RFA DARKDALE SURVEY

SALVAGE AND MARINE OPERATIONS

SURVEY REPORT

BLANK

This document was prepared following the survey of *RFA Darkdale*, at St Helena in 2012 by Salvage and Marine Operations.

Prepared by

Andy Liddell,

Staff Officer Wreck Management

Matt Skelhorn,

Wreck Researcher & Analyst

Approved by

James Ward, Deputy Team Leader

Executive summary

The *RFA Darkdale* was a tanker stationed at the South Atlantic island of St Helena to act as a fleet tanker in World War II. In October 1941, she was attacked and sunk by a U Boat and since that time has been slowly weeping oil that is visible as a light sheen over the wreck site.

In 2010 a larger leak of oil occurred resulting in calls from the Island's Governor and the Foreign and Commonwealth Office (FCO) for the Ministry of Defence (MoD) as the owner of the wreck to take action. Concern was also raised as it was believed that unexploded ordinance was scattered across the bay causing a hazard to visiting ships and yachts.

In May 2012, a MOD team from Salvage and Marine Operations (S&MO) supported by environmental scientists from RPS Consultants surveyed the wreck and the surrounding bay to assess the condition of the wreck and the risk posed by it.

The survey showed that the wreck lies in two parts. The bow section lies inverted and in very good condition given the age of the wreck and the time submerged. The stern section lies on its port side and has suffered substantial torpedo damage.

The bow section is estimated to contain between 2326 and 4952 m^3 of oil. A more precise estimate of the quantity was not possible due to the constraints imposed by the location of the wreck and the survey tools available.

The environmental study found generally low levels of hydrocarbon contamination in the water column. Sediment samples were comparably more contaminated and levels of various hydrocarbon compounds exceeded European Quality Standards (EQS). The majority of the fish samples were found to contain low level hydrocarbon contamination; approximately 10% of the fish /shellfish sampled exceeded the relevant EQS's and may be a hazard to human health if consumed.

The wreck continues to corrode and the eventual release of the oil is inevitable unless there is an intervention to remove it. The environmental study into the potential effects in the event of a large spill, found that there is a short term lethal risk to inshore fish species. Oil persisting in the environment would further hamper recovery of these species potentially causing long term sub-lethal effects.

The socio-economic impact of an acute spill was assessed as being less than £100k. This is due to the tourist industry being in its infancy and the commercial fishing grounds being outside the area likely to be affected by a spill. The opening of an airport on the island in 2015 will mean that the economic impact of an oil spill will rise with time as the tourist industry grows.

The local concern for unexploded ordinance in James Bay is considered to be unfounded. There are a small number of shells on or very close to the wreck but no evidence was found of ordinance being scattered more widely across the bay.

Following the survey and subsequent analysis and review, the following recommendations are made:

1. St Helena Government is advised to prohibit anchoring within 200 m of the wreck site.
2. St Helena Government is advised to impose a fishing ban over the wreck and immediate area.
3. A larger sample of fish from a wider area should be taken and analysed for hydrocarbon contamination.
4. The remaining oil on the wreck is removed.
5. A long term programme of fish and environmental monitoring is set up

Table of Contents

Table of Figures

Introduction

1. In 2010, a leak of oil occurred from the Ministry of Defence (MoD) owned ship wreck RFA *Darkdale* in the waters of the South Atlantic island of St Helena. The wreck is known to have leaked slowly for many years but this larger leak caused greater concern.

2. The Governor of the Island, Andrew Gurr sent a letter to the Secretary of State for Defence (1) requesting that the MoD take action.

3. The letter requested action in 3 specific areas:

   a. The clean-up of the spilled oil.

   b. The prevention of future leaks.

   c. The disposal of Unexploded Ordinance believed to present a hazard to shipping anchoring in the James Bay.

4. Due to the time required to mobilise any specialist equipment to site, no action was taken to clean up the 2010 oil spill. The island possessed no equipment or trained personnel to respond to the spill; therefore the only option available was to leave the oil to disperse naturally.

5. An action plan was agreed between the Maritime Coastguard Agency (MCA) (responsible for providing counter pollution advice to the Overseas Territories), MoD and the Foreign and Commonwealth Office (FCO). It was agreed that the MoD, represented by Salvage and Marine Operations team would carry out an onsite survey of the wreck. The aims of the survey were to establish the condition of the wreck, assess the amount of oil remaining onboard and assess the feasibility of removing any remaining oil from the wreck with a further aim of establishing the risk posed by unexploded ordinance.

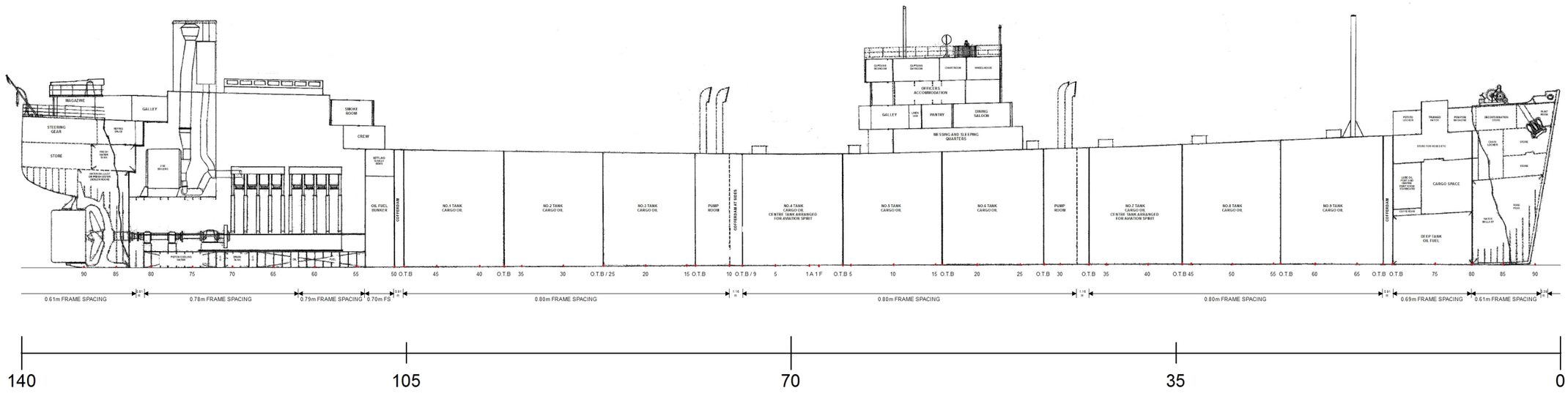
6. The work was divided in to two distinct phases:

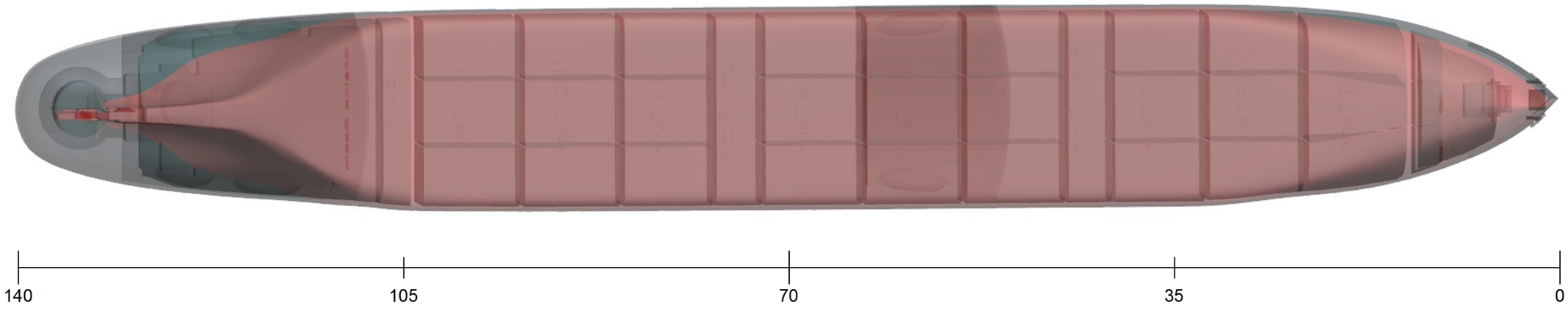
   a. Historical research to allow as full understanding of the wreck as possible and to allow a desk based assessment to be carried out.

   b. An onsite survey to establish the condition of the wreck.

7. This document reports on the work carried out and the resulting findings, conclusions and recommendations.

Layout


MAGAZINE
GALLEY
STEERING GEAR
STORE
SMOKE ROOM
CREW
OIL FUEL BUNKER
COFFERDAM
NO.1 TANK CARGO OIL
NO.2 TANK CARGO OIL
NO.3 TANK CARGO OIL
PUMP ROOM
COFFERDAM AT SIDES
NO.4 TANK CARGO OIL CENTRE TANK ARRANGED FOR AVIATION SPIRIT
NO.5 TANK CARGO OIL
NO.6 TANK CARGO OIL
PUMP ROOM
NO.7 TANK CARGO OIL CENTRE TANK ARRANGED FOR AVIATION SPIRIT
NO.8 TANK CARGO OIL
NO.9 TANK CARGO OIL
COFFERDAM
OFFICERS' ACCOMMODATION
GALLEY
PANTRY
DINING SALOON
MESSING AND SLEEPING QUARTERS
CARGO SPACE
DEEP TANK OIL FUEL
0.61m FRAME SPACING
0.78m FRAME SPACING
0.79m FRAME SPACING
0.70m FS
0.80m FRAME SPACING
0.80m FRAME SPACING
0.80m FRAME SPACING
0.69m FRAME SPACING
0.61m FRAME SPACING
140
105
70
35
0
SCALE IN METRES


140
105
70
35
0
SCALE IN METRES

Description of the vessel

8. *RFA DARKDALE* was a Dale class tanker and was entered into Lloyd's Register (2) with the following comments:

- Name: *DARKDALE*
- Classification: LR *100A1
- Type: Petroleum Carrier in Bulk,
- Built: Glasgow in 1940
- Length between perpendiculars: 463'2" (141.173 m)
- Length overall: 479'8" (146.202 m)
- Beam: 61'2" (18.644 m)
- Depth: 33'1" (10.084 m)
- Draught: 27'0.5" (8.242 m)

9. The *RFA Darkdale* was an oil tanker typical of her time. She was a single hulled tanker with an engine room and crew accommodation arranged aft and an amidships bridge and officers accommodation.

10. She was a motor propelled ship driven by six cylinder slow speed diesel engine built by Kincaid & Co. of Glasgow turning a single four blade propeller.

11. The vessel was arranged with nine cargo tanks that were longitudinally divided in to port, centre and starboard tanks. In addition she had a cargo deep tank forward.

12. There were two cargo pump rooms, the aft pump room located between No.3 and No.4 tank located and the forward room between No.6 and No.7 tank.

13. The vessels own bunker fuel was carried in two bunker tanks located at the forward engine room bulkhead. Service, settling and lubrication oil storage tanks were all located within the engine room space.

14. The vessel had a crew of 49 persons, 41 of whom were lost with the ship.

15. The vessel was fitted with a selection of weapons for self-defence, the largest of these being the 4.7 in breach loading naval gun located aft.

