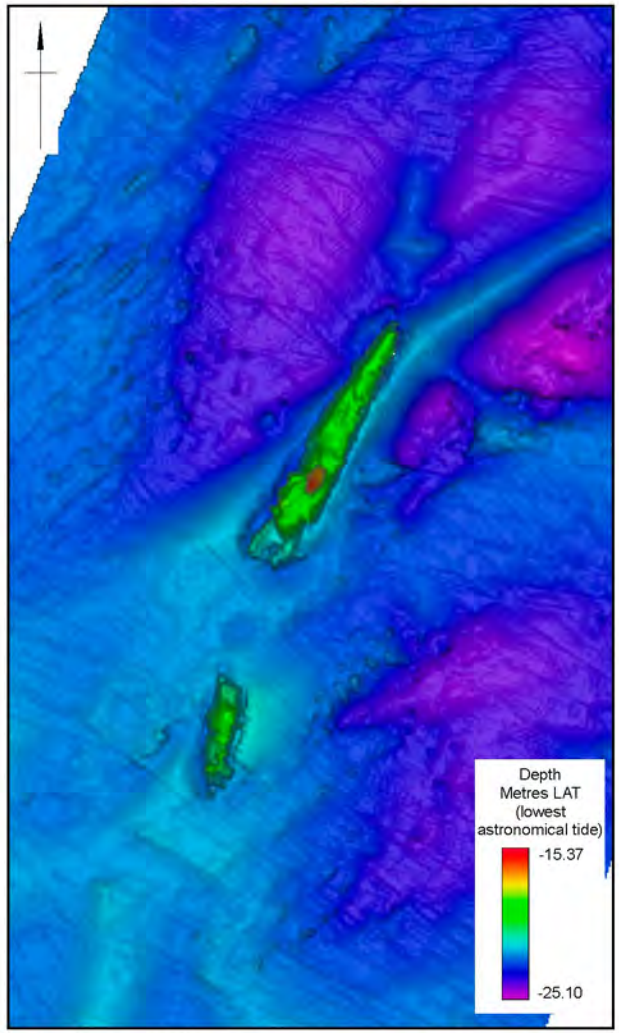
Figure 2



A. Sidescan sonar mosaic



B. Gridded magnetometer data (±35nT)



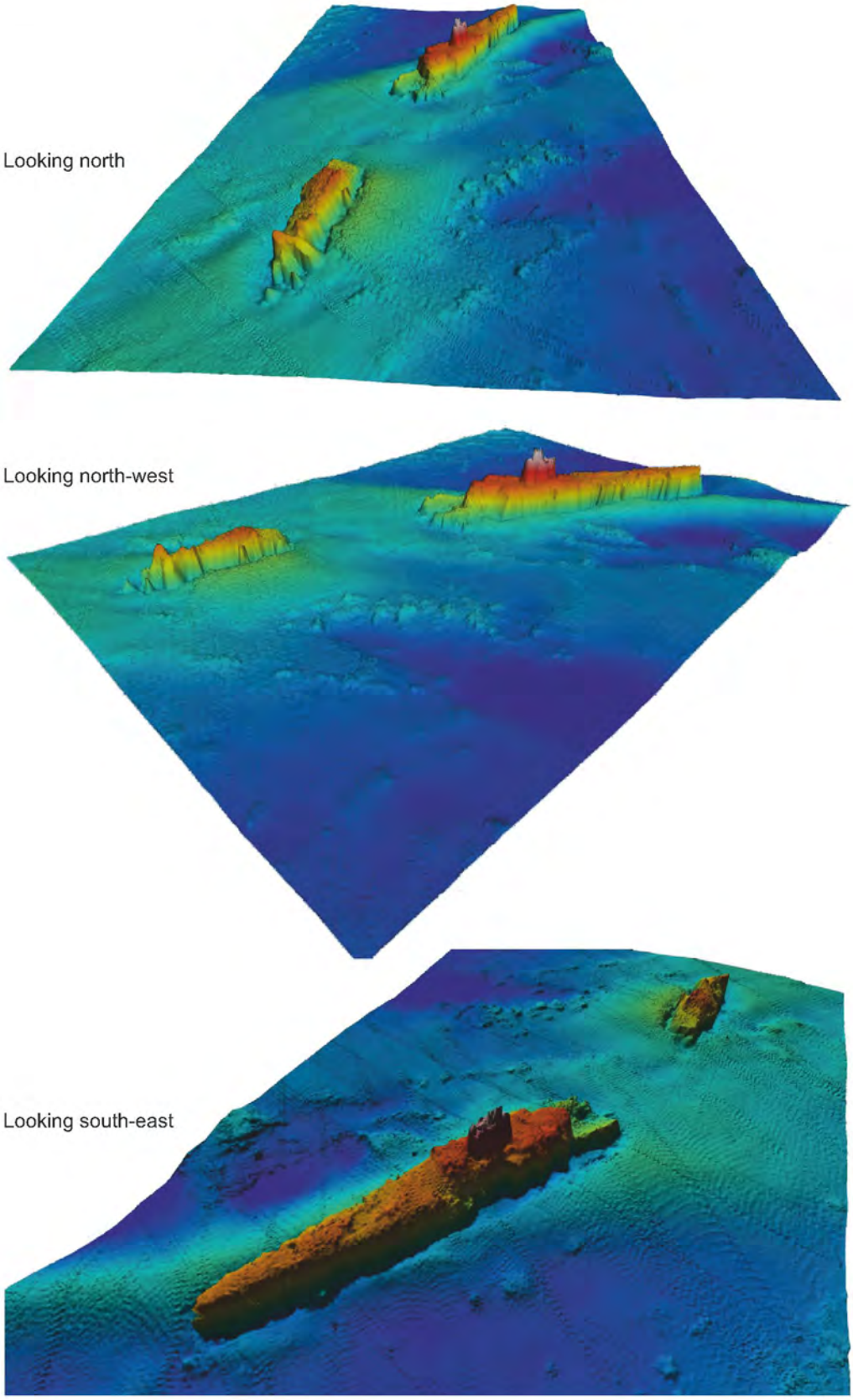
C. Multibeam bathymetry

0 25 m

Date:	03/12/14	Revision Number:	0
Scale:	1:1000 at A4	Illustrator:	KL
Path:	W:\Projects\PWA\Projects\83803\7 DO\UB 109\Arch report\2015_01_17		