Location of the Wreck

16. The wreck of the tanker *RFA Darkdale* is in James Bay, St Helena.

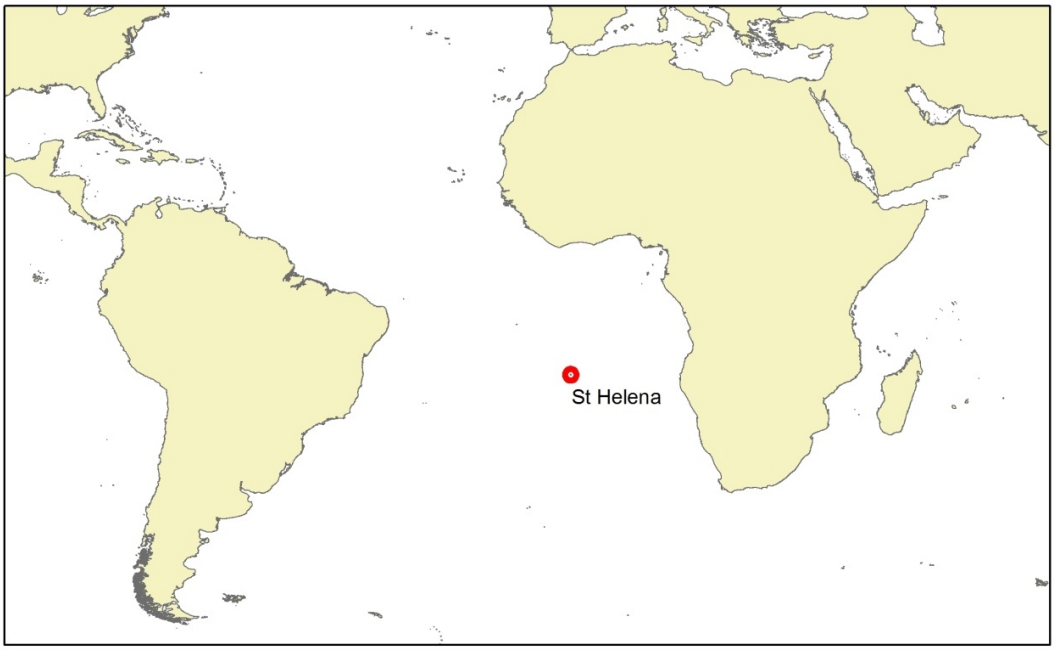


Figure 1 - Location of St. Helena

17. The wreck lies in 45 m of water, 600 m off the shore of Jamestown, the main town of the island.

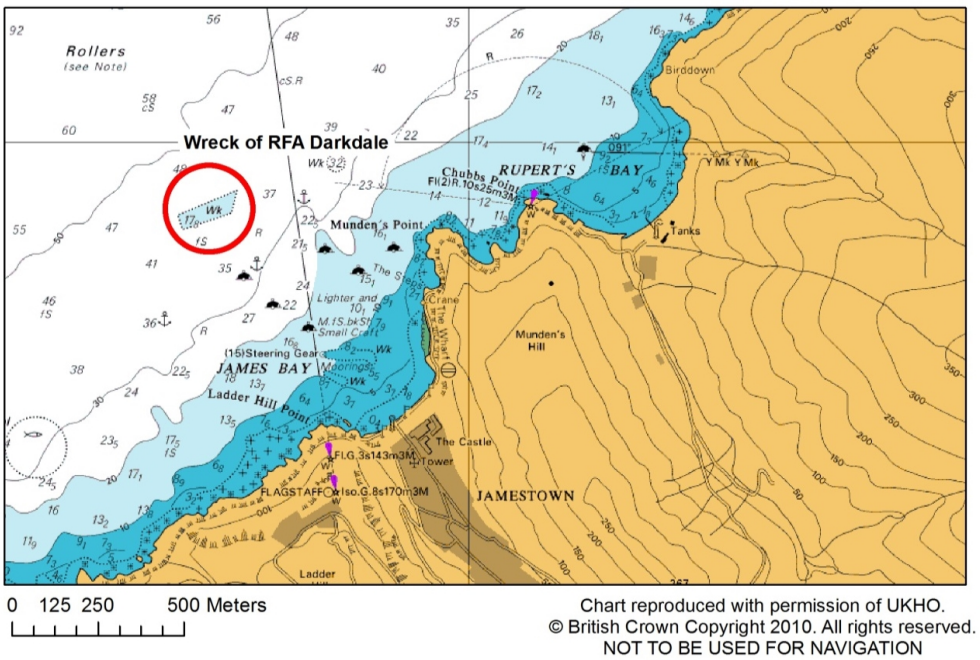


Figure 2 - Location of wreck

St Helena

18. The island lies 1000 nm west of the coast of Africa and 1600 nm from South America. It is a small volcanic island with an area of only 147 square miles and a population of 4000 people.

19. The only way of accessing the island is by ship with a regular mail service running between South Africa, St Helena and Ascension Island. An airport is currently under construction but this is not scheduled to open until 2015.

Political and economic overview

20. St Helena is a British overseas territory, as defined by the British Overseas Territories Act 2002.

21. The Foreign and Commonwealth Office appoint a Governor to the island who is the senior official and head of the Island's Government. His role is to administer the island and he is supported in this role by an executive council consisting of five elected members and three ex-officio members.

22. An ageing population and outwards economic migration has resulted in St Helena being heavily dependent on United Kingdom funding (3). The Department for International Development gave an aid package averaging £23.5m in the period 2009 – 2012. The island's GDP for 2009/10 stood at £15.5m with the public sector employing 44% of the working population (4).

23. The Government white paper on Overseas Territories (3) states that a ten year development plan is being written for the island. This plan will look to develop tourism in the private sector with a view to eventually reducing the amount of aid provided by the UK government.

Climatology and oceanography

24. Climatology and oceanography data is very limited for St Helena; there is a single weather station on the island and sparse observations at sea. For this reason the area can only be generally described and conditions within James Bay interpreted from the data and anecdotal evidence from locals. The UKHO produced an Environmental Brief (5) for St Helena in support of this project.

25. St Helena is an island of volcanic origin that rises from the Mid Atlantic ridge to a maximum height of 823 m. From the coastline, the water depth increases rapidly with depth in excess of 2000 m five miles offshore.

26. In the seas surrounding the island there is little current with typical speeds of less than 0.25 ms^{-1}. The general direction is setting to the North West however in James Bay the current is less consistent.

27. Current monitoring in James Bay was carried out during the survey however this data showed the current to be highly variable in direction and strength with limited correlation to tide. Due to the short term nature of this data set and the lack of any other data, no firm conclusions about the current regime in the bay can be given. The maximum surface current speed observed during the survey was 0.36 ms^{-1}.

28. The island lies 1000 nm south of the equator giving a mild tropical climate with limited seasonal variation in mean daily temperature.

29. The climate is dominated by the SE trade winds which blow year round though mean wind strength does vary across the months.

30. The wreck lies in James Bay to the north of the island so is partly protected from the oceanic swells that the trade winds cause. During December to March, the bay experiences heavier swells locally known as “roller season”.

History of the Wreck

Documentary research

31. Extensive documentary research was carried out in advance of and following the survey of the wreck. A considerable quantity of material relating to the *Darkdale*, the historical context to and circumstances of her loss were reviewed. Copies of key material are included in the annexes.

History of the *RFA Darkdale*

32. As the international situation worsened through the 1930s it became increasingly apparent that the RFA's existing freighting tanker fleet, composed largely of World War One vintage vessels, would be unable to meet the needs of the Royal Navy in any future conflict. Efforts to remedy this situation began in 1937 when the Director of Stores, Sir William Glick, instigated the purchase of six ships from the stocks from the British Tanker Co Ltd. These ships, based on a Shell design, formed the 'A' and 'B' Dale class tankers, they were subsequently joined by two further vessels, forming the 'C' class, purchased from the Anglo Saxon Petroleum Co Ltd.

33. Following the outbreak of World War II, an additional ten vessels were acquired during build from the Ministry of War Transport. These formed the 'D' and 'E' class Dales to which the *Darkdale* belonged. The *Darkdale* herself was launched on 23 July 1940 by the Blythswood Shipbuilding Co Ltd of Glasgow. Originally named *Empire Oil* she was acquired by the Admiralty and renamed *Darkdale* on 15 November 1940.

34. Her active career lasted less than a year. Following trials the ship participated in three convoys (OB 246, BHX 104 and OB 338) (8) and undertook several independent sailings before departing Curacao on 15 July 1941 to take over from the Norwegian tanker *M/T Nyholm* as the Fleet oiler at St Helena (9)

35. The *Darkdale* dropped anchor in James Bay on 4 August 1941. Three days later she carried out her first refuelling operation when the light cruiser *HMS Orion* put in for re-supply. The *Orion*'s log notes that refuelling took place but in common with all of the surviving log books of Royal Navy ships that received oil from the *Darkdale* provides insufficient detail to determine exactly how much was taken on.

36. The seaplane carrier *HMS Albatross* arrived on 21 August. Once again *Albatross*'s log does not state how much fuel she received but it is probable that, besides replenishing her own bunkers, she also took on a quantity of Avgas for the seaplanes she embarked.

37. On the 25 August the Armed Merchant Cruiser *HMS Cilicia* refuelled. The *Darkdale* then replenished the destroyers *HMS Jupiter* on the following day and *HMS Avon Vale* and *HMS Eridge* on the 30 and 31 August respectively.

38. On 17 September the aircraft carrier *HMS Eagle* secured alongside the *Darkdale* to take on oil for her own consumption and, presumably, Avgas for her air complement. *Eagle* was at that time engaged in hunting German supply ships and merchant raiders with the heavy cruiser *HMS Dorsetshire* which anchored nearby. On the following day the *Dorsetshire* herself refuelled to be followed on 23 September by the destroyer *HMS Encounter* and the sloop *HMIS Sutlej*.

39. On 24 September *HMS Repulse* arrived in James Bay. The battlecruiser was at that time escorting a troop convoy around the Cape of Good Hope.

40. By the end of this period, *Darkdale* had refuelled eleven Royal Navy ships including a battlecruiser, aircraft carrier and heavy cruiser and without urgent replenishment of her tanks would be unable to continue in her role.

41. The Norwegian tanker *M/T Egerø* arrived to resupply the *Darkdale*. On 25 September the *Egerø* supplied the *Darkdale* with fuel and provided further fuel to the ship the following day. *HMS Eagle* and *HMS Dorsetshire* reappeared on the 26 with only *Eagle* taking bunkers. After the departure of the two warships the *Egerø* carried out a third refuelling of the *Darkdale* before herself sailing from St Helena.

42. The *Egerø* resupply is highly relevant to an analysis of the wreck of the *Darkdale* and, more particularly, to the assessment of how much oil is likely to remain aboard. The *Egerø*'s log does not directly state how much oil was provided to the *Darkdale* but it does provide details of how much fuel she took on prior to sailing for her rendezvous with her and how much she loaded at her own next fuelling stop upon leaving St Helena. Crucially, the log makes it clear that the only ship that the *Egerø* resupplied between these two episodes was the *Darkdale*. On 23 August the *Egerø* loaded 11095 tons at Abadan prior to sailing to Table Bay and then onto St Helena taking her to near full capacity. After leaving St Helena, and following a brief stop at Cape Town, the *Egerø* took on approximately 8000 tons of diesel, 2200 tons of bunker oil and 8 casks with lubricating oil at Abadan on 30 October. It is probable therefore that the *Egerø* provided the *Darkdale* with somewhere in the region of 8000 tons of oil during the three refuelling operations.

43. Based on the above, it is likely that that the *Egerø* left the *Darkdale* with nearly full tanks. After her departure only three Royal Navy ships visited St Helena before the *Darkdale* was sunk, all on 14 October. On that day, the Dido class light cruiser *HMS Euryalus* arrived and according to the Harbour Master's log took on oil from the *Darkdale*. However, the log of *Euryalus*, while noting her arrival in James Bay, makes no mention of the ship receiving any oil. This is not believed to be an oversight as an earlier entry in the ship's log contains detailed information of a refuelling operation undertaken on 8 October while *Euryalus* was at Sierra Leone. However, *Euryalus* was operating in company with the Hunt class destroyers *HMS Heythrop* and *HMS Farndale* and the Harbour Master records that both of these ships took on oil from the *Darkdale*. Although the logs from these vessels have not been preserved, a plausible explanation is that, while all three ships arrived at James Bay in company, only the two smaller vessels topped up their tanks. The Hunt class were small escort

destroyers of approximately 1000 ton displacement. The amount of oil that these vessels took on, the last to do so before the *Darkdale* was sank, is likely to have been comparatively small. As a consequence the oiler's tanks remained near full when *U-68* surfaced to attack in the early hours of 22 October.

The Attack

44. *U-68* departed Lorient on 11 September 1941 on a patrol of one hundred and six days that would result in the sinking of the *Darkdale* and three other ships (10).

45. In the early hours of 21 October the submerged submarine approached St Helena to reconnoitre the shipping in James Bay by periscope. The submarine's Commander, KorvettenKapitän Karl-Friedrich Merten, was able to conduct a detailed inspection of the unsuspecting tanker which lay approximately 600m from the land swinging on a heading of between 130-180°.

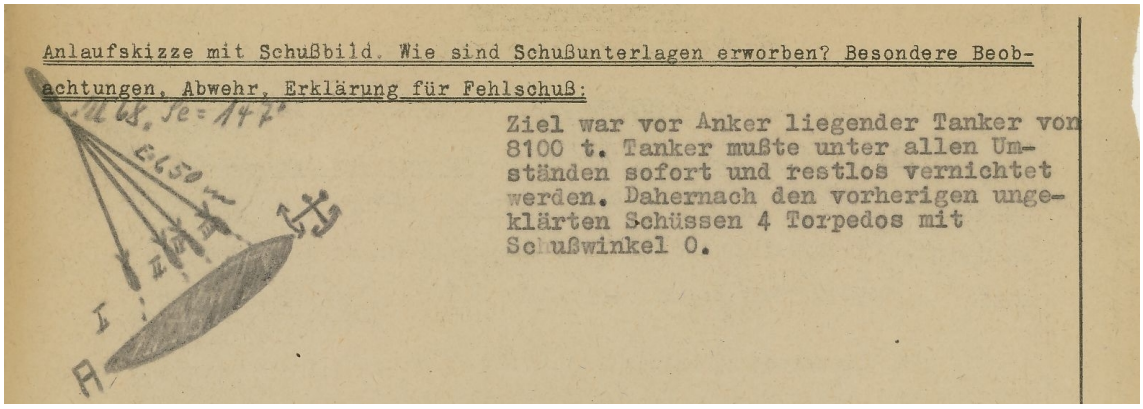
46. The entry in the U-68 log (9) confirms the belief that the *Darkdale*, after refuelling from the *Egerø*, had a considerable amount of oil aboard *"Full of fuel, only at the bow can one see something of the waterline colour. [I] intend to blow it up this night, since by doing so there is the possibility of diverting suspicion to armed merchant men."* (9)

47. In addition, careful note was taken of the recently augmented harbour defences. Merten had been in Jamestown in 1927 and so, as the entry in *U-68*'s log states, was well placed to detect any changes to the harbour. Two years into the war the defences of James Town were substantial, Merten noted the presence of a battery of 6 inch guns overlooking the *Darkdale* on Mundens Point supported by two nearby searchlights and a battery of smaller calibre guns on High Knoll. To these defences could be added the *Darkdale*'s own armament meaning that any attack on the tanker would be a hazardous undertaking. Having completed the reconnaissance *U-68* withdrew to await nightfall.

48. The 21 October seemingly passed without incident for the *Darkdale*. A portion of the crew had gone ashore and though most returned to the ship during the evening a number, including the ship's Captain Thomas H Card, her Chief Engineer and several men recovering from various complaints in the island's hospital, remained on St Helena as *U-68* began her run in to James Bay.

49. The conditions for the attack were, from Merten's point of view, not ideal. Although the moderate swell and reasonable visibility aided the approach to the target the night was clear and starlit and risked revealing the surfaced U-Boat. After spending time manoeuvring into position *U-68* eventually lined up on the *Darkdale*'s port side. The log makes it clear why the following moments were so brutal. Merten was faced with a difficult situation. His approach to the target under clear skies had left him exposed to the nearby gun and searchlight batteries, and believing he would be spotted at any moment he resolved to attack the tanker with overwhelming force to ensure a kill and, presumably, to provide cover to his escape in the subsequent confusion.

50. At 00:43 local time and at a range of 500 m *U-68* fired four torpedoes before veering off hard to starboard and increasing speed to make her getaway. Throughout the attack and during her escape the submarine remained surfaced.


Anlaufskizze mit Schußbild. Wie sind Schußunterlagen erworben? Besondere Beobachtungen, Abwehr, Erklärung für Fehlschuß:

Ziel war vor Anker liegender Tanker von 8100 t. Tanker mußte unter allen Umständen sofort und restlos vernichtet werden. Dahernach den vorherigen ungeklärten Schüssen 4 Torpedos mit Schußwinkel 0.

Figure 3 - Extract from *U-68* Torpedo log

51. Thirty two seconds after firing the torpedoes the log records that all four hit the *Darkdale* at intervals of one to two seconds. The entry notes that the first hit the aft section of the tanker followed by the second impacting the *Darkdale*'s mid-ships, the third hitting the forward third and the fourth striking again in the mid-ships area. As analysis of the wreck of the *Darkdale* now makes clear, the third torpedo did not strike the forward third of the ship but in the conflagration resulting from the impact of the remaining three torpedoes the mistake is easy to explain. .

52. The Harbour Master provides the most detailed account of the aftermath of the attack in a report written the following day. He initially heard three explosions and saw the *Darkdale* "…enveloped in flame from bow to stern" before heading to the landing steps to assist in the attempt to rescue the ship's crew. About ten minutes after the initial explosion the *Darkdale*'s Captain and Chief Engineer arrived at the steps to aid the rescue. Despite the best efforts of all involved, only two gunners who were on the *Darkdale*'s deck at the time of the attack were saved having been blown into the sea by the force of the explosions. The Harbour Master's report mentions a night watchman who witnessed the tanker turning over following the second and third explosions and states that fires continued to blaze until the ship sank at 03:30 leaving the bow projecting out of the water.

53. Captain Card's report is dated 15 January 1942, nearly three months after the sinking. In it he states that there "…were two loud explosions on the port side of my ship." It is not certain that he actually witnessed these explosions but he makes the interesting statement that having arrived at the wharf and taken a launch to assist in the rescue "…the ship was now burning from end to end with the sea round about also on fire." Both the Harbour Master and the Captain therefore seem to agree that the *Darkdale*, though apparently on its side, was still intact ("…bow to stern" and "end to end") at least ten minutes after the torpedoes struck. Card further notes that by 04:00 "… two-thirds of the fore part of the ship was still above water and the after part was completely submerged" before adding that at around "…05:30 the *Darkdale* blew up

and sank within five minutes." Although there is disagreement between Card and the Harbour Master on the timings, the actual breaking in two of the ship may not have occurred on the initial impact of the torpedoes but on the final explosion, some five hours after she was struck.

54. The attack resulted in the loss of significant amounts of oil from the ship. Although the amount is difficult to quantify it was sufficient to leave the water around the wreck burning for several hours after the attack.

Figure 4 - Bow section shortly after sinking. (Picture courtesy of St. Helena Museum)

The Aftermath

55. In the days following the attack, a Court of Enquiry was convened on St Helena to determine the cause of the ships loss. This report could not been traced, but the findings are referred to in the survivors report subsequently submitted by Captain Card. At least two military personnel had glimpsed the submarine on the surface during the attack but their evidence was discounted and it seems the Court concluded the loss of the ship was the result of an accident.

56. The wreck remained undisturbed for two weeks. Lying in shallow water with the bow section protruding above the surface, the remains posed a significant hazard to other shipping and on 2 November the sloop *HMS Milford* arrived at St Helena carrying divers to level the wreck and, presumably, to determine what had caused the *Darkdale* to sink. The ULTRA decrypts had quickly revealed to the Admiralty that a U Boat was

the culprit but it is questionable how far down the chain of command this information had been disseminated.

57. The diver survey therefore may well have provided the British with a useful, and non-sensitive, means of pinning the attack on a submarine. The report likely to have been produced by the divers has not been sourced. However, it appears they found the bow section of the *Darkdale* in much the same position as that shown in the photograph in Figure 4. *HMS Milford* departed St Helena on 13 November.

58. The *Darkdale* was not the last RFA tanker to refuel Royal Navy ships at St Helena but after her loss the Harbour Master's log suggests they operated far more cautiously. *RFA Rapidol* arrived on 3 February 1942 and, in contrast to earlier fleet refuelling tankers which had been stationed on the island for months at a time, refuelled three ships before departing the following day. *RFA Abbeydale* arrived on 5 March and, staying for slightly longer, refuelled two ships before departing on 13 March. In line with the heightened threat of attack, the ships left James Bay each night to return the following morning.

Initial estimate of oil remaining onboard

59. Using the plans located during the documentary research, a computer model of the *Darkdale* was generated to allow tank capacities to be generated.

60. Using tank capacities and the historical information on the vessels that replenished from *Darkdale* and the refuelling of her by *Egerø*, an estimate of fuel remaining onboard was generated. This estimate is shown below.

Date	**Vessel**	**Estimated Quantity (M3)**	**FO ROB *Darkdale***	**Ship disp.**	
			14000		Based on all tanks being 90% on departure load port
07 August 1941	*HMS Orion*	700	13300	7215	
21 August 1941	*HMS Albatross*	400	12900	4000	
25 August 1941	*HMS Cilicia*	100	12800	no ship of this name located	
26 August 1941	*HMS Jupiter*	150	12650	1690	
30 August 1941	*HMS Avon Vale*	100	12550	1340	
31 August 1941	*HMS Eridge*	100	12450	1340	
17 September 1941	*HMS Eagle*	2000	10450	22790	
18 September 1941	*HMS Dorsetshire*	250	10200	9975	
23 September 1941	*HMIS Sutlej*	100	10100	1250	
24 September 1941	*HMS Repulse*	2000	8100	26500	
24 September 1941	*Egero*		8100		Resupply figure included in 28th Sept figure
25 September 1941	*HMS Encounter*	100	8000	1375	
26 September 1941	*Egero*		8000		Resupply figure included in 28th Sept figure
26 September 1941	*HMS Dorsetshire*	250	7750	9975	
27 September 1941	*HMS Eagle*	500	7250	22790	Resupplied 10 days previous, unlikley to have taken large fuel load

28 September 1941	*Egero*	-8000	15250		Times for *Egero* loading not fully noted in log book however loading figures before and after *Darkdale* resupply indicate a ship to ship transfer of at least 8000t
14 October 1941	*HMS Euryalus*	250	15000	12000	No mention in the ships log of taking fuel however it is unlikely the vessel would miss the opportunity to refuel
14 October 1941	*HMS Heythrop*	100	14900	1340	
14 October 1941	*HMS Farndale*	100	14800	1340	

Total pre attack	**14800**		
Loss due to torpedo attack	4500		Based on a total of 9 tanks being open to the sea
ROB sunk	10300		
Estimated leakage rate per year	36.5		Estimated on 100L per day over entire period. Current leakage rate is probably higher but there was a period when the ship leaked little oil
Leakage since sinking	2555		
Remaining onboard 2011	**7745**		

Table 1 - Estimate of Fuel remaining onboard

History of oil spills

61. The *Darkdale* released a large quantity of oil at the time of sinking. Contemporary accounts report that the oil caught fire engulfing the *Darkdale* and lighting up the entire bay area. This fire raged for several hours before finally burning out.

62. Since the time of the fire going out, the wreck has always leaked. Anecdotal accounts suggest that the rate of leakage was high immediately following the loss of the ship then reducing over a period of years to minimal leakage in the 1950's.

63. The wreck then leaked very little for a period of 20 years before the rate of leakage gradually increased to its current rate.

64. The leakage from *Darkdale* is not at a constant rate and is affected by weather conditions. In 2006 and 2010, during storms, the wreck gave out larger quantities of oil than normal, most likely due to the effect of the water movement and pressure changes induced by the swell above.

65. The Ministry of Defence was not informed of the 2006 leak and no detailed information on the extent of the spill or likely quantity is available. However from discussions with local residents, it would appear that this leak was of a similar scale to the 2010 leak.

66. In late February 2010 St Helena experienced exceptionally bad weather with heavy swells and high winds in James Bay. The master of the *RMS St Helena* described the conditions (12) in the bay as the worst he had seen, anecdotally putting this storm in the category of a 50 year storm.

67. Following the storm a large quantity of oil was seen on the surface. The MOD was notified on the 5th March 2010 (13). Unfortunately due to the remote location and time required to reach the island, no representative of the MOD was able to observe the oil spill. The local government assisted in assessing the spill by providing observations and photographs in the days that followed the leak. The spill extent was measured and photographed using a fishing boat and observations from the cliffs above.

68. The main drift of the spill was to the north west away from the land and moored boats in the bay however some of the oil did come in to the bay and was reported as close as 200 m from the wharf. No oil was found to have beached during this spill.

69. The oil was seen to make a sheen and act like a light low viscosity oil. No emulsification was reported with the oil apparently weathering mainly by dispersion and evaporation. The rough seas reported at the time of the leak will have assisted in the weathering of the oil, speeding up the natural processes.

70. There were no reports made of any dead fish, oiled seabirds or mammals following the spill.

71. A sample of the oil was taken from the sea surface and sent to a laboratory for gas chromatograph/mass spectrometry analysis (14). The samples showed:

a. The oil to be similar to an Iranian light crude oil that had undergone some marine weathering (approx. 1 day)

b. The oil was not a fully refined product, having undergone a small amount of refining only.

c. It has not been thermally cracked like modern fuel oil.

d. The Asphaltene content was approximately 1% indicating that the oil may form stable emulsions in water.

72. The quantity of oil released can be approximately calculated using the Bonn Agreement procedure (15) as follows:

Size of spill		
length	3	km
width	0.4	km
Area	1.2	km^2
Percentage of area covered	100	%
Overall area covered	1.2	km^2

			Thickness band (µm)	
Appearance coverage allocation			min	max
Code 1 (sheen)	98	%	0.04	0.3
Code 2 (Rainbow)	2	%	0.3	5
Code 3 (Metallic)	0	%	5	50
Code 4 (True colour)	0	%	200	

Minimum volume calculation		
Code 1 (sheen)	4.704	m^3
Code 2 (Rainbow)	0.72	m^3
Code 3 (Metallic)	0	m^3
Code 4 (True colour)	0	m^3
Total	5.424	m^3

Maximum volume calculation		
Code 1 (sheen)	35.28	m^3
Code 2 (Rainbow)	12	m^3
Code 3 (Metallic)	0	m^3
Code 4 (True colour)	0	m^3
Total	47.28	m^3

73. From the calculations above the minimum size of spill was 5.4 m^3 and the maximum size was 47.3 m^3. The photographs and information provided do not support the size of the spill being at the upper end of this range. The 1.2 km^2 spread area is after a period of days has elapsed since the release, in this time the oil will have spread

out rapidly to form a very thin layer. Given the timescale, if the release was at the upper end of the range, it is likely that the area affected would have been much larger.

74. It is most likely that the quantity of oil released in the 2010 spill was less than 10 m^3.

Figure 5 - James Bay, *8th March 2010*

75. The Figure 5 shows the extent of the oil spill one week after the storm that caused the release. The oil can be seen to be dispersed in to bands but still covering a significant area including most of the bay.

76. Following the 2010 spill, the MOD has not been made aware of any economic loss directly caused by this spill; no action has been taken against the MOD.

77. Regular monitoring of the spill has taken place since the 2010 spill with reports being sent from the Harbour Master to the MoD on a fortnightly basis. The island is not equipped to be able to accurately quantify the amount of oil released however a general trend has emerged:

a. The *Darkdale* continues to leak at a slow rate.

b. The size of the leakage is not sufficient to create a large or persistent slick.

c. The leakage rate does vary but is normally low magnitude; sufficient for there to be a smell of diesel in the area close to the wreck site but not large enough to form a significant slick.

Survey Methodology

Initial Research

78. Following the initial report of the leak by the St Helena Government in 2010, and the research detailed above, a detailed risk assessment (16) was carried out.

79. The risk assessment identified the risk as “Intolerable” meaning a survey operation was required (see annex 1 for definitions).

Survey aims

80. The principal objective for the operation was to gain a full understanding of the wreck and its current and potential impact on the island’s ecosystem.

81. The project aims can be divided in to three areas:

a. To fully survey the wreck of the St Helena and understand how much oil may be remaining onboard the wreck.

b. To carry out an environmental survey to understand the impacts the chronic leakage of oil has already had and the potential impact of a catastrophic leak of oil.

c. To survey the bay for unexploded ordinance

Environmental Survey

82. The survey was divided in to two parts; the wreck survey and the environmental survey. The MoD does not have the in house expertise to carry out a marine environmental survey of this nature therefore following a competitive tendering process, RPS Consulting was appointed to provide expert environmental advice. The survey equipment and methodology for the environmental survey is detailed in a separate report published by RPS and annexed to this report (17).