Sidescan Sonar Mosaic, Gridded Magnetometer Data and Multibeam Bathymetry

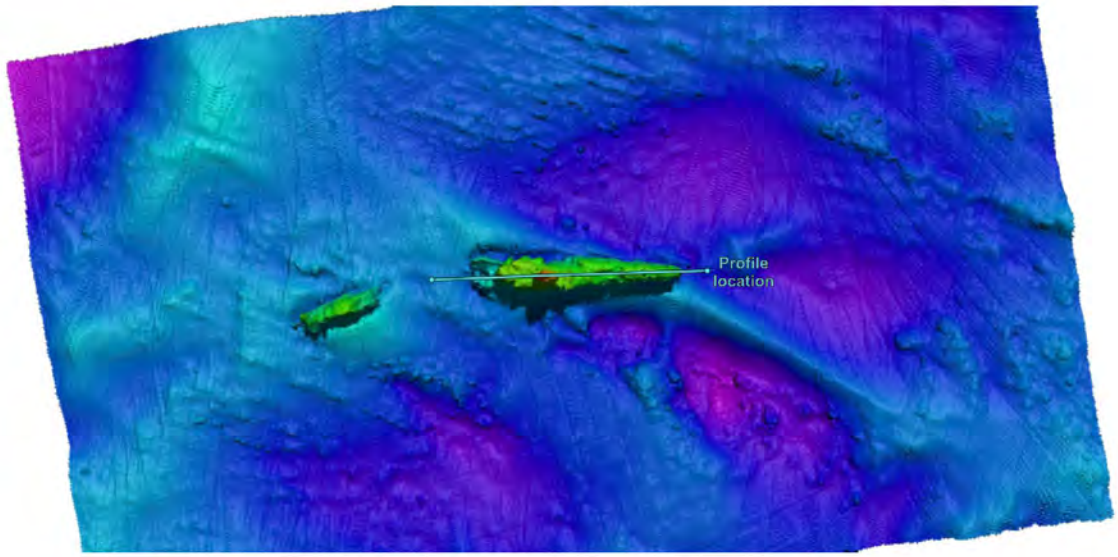
Figure 3

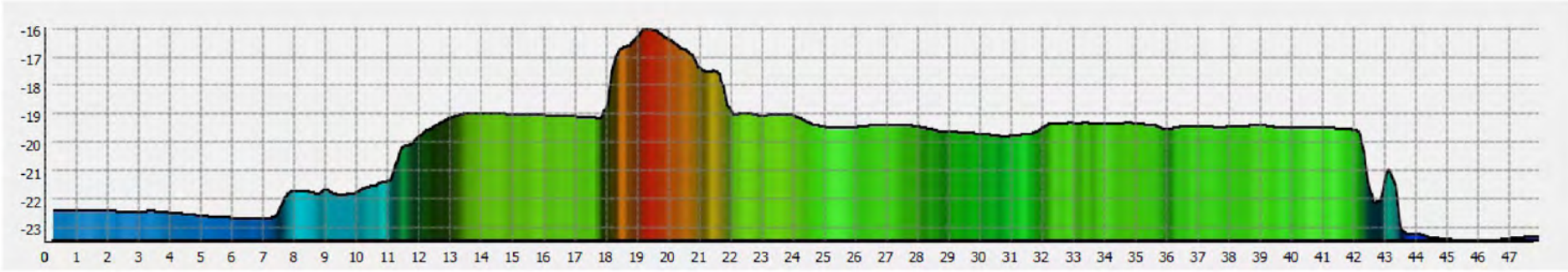


Date:	07/01/2015	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Archaeological report\2015_01_17		

Multibeam swath bathymetry results

Figure 4

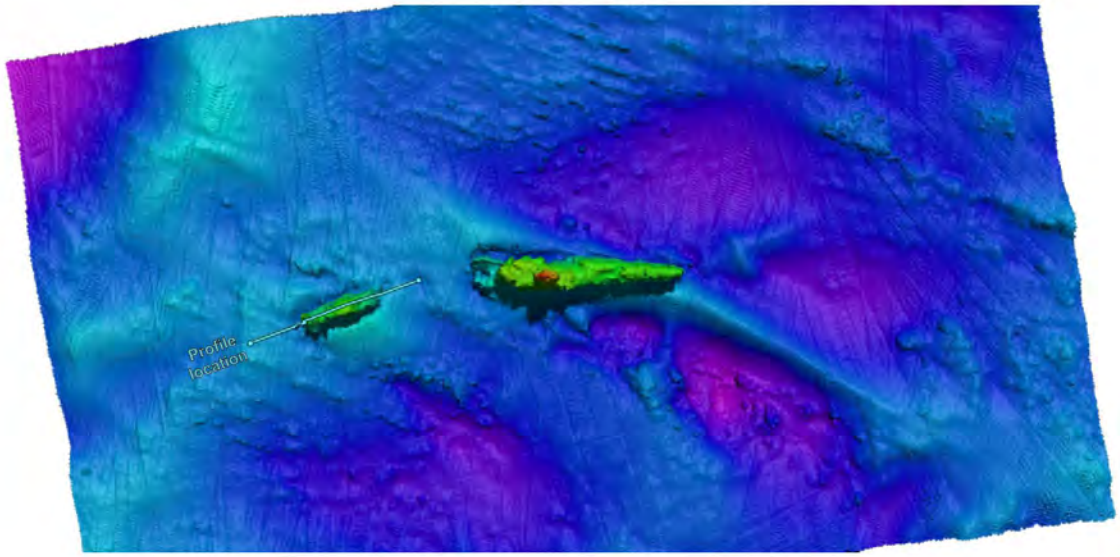




Date:	07/01/12015	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Archaeological report\2015_01_17		