Equipment and logistics

83. Due to budgetary constraints and the availability of vessels locally, the survey was designed to be a light weight operation. All equipment was packed in to a shipping container and sent to St Helena via the mail ship the *RMS St Helena*.

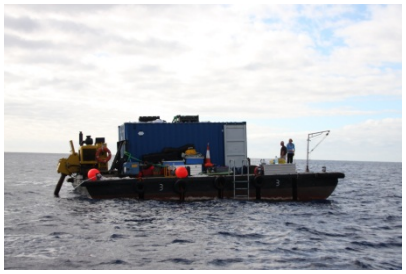
84. The survey was carried out using two local boats and a barge. The boats were normally used for recreational fishing and diving trips and were not fitted with A frames or cranes so deployment of heavy equipment was not possible.

85. The barge was provided by Solomon’s Shipping and was customarily used for discharging cargo from the mail ship. The barge provided a flat area to carry out

Remotely Operated Vehicle (ROV) operations from and was the largest vessel available locally.

86. The survey was carried out using the following equipment:

a. Solomon Shipping barge



The Solomon shipping barge was used as the ROV platform for the wreck survey. It was moored on a four point pattern to give a stable position and to allow the barge to be moved easily to the required position over the wreck. A container was positioned on the deck to provide an area to work out of direct sunlight and security for more expensive equipment.

b. Sea horse

Sea horse was used as the environmental science boat due to being fitted with a winch on the starboard side.

c. Starlight

Starlight was used in support of the wreck survey to carry out side scan survey and assist in positioning the barge. It was also used to collect fish samples from the wreck area.

d. Leica GS10 RTK system

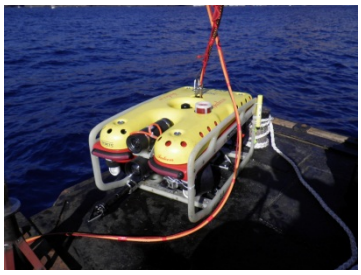
There is no Differential GPS station in St Helena therefore a Real time Kinematic (RTK) system was used to provide accurate and stable positioning.

e. C Max CM2 Side scan.

This is a digital side scan system equipped with a LF/MF and MF/HF fish with frequencies user selectable between 100 KHz and 780 KHz.

The side scan was deployed from Starlight using a purpose made A frame through the stern gate.

f. Seaeye Falcon ROV



The Seaeye Falcon was the primary survey vehicle. The ROV was fitted with a black and white low light camera and a colour camera both fitted to a tilt unit. The video feed was recorded on to Data Video hard disc recorders. In addition a Go Pro Hero2HD camera was fitted as a backup and to provide HD footage of the wreck.

A single function manipulator was fitted to take samples, which was interchanged with the thickness gauge when required.

g. Seabotix LBV 150

Two Seabotix LBVs were included in the survey to act as a backup to the Falcon but also because their small size makes them more suitable for penetrating the inside of the wreck.

h. ACSA Gib Lite System

This system was the primary means of tracking the ROVs during the survey.

The Gib Lite system is an array of 4 buoys laid to provide good acoustic coverage of the wreck site. The buoys are fitted with GPS and hydrophones that transmit data back to a base station mounted on the barge.

The system allows for the position of the ROV to be accurately tracked and relative measurements can be taken on the hull of the wreck by using a reference beacon positioned on the wreck.

The Gib System provided an output to the Arc GIS system so that data could be collected directly on to GIS.

This system was reliable and provided consistent tracking of the ROV but required the buoys to be carefully laid in relation to the work area to avoid acoustic shadowing.

i. Sonardyne Scout USBL

The USBL system was used as a backup for positioning the ROV on the wreck. The transducer head was mounted on a rigid pole on a pivot welded to the side of the barge. In the lowered position, the transducer was approximately 3m below the hull of the barge.

The system performed well if line of sight was maintained between transducer and vehicle however on the wreck site this was not always possible.

j. Tritex Multi Gauge 4000 Ultrasonic thickness gauge

A Tritex thickness gauge was used to take measurements of hull thickness. The gauge transmits data to a laptop on the surface to allow the surveyor to record location and thickness reading.

The ROV was fitted with a rotary cleaning brush to allow selected locations to be cleaned prior to thickness readings been taken.

87. An initial side scan survey of the wreck site was carried out to accurately locate the wreck. The survey was carried out using the C Max side scan system with positioning provided by RTK GPS

88. With the position of the wreck accurately established, a 4 point mooring system was set to enable the barge to be positioned over the wreck and held accurately in position. Each mooring consisted of a Bruce anchor, 50 m of chain and 200 m of multi-plait rope. The holding ground was found to be excellent and no mooring had to be reset due to dragging during the survey.

89. The survey work was commenced by the ROV carrying out a first fly through of the wreck to establish the nature and layout of the site and identify significant snag hazards for the ROV. This was followed by a detailed video survey of the wreck starting from the bow and working methodically aft. All video was recorded and significant features were marked on paper A0 copies of the ships plans.

90. Once the video survey had been completed, the ROV was then used to carry out thickness readings of the bow section of the hull. No readings were taken on the stern section due to the lack of oil tight integrity.

91. The ROV was used to position a “top hat” over the leak site identified during the survey to allow a sample to be taken and the leakage rate estimated.

92. The survey concluded with video transect lines to investigate the area surrounding the wreck site for debris identification, unexploded ordinance detection and seabed typing for the environmental scientists.

93. The survey methodology for the environmental science study is covered in a separate report by RPS (17)

Timeline

April 2012

27	Team board the *RMS St Helena* in Ascension Island
29	Team arrive in St Helena
30	Mobilisation of equipment and meetings with local Government, initial side scan survey

May 2012

1	Commence ROV survey of the wreck – mooring pattern laid, initial survey of wreck site.
2 & 3	Detailed survey of bow section.
4	Detailed survey of stern section.
5	Oil sampling and survey of the break area
6	Thickness readings
7th	Internal survey of 1 & 3 Cargo tanks
8	Transects of surrounding area, investigations of targets
9	Detailed side scan survey of the bay. Collection of samples for science team
10	Revisit areas of particular interest. Additional transects for Science team.
11	Demobilise. Post survey meeting with local Government
14	Team depart St Helena

Survey Findings

Survey conditions

94. On most days during the survey, no bottom current was observed over the wreck. Occasionally slight bottom current was experienced and seen to vary in rate and direction and was independent of tide. The rate of current was not measured over the wreck but is estimated to be less than 0.5 knots generally but reaching 1 knot in the region of the stern as the water accelerated around the structure at this point. The bottom current typically disappeared after a few hours.

95. The visibility in the water was excellent at all times during the survey, typically in excess of 30 m. At all times during the survey, the wreck was brightly illuminated by natural light; ROV lights were rarely used. The course sand seabed meant that any seabed disturbance by the ROV quickly dissipated to return excellent visibility.

96. The wreck is heavily populated by fish, especially in the region of the break, the density of fish at times obscured the wreck.

97. The wreck is regularly used by recreation divers and fishermen. Due to this activity there is some debris on the wreck and in the surrounding area including clump weights, shot line and mono filament fishing line that has become tangled in the wreck. The presence of these hazards hampered ROV operations in some areas.

General area

98. The depth in the bay increases gradually from the shoreline to the site of the wreck at 42 m to 45 m. Beyond the wreck the water slowly gets deeper until the shelf break, approximately 1000 m beyond the wreck.

99. The sea bed in the area of the wreck is coarse sand with very little texture and no notable sand waves.

100. There is no notable sedimentation in the area of the wreck; historic items that clearly predate the RFA *Darkdale* were observed to be sitting proud of the seabed with no burial or sediment build up.

Overview of the wreck site

101. The wreck lies in two parts, the parts separated by only 6 m. The bow section lies heading 035˚ the stern section lies heading 056˚.

102. The wreck is covered in light concretion and minimal marine growth.

Figure 6 - Bow showing typical degree of marine growth

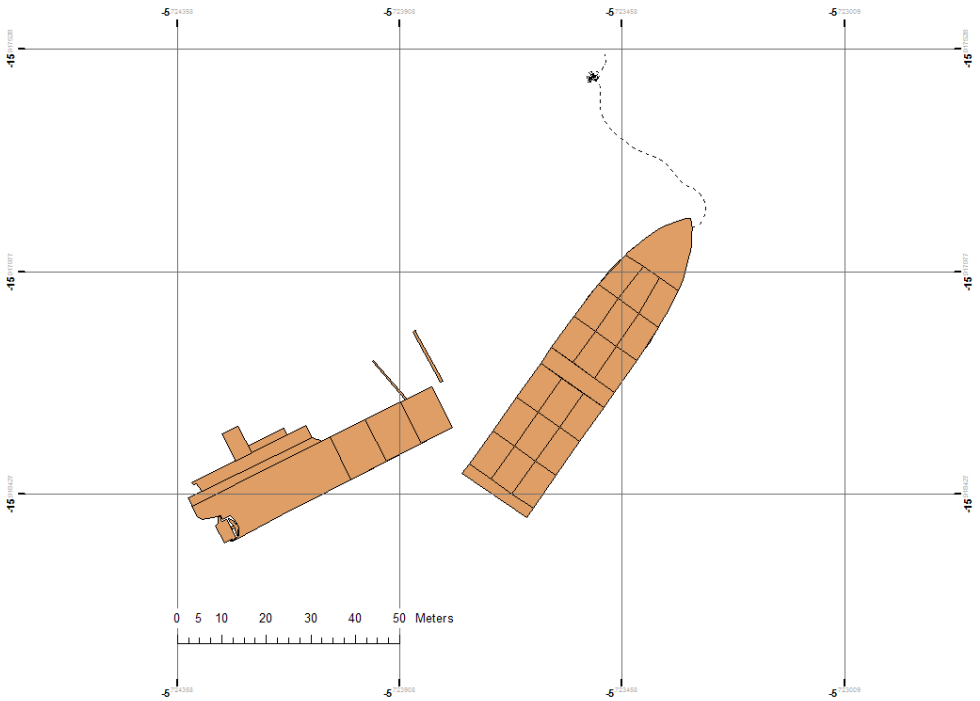


Figure 7 - Layout of the wreck site

Bow Section

103. The bow section is 75 m long and lies inverted, flush to the sea bed. It sits approximately 5 degrees from vertical to starboard (north) with no noticeable torsion, hog or sag.

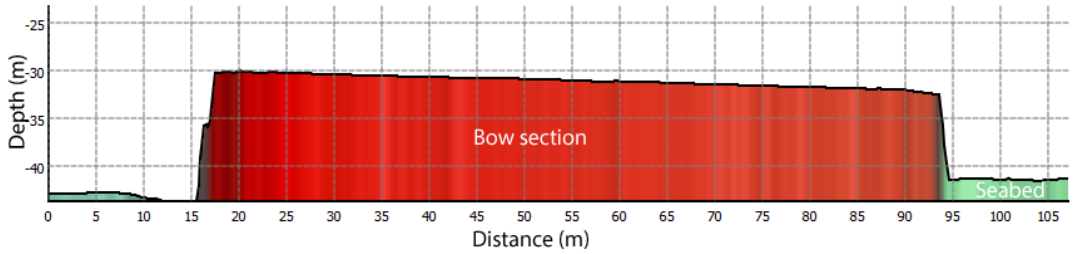


Figure 8 – Longitudinal slice through bow section (bow on left of image, break on right)

104. The bow section is trimmed 2 m by the stern, the shallowest point of the bow section being at 30 m deep. The trim appears to be caused by the shape of the foc's'le as there is no burial or settlement evident towards the aft end of this section. It appears that the Bridge and accommodation structure is crushed or missing and provides no support to the aft end of this section.

105. The bow section is in excellent condition for a ship of this submerged age. The shell plating is all intact with the exception of the plating in the region of the forward paint locker. This plating has fallen to the sea bed though the exposed frames are still in good condition.

106. The riveting generally appears to be tight but localised corrosion in the plate steel around the rivets is evident. Corrosion of rivets is not uniform with the steel surrounding some of the rivets being more corroded than others. No perforation in way of the steel surrounding the rivets was found on the bow section.

107. The plate joints are in such condition that they will provide a water/oil tight boundary to any contents contained within the tanks.

108. A light layer of concretion covers the hull but there is minimal marine growth or colonisation by sessile organisms. The concretion is approximately 1 cm in thickness.

109. There is some scour around the bow of the wreck with the bow sitting in a depression approximately 1 m deep. The area of scour extends in a horse shoe shape around the bow region, stretching back to 10 m aft.

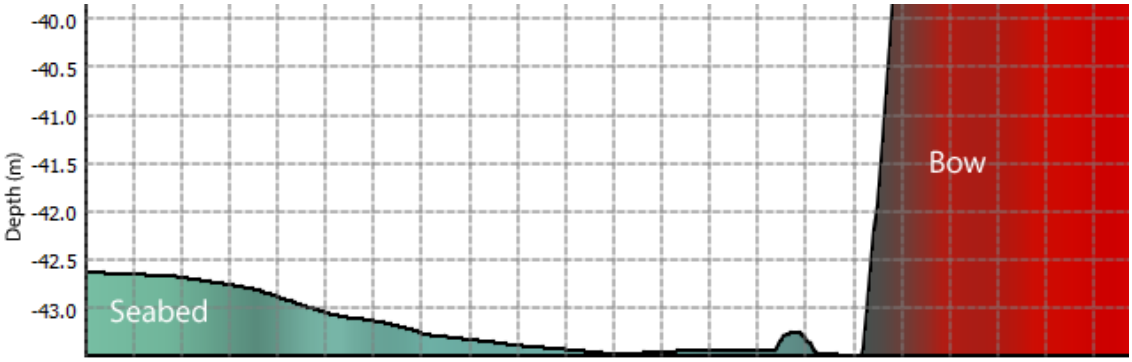


Figure 9 – Longitudinal section through bow area showing scour

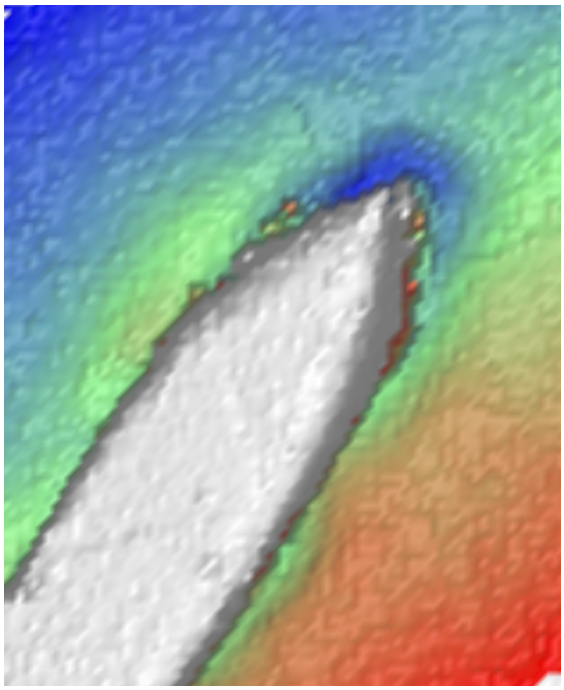


Figure 10 – Multibeam sonar image showing scour in region of the bow

Anchor and chain

110. The vessel was lying to her starboard anchor at the time of the attack.

111. The stockless anchor and chain leads north of the vessel, and is clearly visible on the sea bed with no burial. The stud link chain runs for approximately 50 m from the vessel to a large pile of chain, then a further 10 m to the anchor. The stockless anchor has not dug in or buried.

112. The chain and anchor are both in good condition with minimal marine growth and light concretion/corrosion.

113. Close to the anchor chain are four 205 litre drums, all holed, these are likely to have been lubricating oil drums carried as deck cargo on the *Darkdale*.

114. The chain runs to the bow of the ship but is no longer connected to the vessel. The hawse pipe lies detached from the wreck, 1m from the portside of the bow. It is unclear what has caused this to become detached.

Figure 11 - Anchor

Stem to No.9 Cargo tank

115. As described above, there is scour around the stem area with the deck of the foc's'le lying flush to seabed. The deck machinery is embedded in the sand.

116. The fine lined bow rises from the sea bed at 42 m to the top of the wreck at 30 m.

117. In the area of frame 90F to 77F, the shell plating on both sides of the bow has fallen away leaving the frames exposed and allowing a clear view in to the spaces behind. The spaces are the Paint room and Decontamination store. All contents of these spaces have gone leaving only an open space. This is the only area of the bow section where plating is missing or has perforated, in all other areas the plating is intact and with minor exceptions, undistorted.

118. The plating of the Potato Store is still in place though the structure has partly collapsed/embedded in the sediment as there is a small void beneath the wreck between deck and seabed at the break of the Foc's'le.

119. The Forepeak tank and Deep tank show no signs of perforation or damage and it is believed that these remain water/fuel tight.

120. On the starboard bow, there is no evidence of either the hawse pipe or the starboard anchor. As this area is missing its plating, the hawse pipe could easily be concealed under the pile of plating lying on the seabed below however there is no evidence of the anchor or chain. A possible explanation is that this anchor has either been salvaged since the sinking or was not in place at the time of her loss.

121. To the south of the wreck close to the port bow, there is a small amount of debris, mainly plating and unidentifiable pieces of steel. The debris covers an area 10 m long, extending 5 m from the wreck

Figure 12 - Bow showing missing plating

Cargo tank No. 9

122. All of the shell plating of this tank is intact with no perforations or noticeable distortion. There is no evidence to suggest that the tank is no longer oil tight.

123. The wreck in this region is not fully supported by the seabed. On the north (starboard) side of the wreck, there is a low bank of sediment clear of the wreck, probably displaced when the vessel sank, that leads down to the deck edge. There is a gap of approximately 0.5 m at the break of the foc's'le, decreasing to zero by No. 8 cargo tank.

The handrails are still in place and visible in this area.

124. Above the unsupported area, there is some laminar corrosion, though no cracking was evident.

Figure 13 - Unsupported area, No.9 tank

125. Due to the constraints of surveying with an ROV, it was not possible to obtain a view under this section to the deck to gain an understanding of the condition of the deck.

Cargo tank No. 8

126. All of the shell plating of this tank is intact with no perforations or noticeable distortion. There is no evidence to suggest that the tank is no longer oil tight.

Cargo tank No. 7 and Forward Pump room

127. All of the shell plating of this tank is intact with no perforations or noticeable distortion.

128. The bilge keel starts to run aft from this tank. After a few metres, the starboard bilge keel detaches from the hull and over hangs the side of the wreck. It is known that at various times, the mail ship *RMS St Helena* that supplies the island has either had her anchor snag on the wreck or had her anchor chain run across the wreck. It is likely that this damage is caused by such an event. The *RMS St Helena* is not the only vessel to have anchored in the bay and it is likely that other vessels may also have had their anchors snag on the wreck.

129. At the deck edge, on the port side, the shell plating is distorted. The distortion extends from frame 39F through the pump room and in to No. 6 tank at frame 26F. The shell plating is bent outwards away from the frames from deck edge to about 0.5 m below deck edge.

130. The distortion may be sufficient to affect the oil tight integrity of tank No.7 Port; the Centre and Starboard tanks are unaffected and there is no evidence that they are no longer oil tight.

Cargo tank No. 6

131. All of the shell plating of this tank is intact with no perforations or noticeable distortion. There is no evidence to suggest that the tank is no longer oil tight.

132. On the centreline of the tank, close to midships of the up turned hull, there is a corroded rigging sheave. This has probably come from the replenishment rig.

133. An intake is situated to port of midships, in line with the pump room space. The grating for the intake is still in place but has a heavier layer of concretion & marine growth than the surrounding shell plating.

Cargo tank No. 5

134. All of the shell plating of this tank is intact with no perforations or noticeable distortion. There is no evidence to suggest that the tank is no longer oil tight.

Cargo tank No. 4

135. The aft bulkhead of No. 4 tank is the location of the break of the hull. The bulkhead is partially intact but the tanks are no longer oil tight.

136. The shell plating on the keel is intact to the bulkhead and extends beyond the bulkhead by 2 – 3 m; the keel plating break has occurred at the rivet lines.

137. Due to a large number of recreational diver's shot lines and entangled fishing lines, ROV survey of this area was extremely difficult and a full detailed survey could not be carried out.

138. Port and centre tanks are open to the sea but part of the bulkhead still remains. In 2002 a recreation dive team accessed this space and found oil trapped, using a stick they measured the depth of this oil to be approximately 0.5 m. The divers were interviewed but could not confirm which tank they found this in, but the most likely tank is No. 4 Port.

An oil depth of 0.5 m in this space gives a potential volume of oil trapped as circa 25 m^3.

139. The starboard tank is thought to be open to the sea however the full extent of the damage to the bulkhead could not be examined due to the high risk of the ROV being entangled.

140. If oil is trapped in the port tank, it is probable that oil will also be trapped in the centre and starboard tanks. Combined there could be 100 m^3 of oil within this space.

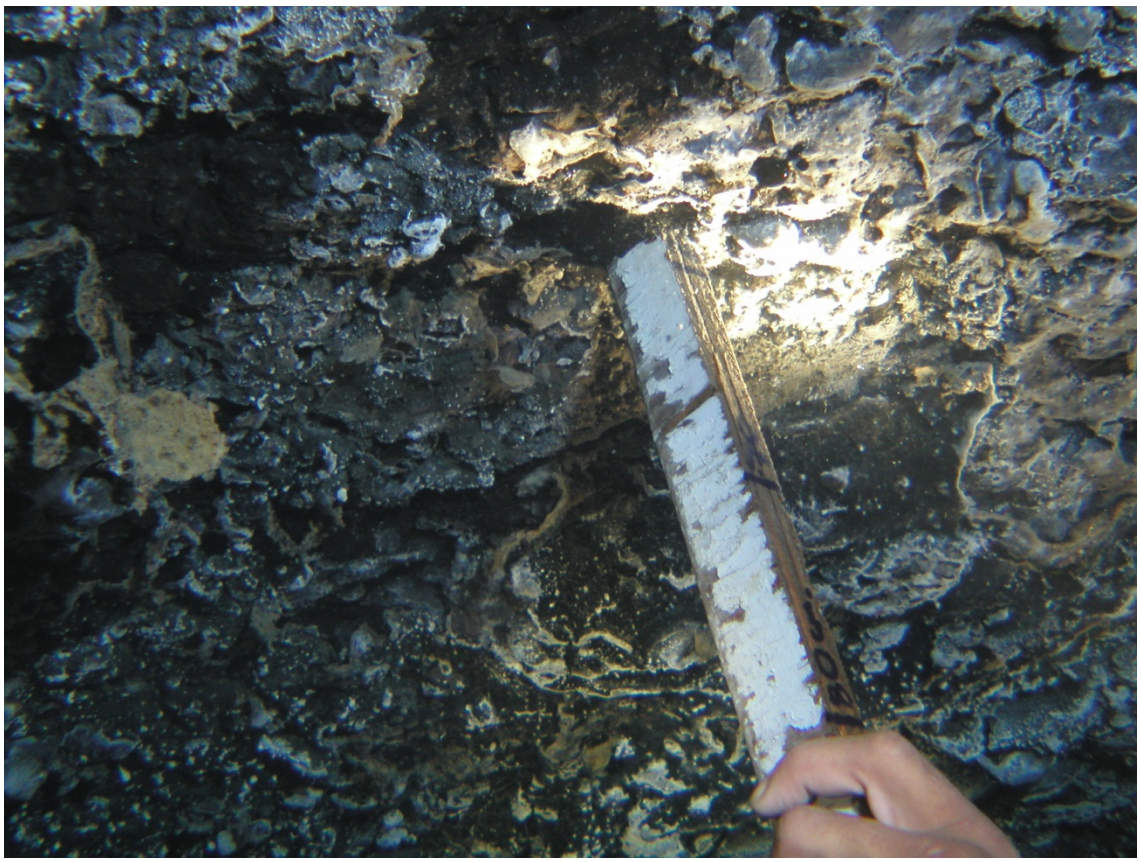


Figure 14 – Divers picture of oil inside No. 4 tank

Bridge and Officer's accommodation

141. The Bridge and Officer's accommodation was constructed over cargo tanks No. 5 and 6. It was constructed from thin steel as it did not require great structural strength like the hull; it was an accommodation area only.

142. The hull in this area sits with the deck flush to the seabed. As the figure below shows, if the accommodation was still to be in place, it would have to extend in to the seabed a considerable distance. This is not believed to be the case.

143. As described earlier, following the loss, a dive team carried out some work to sink the bow section and reduce the hazard to other shipping. It is likely that the accommodation block was destroyed as part of this work. The remaining steel work will have buckled under the load of the hull above with a small amount of burial in the seabed.

144. It is possible that the steel from the accommodation block could have penetrated the deck above. Whilst this would breach the tank, the bouyancy of the oil contained within would prevent its escape, keeping it trapped in the envelope of the hull above.

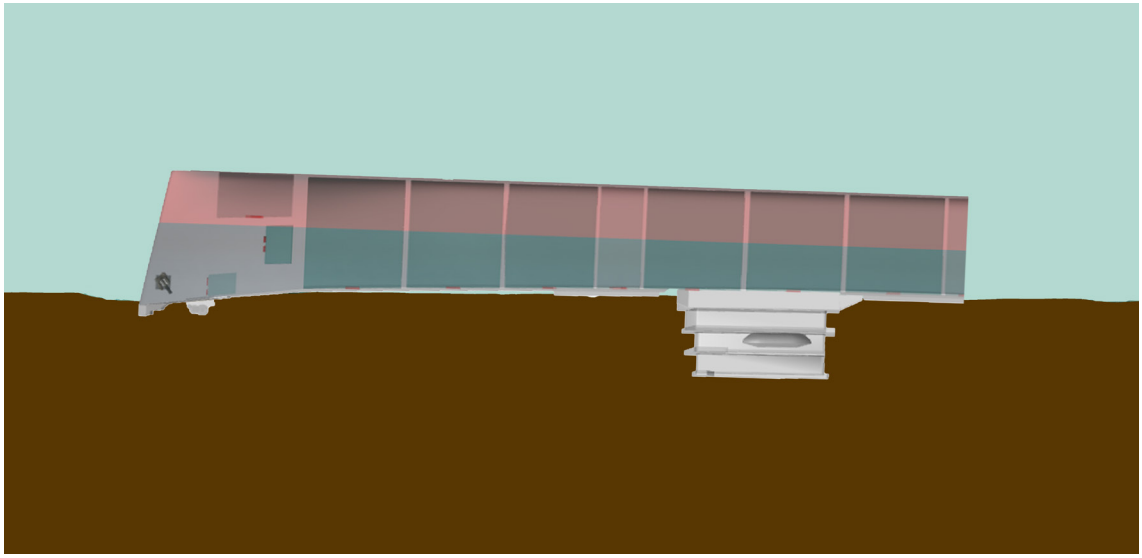


Figure 15 – Bow section upturned showing where the Bridge and accommodation would have been.