7000 profile (bathymetry)

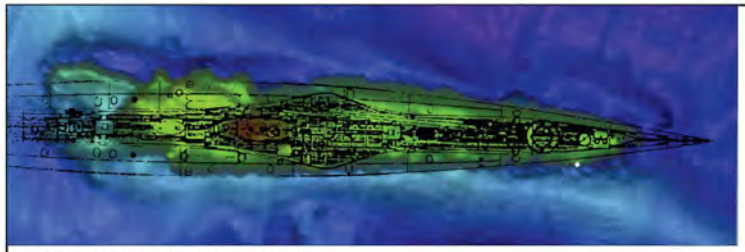
Figure 5



Date:	07/01/12015	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Archaeological report\2015_01_17		

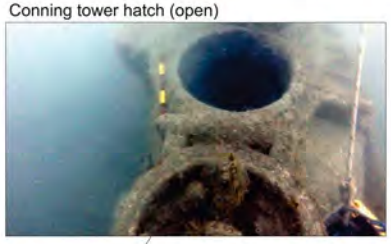
7001 profile (bathymetry)

Figure 6



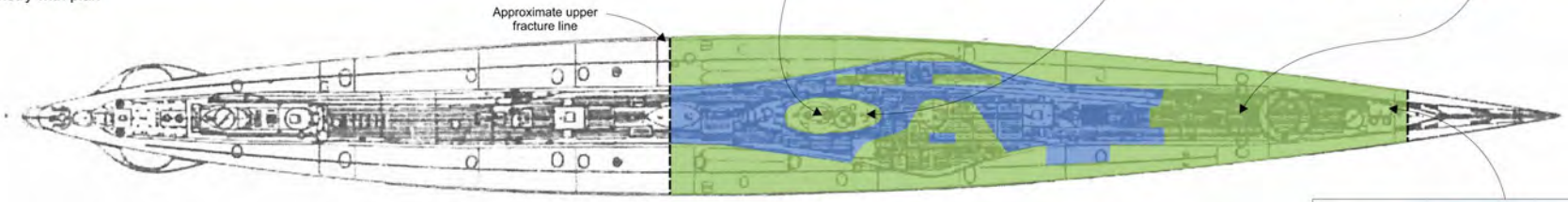
7000: Multibeam bathymetry with plan

Attack periscope



Conning tower hatch (open)