145. On the upturned hull there is no evidence of damage or deformation to the tanks that once would have supported the accommodation.

146. Whilst it is possible that these tanks are breached, the state of the hull above would contain the oil. Therefore it must be assumed that they could still contain a large percentage of their original cargo of oil.

Thickness readings

147. Thickness readings were taken in four locations on the bow section. No thickness readings were taken on the stern section as the readings are likely to be broadly similar and there are no intact cargo tanks in this section.

148. The readings were taken in the following locations:

a. Port bow, close to the stem,

b. Port side, 6 m above seabed, 20 m aft,

c. Port bow, 0.5 m above seabed, 3 m aft of bow

d. Starboard side, 8 m above seabed 20 m aft

149. The Falcon ROV struggled to maintain position whilst the hard concretion was removed with a rotary brush. This difficulty in adequately cleaning the area means that it was hard to get a clean area for the thickness gauge to take an accurate reading. For this reason, the extreme high and low results have been discounted from these figures.

150. The average thickness readings for the 4 areas were: Port bow 6.45 mm, Port side 7.96 mm, Port bow at sea level 6.45 mm, Starboard side 7.67 mm.

151. The readings varied between 4.35 mm on an area that had suffered from considerable laminar corrosion to 11.90 mm. Several readings in the region of 11 mm were recorded and it is likely that these higher readings are due to underlying structure of joins in the plates.

152. Localised corrosion such as pitting was observed widely on the hull. The average reading of 7 mm should be taken to be an average of the plate thickness excluding the effects of pitting.

153. The thickness of the steel in the pits will be in the region of 3 mm, less in some places where deeper pitting is evident.

Corrosion prediction

154. Prediction of corrosion rates on ship wrecks is difficult to quantify as it is dependent on a large number of variables. Work has been done on several wrecks off America to try to generate a formulaic method of predicting corrosion dependant on a number of environmental parameters (18).

155. The Weins number has not been tested against a large number of wrecks but is currently the best methodology available to predict corrosion rates.

156. Using the known environmental parameters for James Bay, and estimating the unknown parameter (dissolved oxygen content estimated at 70%) the corrosion rate for RFA *Darkdale* is predicted to be 0.092 mm per annum (mmpa).

157. Based on the vessel being submerged for over 72 years, this rate gives a loss of circa 7 mm of steel which when combined with the current thickness readings of 7 mm returns an original thickness of 14 mm. The original plate thickness in the region sampled is believed to have been 5/8 inch plating (15.875 mm) giving an error of 1.85 mm. Given that no measurement of dissolved oxygen was taken during the survey and an estimated value has been used, this is a reasonable correlation.

158. The minimum thickness reading recorded (excluding outliers) was 4.35 mm. Based on a predicted corrosion rate of 0.092 mmpa, the hull plating will perforate in 47 years.

159. Collapse of the wreck will occur before the perforation of the shell plating steel as perforation does not take in to account any forces such as the self-weight of the structure, movement of the water, hydrostatic head or buoyancy forces from trapped oil.

160. The figure of 0.092 mmpa does not include any localised effects such as pitting or increased corrosion around rivets which is known to be causing more rapid corrosion in some areas. As the rate of corrosion in these areas is more than double the rate for the surrounding steel, the hull will lose oil tight integrity around the rivets by corrosion alone in less than 20 years. When combined with the dynamic effects of water

movement and changing hydrostatic head caused by heavy seas, the time line to failure could be less than half that figure.

Stern Section

162. The stern section lies on its port side and appears to be supported overall by the sea bed.

163. The stern section suffered significant damage during the attack and there has been collapse of some parts of the structure in more recent times. The overall condition of the stern section is poorer than the bow section.

164. The U Boat logs state that four torpedoes were fired and the detailed log of the U Boat Commander show the first torpedo being aimed at the stern of the vessel and subsequent torpedoes aimed further forward on the ship.

165. The torpedoes struck the stern section on the port side in the following locations:

a. No.1 cargo tank

b. Engine room

c. No.3 cargo tank/Aft Pump room

d. There is no evidence of the fourth torpedo striking the vessel. This could be due to either the torpedo missing the target or failing to detonate

166. There is no noticeable hog, sag or torsion in the stern section, however the section was badly damaged during the attack making the detection of any deformation difficult.

167. The cargo tanks of the stern section are badly damaged and are no longer oil tight with large openings to the sea. The state of these tanks is as follows:

Cargo tank No. 3 and Aft Pump room

168. The Aft Pump Room appears to be the impact point for one of the torpedoes. The aft Pump Room has been destroyed with no structure remaining. The seabed below the area is littered with a large number of plates, pieces of frame and pipework. Much of this steel work is badly distorted and bent from the explosion of the torpedo or possibly the explosion that occurred five hours after the attack; this is likely to have been in the Avcat tank located in this area.

169. The bulkhead between the Aft Pump Room and No. 3 cargo hold has been destroyed, the damage from the pump room propagating back approximately 5 m in to the tank. The side shell and deck in this area has been destroyed but some of the double bottom structure remains intact, extending approximately 2 m beyond the end of the side plating.

170. The structure that supported the longitudinal subdivision is still in place but the majority of the plating is corroded or has fallen to the bottom (port side as she is now lying) of the tank.

171. As the forward end of this tank is open to the sea, no significant oil remains within the space. It is possible that small amounts of residue remain within the tank, trapped behind the remaining structure but none was sighted by the ROV.

Figure 16 – Shell plating from Aft Pump Room on the seabed

Cargo tank No. 2

172. No. 2 cargo tank has a small amount of distortion to the shell plate but is largely externally structurally intact. Internally, the transverse bulkheads to No.1 and No. 3 hold have been destroyed and all 3 tanks are open to the sea.

173. The longitudinal subdivision is largely collapsed though is some places, some of the supporting frames are in place.

174. The ROV did not penetrate in to the wreck as far as No. 2 Cargo tank but there is no evidence to suggest that any significant oil remains trapped in the structure.

Cargo tank No. 1

175. This tank has a large opening on deck that allows access to the port side No.1 tank.

176. The tank no longer has any oil tight internal subdivision; the longitudinal bulkheads have been destroyed opening port, centre and starboard to the sea. This has resulted in substantial damage to the frames and stiffeners.

177. The bulkhead to the engine room cofferdam and bunker tanks appears to be intact; no view into the tank or engine room was possible.

178. The starboard shell plate is perforated in the region of frame 41A, 3 m from the keel with a piece of shell plate detached on 3 sides and bent away from the frames at frame 44A.

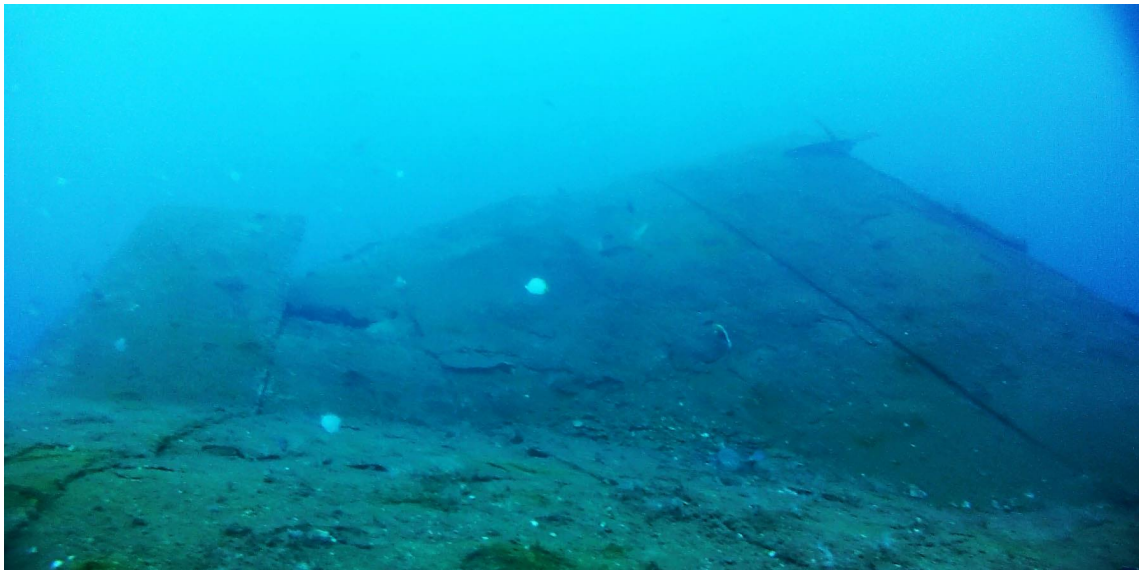


Figure 17 - Damage to No. 1 tank – plating bent away from the frames.

179. From frame 45A to the cofferdam bulkhead at 49A, the shell plate is heavily distorted and damaged by the detonation. The damage in this area extends from keel to deck edge with the plating being bent outwards, away from the frames. The shell plate is also bent away from the frames from the deck edge to 2 m down.

180. This tank was the site of the leak in 2010, the location was identified from the video provided by the recreational divers at the time of the leak. During the ROV survey, this location was seen to leak and appeared to be the main source of the oil causing a sheen on the sea surface.

181. A “top hat” was placed over this leak to collect a sample and estimate the leakage rate.

182. The leakage rate from this sampling method was recorded as 900 ml/day but it is known from local reports that the extent of the sheen does vary. However this rate is believed to be typical of the average rate of leakage.

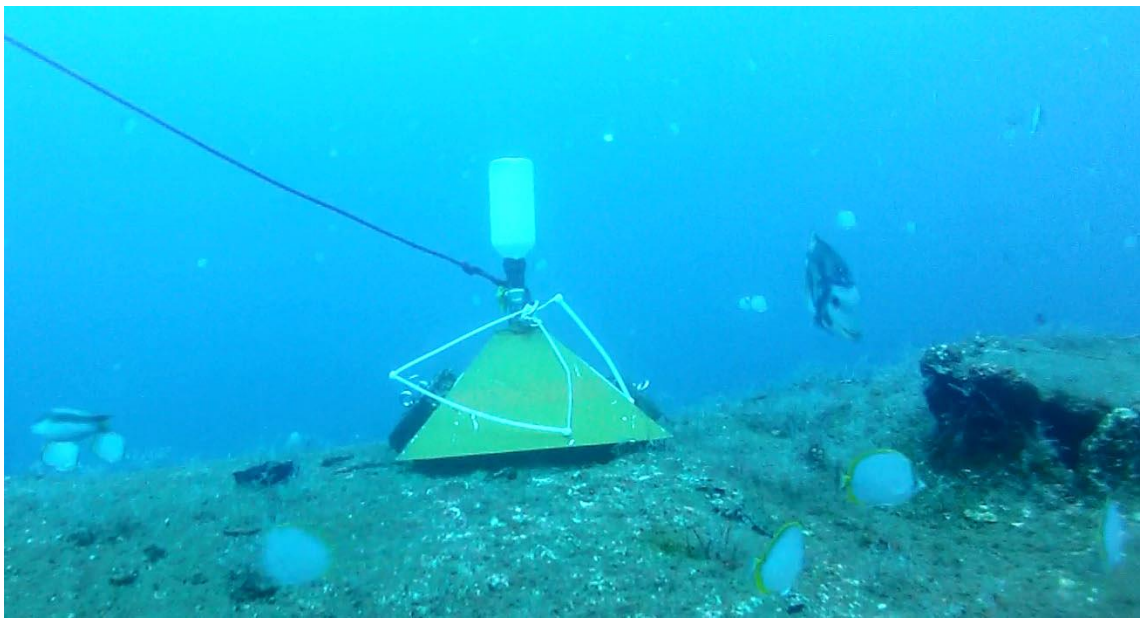


Figure 18 – Top hat oil sample collector

183. This tank was penetrated by the Seabotix LBV through the deck opening allowing an internal inspection to try and identify the source of the leak. The location of the leak was sighted but no obvious source of the leak could be seen. It is possible that this is the result of small amounts of oil remaining trapped behind stiffeners however given the length of time this has leaked for and the degree that the tank is open to the sea, this is an unlikely theory.

A more plausible theory is that the oil is migrating to this point from the bunker fuel tank located aft at frames 50A to 54A.

184. It was noted that following the ROV penetration of the tank, the disturbance of the tank did cause a slight increase in the amount of oil reaching the surface. Most likely this was caused by the ROV disturbing sediments and oil trapped behind parts of the structure.

185. The forward bulkhead of No.1 tank is damaged making it common with No. 2 tank.

Engine Room

186. The Engine Room is largely intact with the starboard shell plating all in place affording no view into the main machinery space with the ROV.

187. The sky lights above the engine are missing but there is no visibility in to the space due to obstructions.

188. The shaft tunnel area is all intact with no damage.

189. The forward end of the Engine Room where the Oil Fuel Bunker tanks and Service and Settling tanks are located is believed to be intact. There is no sign of any damage to the shell plating in this region and no damage was seen to the bulkhead separating it from No. 1 Cargo tank. There is no evidence to show that this tank is no longer oil tight however damage from the port side is likely.

190. Above and aft of the Main Engine Room is the Boiler Flat. The shell plating in this area is missing and the supporting structure has collapsed, exposing the boilers contained within. The boilers and exhausts are still in place on their mountings and appear to be in good condition.