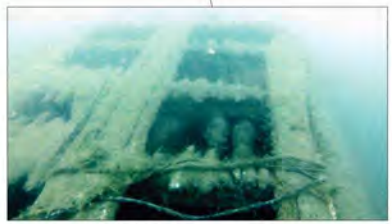
Capstan base plate



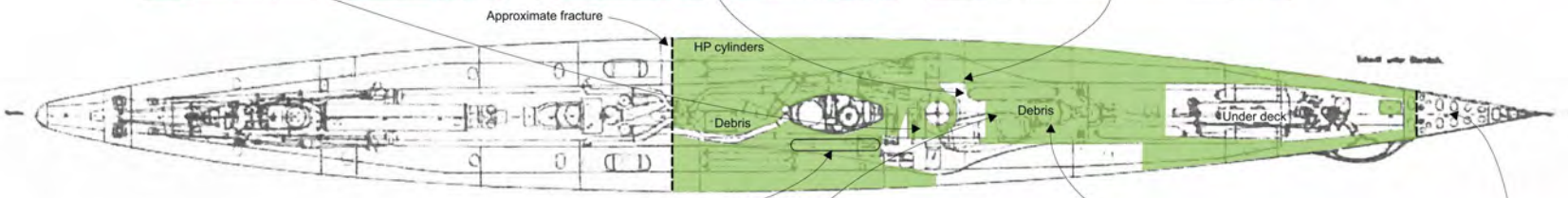
Gun mounting base

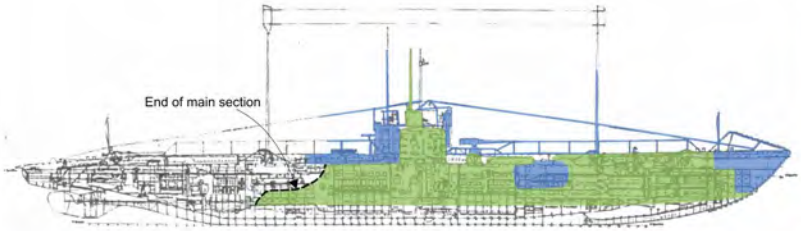
HP air cylinder

Gun base plate

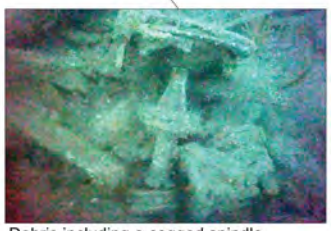


Surviving deck and casing





Forward torpedo loading hatch (open)



Debris including a cogged spindle

Webbed transverse frames at bow

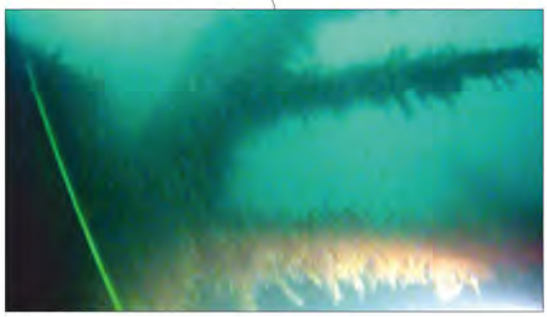
Surviving
Missing

Date:	07/01/2015	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Arch report\2015_01_17		

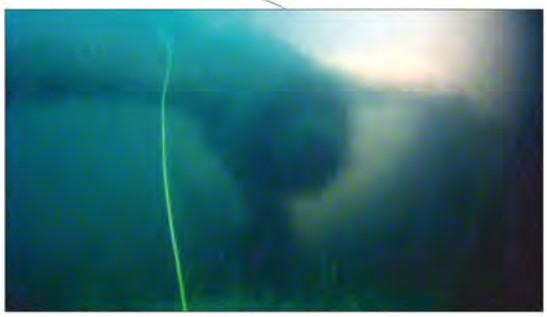
Diver survey results (7000)

Figure 7

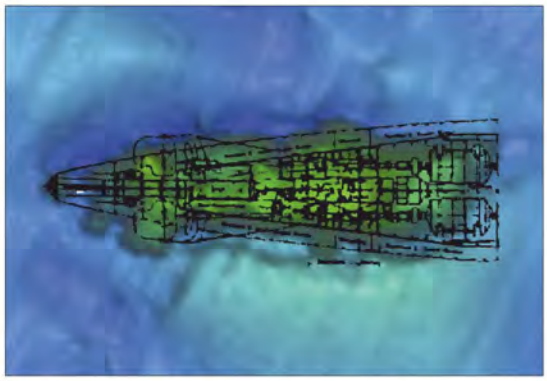
Stern torpedo tube door (closed)