Figure 19 - Starboard side of Boiler Flat

191. The shell plating is missing from the Steering Gear compartment and Refrigeration Space though the framing remains in generally good condition. Both of these spaces appear empty.

192. The shaft area extending back to the propeller and rudder are undamaged. The rudder is in the amidships position and the four blade propeller is in place. Just forward of the propeller are two pieces of shell plate that have fallen, most probably from the boiler flat above.

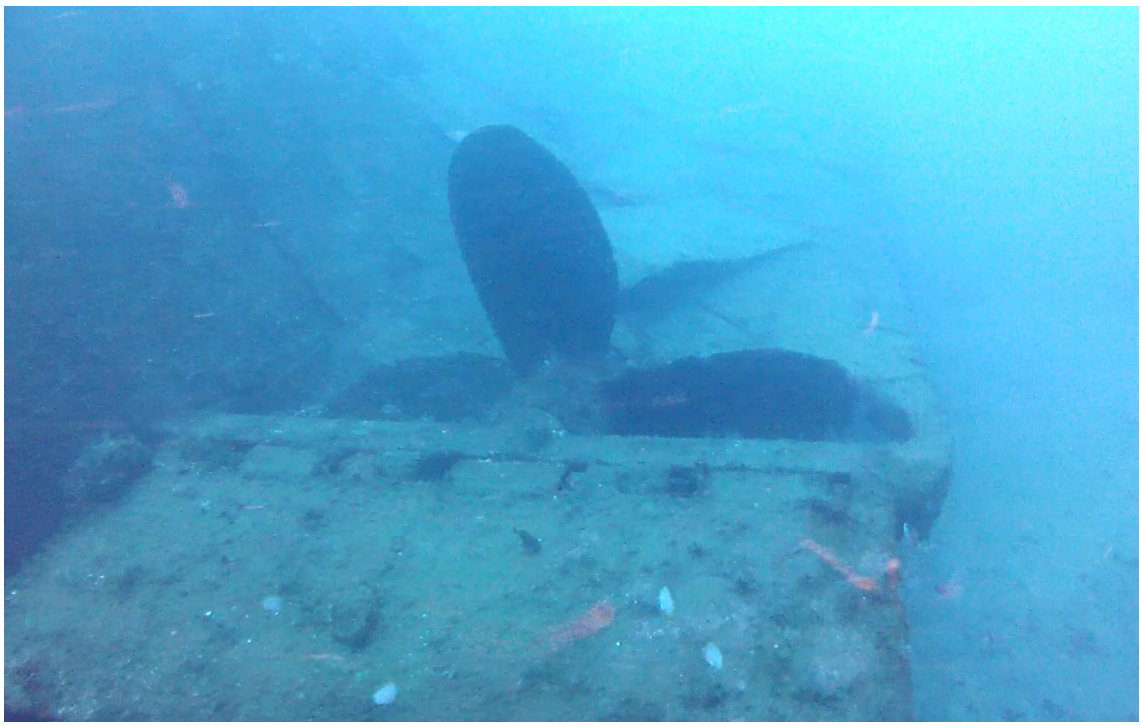


Figure 20 - Rudder and propeller

Crew Accommodation

193. The rough form of the accommodation is clearly visible but subject to a large degree of collapse. From the forward end of the aft deck house (frame 51A) the state of the accommodation is as follows:

a. Ladder leading from deck level to A deck (smoke room) level is in good condition complete with hand rail.

b. Smoke room has largely disintegrated, some vertical framing still visible

c. Gun mount above the smoke room is missing. The debris from this could not be located in the debris field below however there are a significant number of plates in this region which could have masked it.

d. The sky lights above engine room have gone leaving an opening in to the engine room.

e. The funnel stack is lying on the sea bed directly below where it would have been on the ships structure. The outer plating for this has mainly corroded away but the engine and boiler exhaust, silencers/spark arrestors are visible and in fair condition.

f. The galley (frame 77A – 83A) is badly corroded and collapsed, some shell plating remains and framing is visible in some areas.

g. The crew cabins on main deck level are all in good condition with no large perforation in the shell plate. The port holes are all in place, many still with glass in place.

Figure 21 – Collapsed crew accommodation

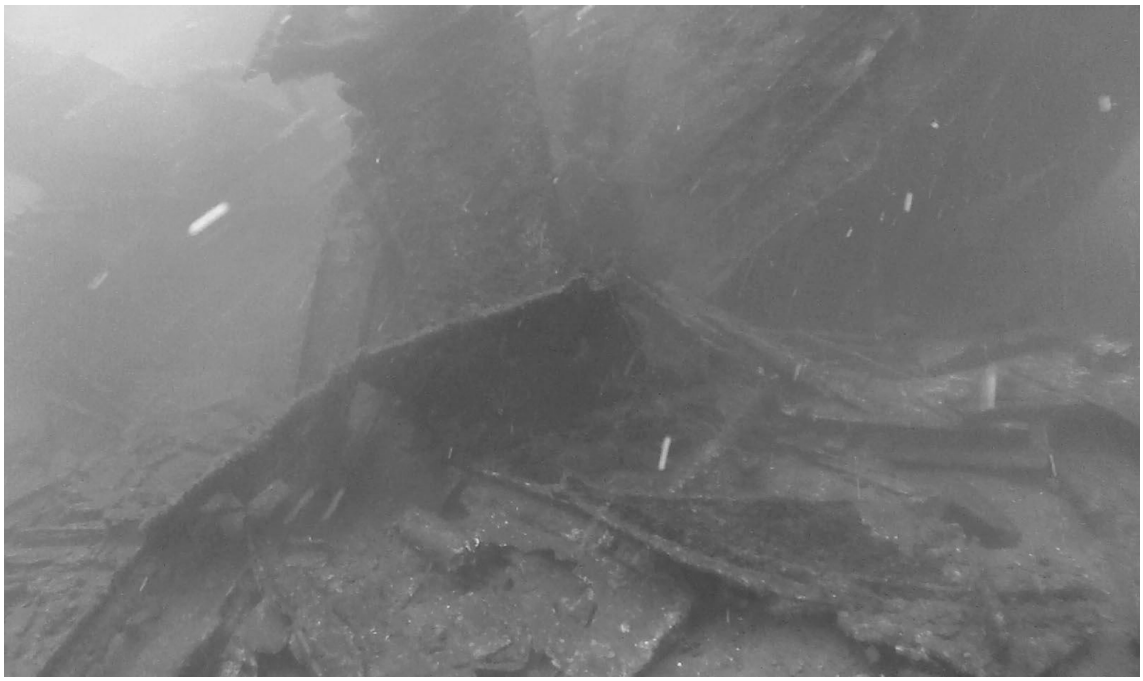


Figure 22 - Collapsed crew accommodation

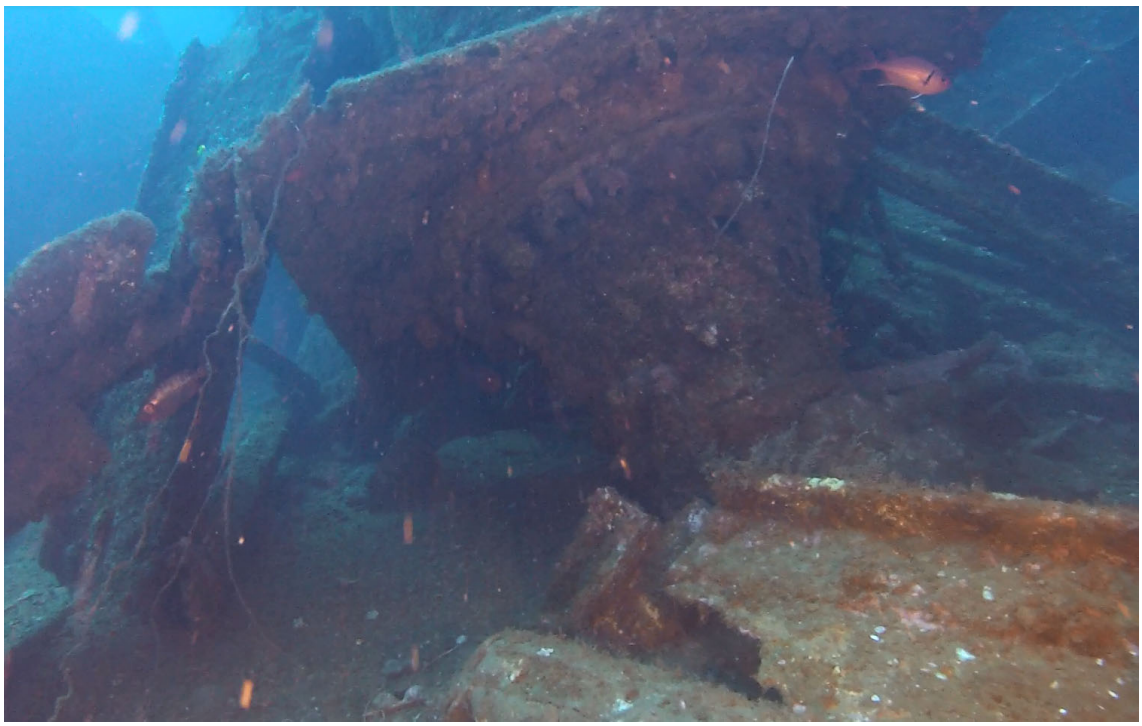


Figure 23 – Gun mount, detached and inverted

Naval Architecture review

194. From the ROV survey, it was not clear what caused the bow section of the vessel to remain partially afloat following the torpedo attack. It appeared that the bow section retained some buoyancy however the amount of buoyancy required to give the vessel the attitude seen in the post attack picture was un-quantified and affected the assessment of how much oil remains onboard the vessel.

195. A basic hydrostatic model of the vessel had been created prior to the onsite survey however the question of what caused the bow section to sink required a more complex model to be built.

196. The Naval Design Partnership were contracted to carry out a review of the sinking (19). A computer model was built using Paramarine software and validated to allow a more exact assessment of the wreck to be carried out.

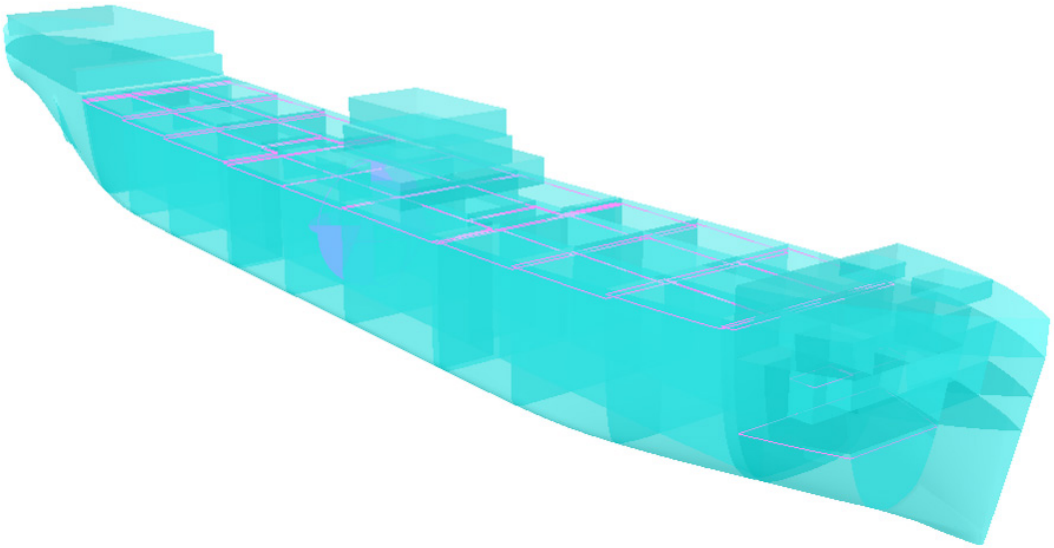


Figure 24 - Paramarine model of Darkdale

197. For the review, an assumed load case of 90% was used. This gives a volume of cargo oil onboard the vessel immediately prior to sinking of 13640 m^3. Based on the where the vessel broke, the maximum volume of oil in the bow section was calculated to be circa 8800 m^3 of cargo.

198. A number of load cases were generated to try and replicate the angle of list and trim seen in the post sinking photograph. This angle was calculated as 27.5 degrees to starboard with a trim of 52.89m.

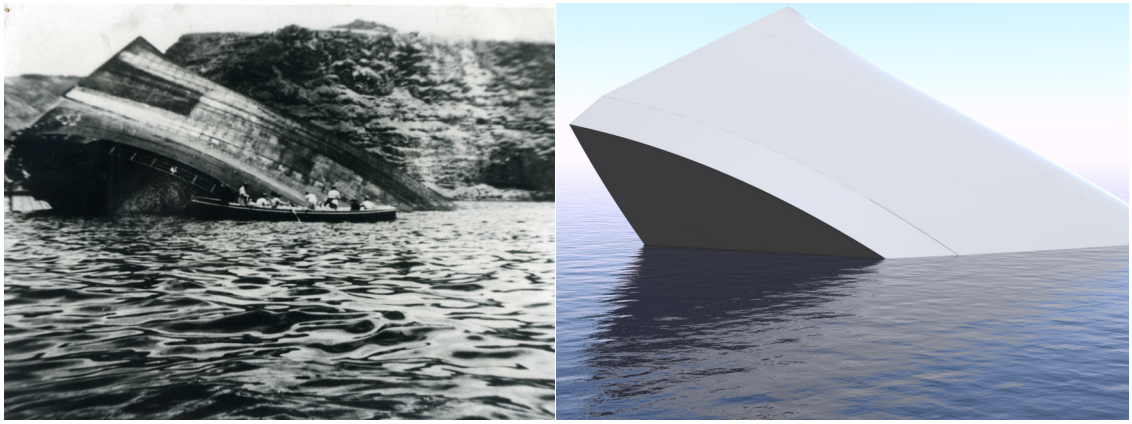


Figure 25 – Bow section following attack – photograph[1] and computer model rendering

199. The range of load cases identified two feasible damage scenarios that would replicate the condition seen in the photograph. The worst case of these scenarios was No. 4 and No. 5 Cargo tanks both ruptured and the oil lost to the environment with the remaining tanks being intact. In this scenario, the total quantity of oil remaining onboard is 4952 m^3.