Starboard rudder



Starboard propeller shaft bracket



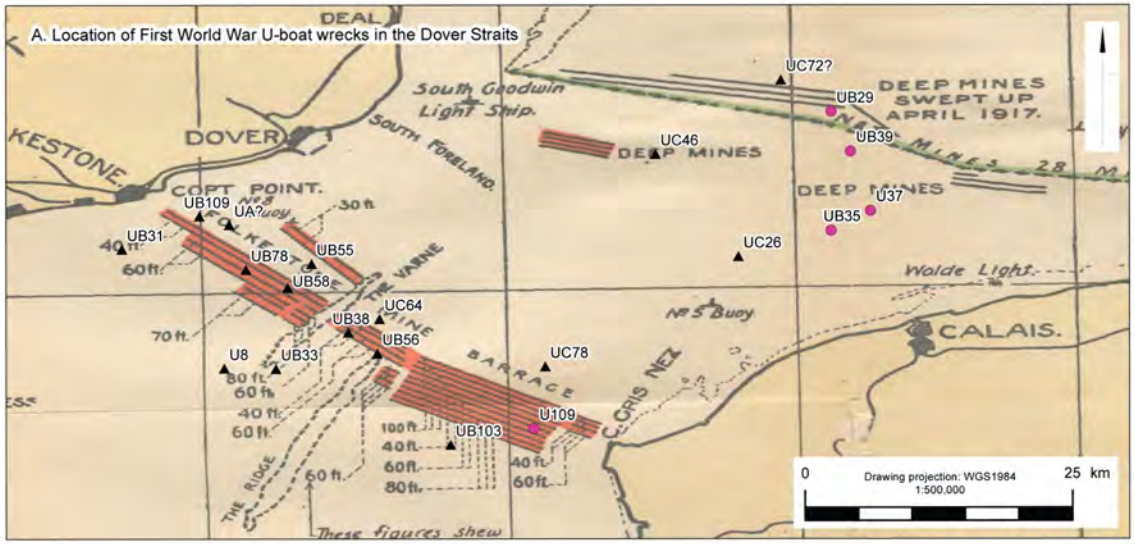
7001: Multibeam bathymetry with plan

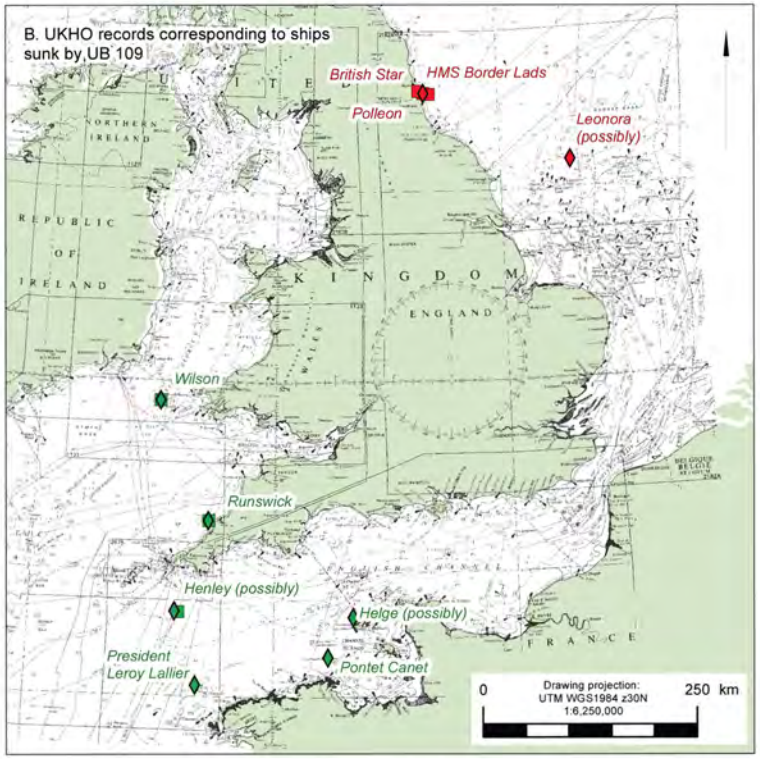
Surviving
Uncertain

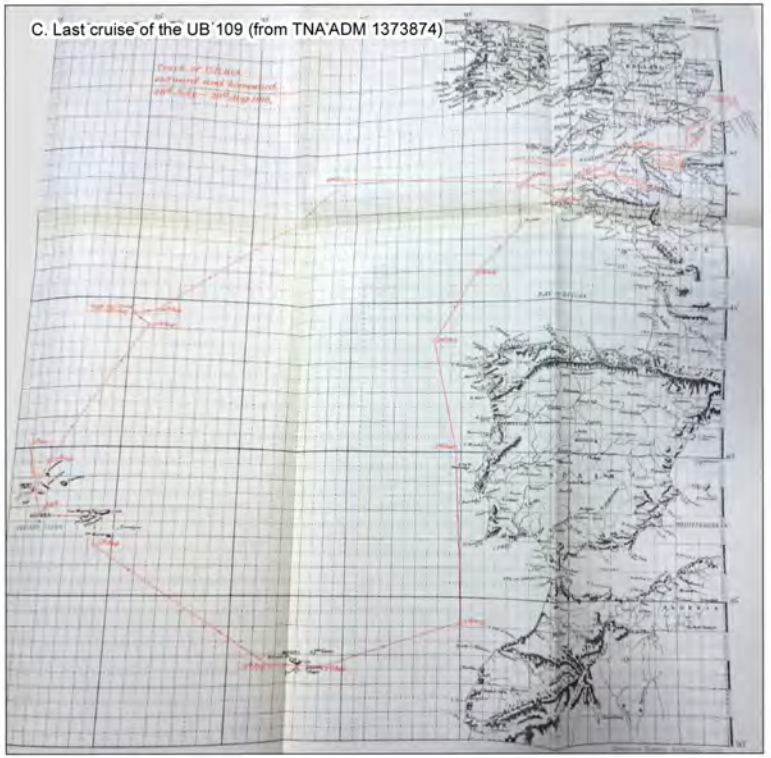
Date:	07/01/2015	Revision Number:	0
Scale:	N/A	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Archaeological report\2015_01_17		

Diver survey results (7001)

Figure 8







A.

Location of wrecks (McCartney, 2002)

- Wreck
- Historical Position

B.

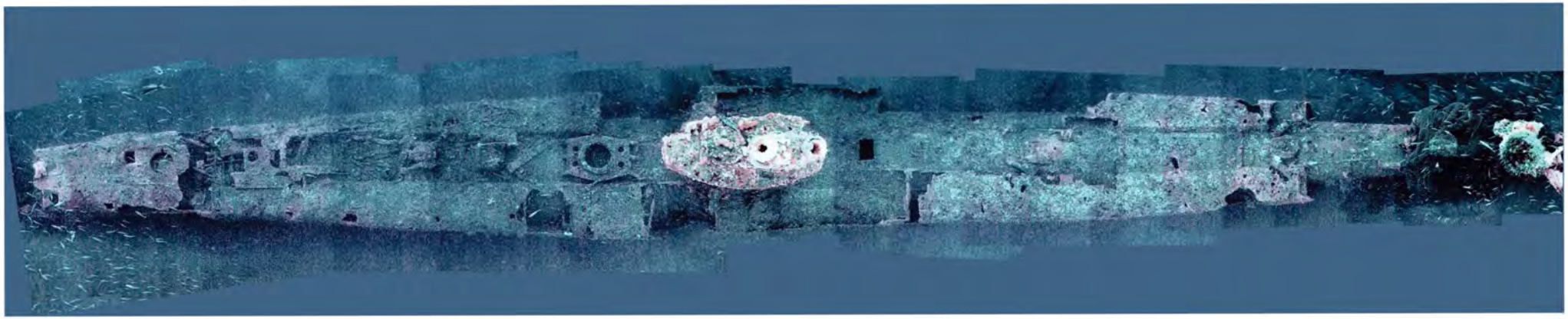
- UB 78 victims (UKHO)
- UB 78 victims (NRHE)
- UB 109 victims (UKHO)
- UB 109 victims (NRHE & NMRW)

Location of wrecks taken from McCartney 2002
Basemap: Dover Patrol, Mines and Net Barrages December 31st 1917 from Admiral Sir Reginal Bacon , THE DOVER PATROL 1915-1917, Volume II.

Date:	08/01/2015
Revision Number:	0
Scale:	See scale bar
Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\
83803\7 DO\UB 109\Arch report\2015_01_17	

Mapping relevant to the UB 109

Figure 9



Date:	08/01/2015	Revision Number:	0
Scale:	Not to scale	Illustrator:	KJF
Path:	W:\Projects\PWA\Projects\83803\7 Drawing Office\UB 109\Arch report\2015_01_17		

UB 88 photomosaic

Figure 10

wessex archaeology

salisbury rochester sheffield edinburgh

Wessex Archaeology Ltd registered office Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB
Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk www.wessexarch.co.uk