200. The best case scenario that resulted in the condition seen in the photograph was tanks No. 4, 5 and 6 being ruptured with a total amount of oil remaining onboard calculated as 2326 m^3.

201. Both cases are plausible however as limited damage was seen to the external structure of the hull, it must be assumed that the worst case scenario is possible.

[1] Photograph courtesy of Museum of St Helena

Surrounding seabed

202. The surrounding seabed is smooth and flat with no significant form and only a gentle slope.

203. There are no significant features close to the wreck; no boulders, large pieces of debris or other items of note. Given the severity of the attack on *Darkdale* it is perhaps surprising that there is not a significant debris field extending from the wreck, this may be due to the speed the vessel sank.

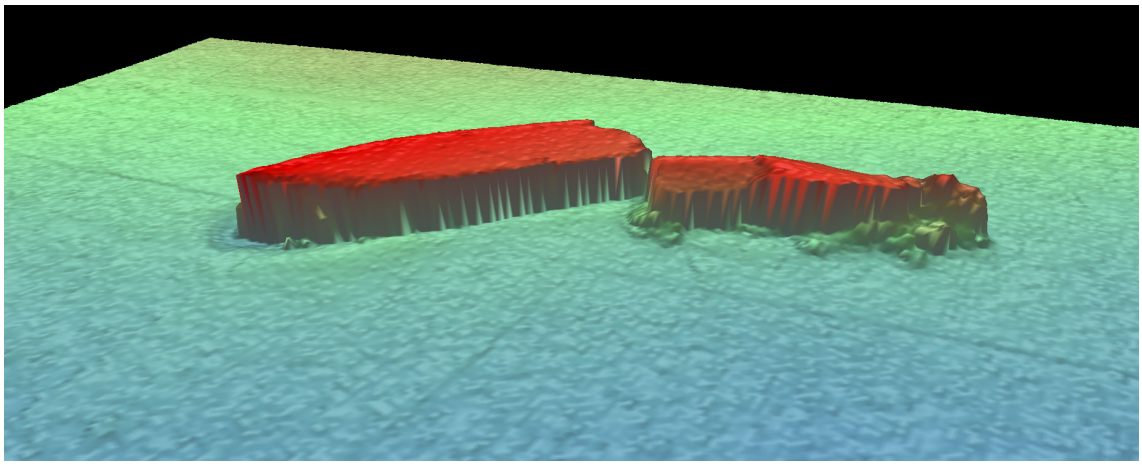


Figure 26 - Multibeam of the wreck site showing smooth seabed around the wreck

204. To the north of the vessel there are a few small items of debris including:

a. A spar from one of the masts

b. 205 litre lubricating oil drums

c. A steel box – may have contained ready use ammunition.

205. In the area immediately surrounding the bow, lengths of Cordite can be found lying on the seabed. The cordite will have been stored in the forward magazine as a firing charge for the 4.7 inch gun. Originally it would have been contained in silk bags but the bags are no longer apparent allowing the cordite to scatter on the seabed.

Figure 27 - Cordite strands on seabed

Unexploded Ordinance

206. According to the report submitted by the Captain of the *Darkdale* following her loss the ship's armament comprised the following:

a. 1 x BL 4.7in gun

b. 1 x 12 pdr gun

c. 2 x Pig troughs

d. 2 x Hotchkiss machine guns

e. 2 x Marlin machine guns

f. 2 x Lewis machine guns

g. Kites

h. Parachute And Cable (PAC) rockets

207. The 'Pig trough' was an anti-aircraft launcher comprising fourteen 2-inch rockets mounted vertically in two rows of seven and fired vertically against attacking aircraft. No evidence of the Pig trough was seen during the survey. It is likely that any remains of this weapon have been buried under the debris field. The rockets themselves would have been made of thin materials that would corrode or decay quickly exposing the contained explosive to sea water. It is not considered likely that any viable explosive remains for this weapon.

208. Kites were large box kites that were used in a similar way to barrage balloons as an anti-aircraft deterrent. It is highly unlikely that these would survive in the marine environment and even if they did, they do not cause a safety concern.

209. PAC rockets comprised a single large rocket that was fired into the air in the event of an aircraft attacking the ship, the rocket was attached to a length of cable which descended slowly by parachute. If the wire fouled the aircraft it could cause it to crash. The rockets themselves would have been made of thin materials that would corrode or decay quickly exposing the contained explosive to sea water. It is not considered likely that a viable explosive remains for this weapon.

210. Determining the amount of ammunition carried by the RFA *Darkdale* is difficult. The armament of Dale class vessels varied and no document has been found which gives the quantity of 4.7 in ammunition likely to have been stowed. A pre-war document (20) gives details of the number of shells provided to Dale class vessels armed with 1 x 4 in BL gun and 1 x 3 in HA gun, noting that they had space for forty eight 4 in and forty 3 in rounds. This may have been increased to eighty eight 4 in and eighty 3 in rounds. On the basis of this information, it is likely that the wreck contains a minimum of 100 rounds of the larger 4.7 in ammunition and possibly considerably more. The same document mentions that the 12 pdr gun is likely to have been

provided with 98 rounds of ammunition. The shells are likely to have survived but their location is unknown. The forward magazine is beneath the upturned bow section and is likely to still contain shells. The aft magazine is open to the sea and no shells are visible within this space. The fate of any shells from the aft magazine is unknown but it must be assumed that they remain within the wreck.

211. In addition to the ammunition carried by the *Darkdale*, the survey located shells on the upturned hull of the bow section and in the immediate area around the wreck. Given their location, it is highly unlikely that these originated from the ship. If left undisturbed, they pose no threat to the general population of St Helena.

212. It is likely that the shells on the upturned hull originate from the two 6 in BL Naval guns that were stationed on St Helena as a defensive measure (21). If shells were dumped at the end of war, it is possible some were dumped on the wreck site of the *Darkdale*.

213. Early shells for 6in guns were lyddite filled which can sensitise over time if picrate salts are formed. Later shells were filled with more stable explosive. The shells on the wreck site pose no danger to the general population of St Helena; recreational divers should avoid disturbing the munitions in case of sensitisation.

214. In addition, the War Diary of *U-68* notes that, besides the 6in battery, a second small calibre battery was present on the island. This may be the battery at Mundens Point referred to in the Commanding Officers report (21). If ammunition from this second battery was also dumped offshore at the end of the war it might explain the mix of different sized shells apparent on the wreck.

215. Although the Commander of *U-68* noted four hits from the four torpedoes fired by the submarine there remains the likelihood that one may have missed its target or not exploded on impact (this was a known problem with some types of German torpedo). This is supported by the evidence in the Harbour Master's report of the *Darkdale* loss. He noted only three loud explosions. This would concur with the damage sustained by the vessel.

216. The Captain of *Darkdale*'s report conflicts with the Harbour Master's as he notes only two explosions but is specific in saying "on the port side". Given the time it took him to get to the landing steps, he clearly was not nearby and isolating the location of the explosions to the port side is questionable. Given the elapsed time between the incident and the writing of the report, the accuracy is questionable.

217. The only report that notes the explosion of all four torpedoes is the Torpedo Officer's log. It would be in his interest to declare all four torpedoes as confirmed explosions but the damage to the ship does not support this statement.

218. If a torpedo missed or failed to detonate there is a possibility that it may have come to rest on the surrounding seabed. The wider bay area was surveyed using side scan sonar and no evidence of a torpedo was found. The fate of the fourth torpedo remains unknown.

Environmental Assessment

The following is an extract from the RPS Consultants report (17)

Non Technical Summary

Introduction

219. RPS Consultants Ltd (RPS) was commissioned by the Salvage and Marine Operations (S&MO) organisation of the Ministry of Defence (MoD) to conduct Marine Environmental Impact Research on the wreck of the oil tanker RFA *Darkdale*, which is located in James Bay, St Helena in the South Atlantic.

220. Since its sinking in 1941 with a full cargo of oil, the *Darkdale* has experienced a long term, slow chronic oil leak and, during storms, larger leaks have occurred from the wreck. The purpose of this study, therefore, was to assess the current impacts to the marine environment and local businesses from the existing slow leak from the wreck and to consider the risk and potential impacts to these receptors from a major acute oil spill.

221. This report presents the results of the study, comprising this main report and six supporting annexes. This main report contains all the information and evidence to support the conclusions and recommendations; the annexes contain the supporting information in the form of original study reports, each of which have been summarised in this report.

Environmental Impact Research Overview

222. To inform the environmental impact and risk assessment, an extensive desktop review of available information was undertaken prior to a field survey to St. Helena with S&MO in May 2012. During this time, site-specific surveys were undertaken to collect samples of water, seabed sediments and fish flesh for analysis of oil compound content to assess the effect of the long term oil leak on these aspects of the marine environment and also to inform an assessment for potential toxic effects on marine organisms and human health.

223. In addition, surveys were undertaken to gather data on the speed and direction of currents in James Bay to inform an oil spill modelling exercise to enable predictions to be made about the likely movement and extent of a large oil spill from the wreck. Marine ecology surveys were also undertaken to characterise the communities present in seabed sediments and along the shores of James Bay and the surrounding area to identify receptors, which may potentially be affected by an acute oil spill. Similar information on fish, shellfish and marine mammals in the area was also acquired through the extensive desktop review.

224. A study was also undertaken during the field survey, alongside the environmental surveys, to investigate what, if any, effect the long term leak is having on local

businesses in St Helena, and also any potential effects that a major spill may have on these.

Effects of the Long Term Oil Leak

225. The water samples were found to generally contain low levels of oil related contamination and levels were typically below relevant environmental quality guidelines. Similarly, the majority of the samples of fish flesh had low levels of oil related contamination, although a few samples did contain high levels of substances which exceeded quality guidelines, indicating that fish caught in the vicinity of the wreck may pose a threat to human health.

226. Sediment samples collected from James Bay were comparatively more contaminated and levels of many hydrocarbon compounds exceeded quality guidelines, indicating the potential for effects on marine organisms. Patterns observed in the communities of benthic organisms living in the sediment suggested that the level of contamination in the sediment does play a part in determining which species are present. However, it is likely that the levels of contamination are not as important as other environmental factors, such as sediment particle size, in determining the structure and composition of these communities.

227. Although some contamination was observed, it was not possible to conclusively attribute the contamination observed in fish and sediments to the oil coming from the wreck. However, it was true to say that there was a pattern of more frequent exceedance of environmental quality standards in the vicinity of the wreck.

228. The results of the socio-economic study showed that commercial fishing is currently not affected by the existing long term oil leak, as this activity does not take place near or around the wreck area; fishing grounds are typically further offshore. Similarly, the marine leisure sector is currently unaffected by the chronic oil leak as these activities predominantly take place away from James Bay.

Marine Ecology Characterisation

229. The marine ecology surveys, to characterise the marine environment, identified that the intertidal zone of James Bay was completely dominated by rocky shores and hard substrate, which typically supported low number of species, including periwinkles, limpets, pink crustose coralline algae, limpets, red algae and sea urchins. Overall, species diversity was low and the floral assemblage was particularly sparse. No species of particular conservation or commercial interest were observed in the intertidal zone.

230. The subtidal benthic surveys showed that the predominantly gravelly sand and sandy gravel sediments between the 5 m and 50 m water depth contours in James Bay were characterised by diverse communities of marine organisms; a total of over 11,000 individuals were recorded across 270 different species. It is likely that many of the infaunal species discovered are new and that some will prove to be endemic to St

Helena. Many of those taxa that are not new will not have been recorded from St Helena previously.

231. On the whole, the subtidal benthic communities were characterised by typically soft sediment species, including a range of polychaetes, nemerteans, sipunculids and molluscs. The extent of the epifaunal community present was largely dependent on the availability of hard gravelly substrate and stones which, where present, supported sessile fauna, including bryozoans and sponges. Similar encrusting organisms were also observed on the wreck, although the extent of encrusting was generally low. The diversity of the benthic communities present was typically higher in deeper water than in the shallower, sandier sediments. Of greatest interest were extensive maerl beds, which were identified in water depths of around 45 m and in the immediate vicinity of the wreck site. Maerl beds are of conservation interest worldwide and elsewhere are identified as important nursery areas for the juvenile stages of commercial species of fish and shellfish.

232. The fish assemblage of James Bay and in the vicinity of the *Darkdale* wreck is predominantly comprised of small reef fish, several of which are endemic to St Helena and/or restricted to the central Atlantic islands (i.e. Ascension, St Helena and St Pauls Rocks). The wreck itself has also become an important artificial reef in an otherwise relatively featureless soft sediment environment, which has attracted an abundance of fish species. Of particular note, the bastard cavalley pilot and bastard fivefinger, both of which are endemic to St Helena, are listed, as 'Vulnerable' on the International Union for Conservation of Nature (IUCN) List of Threatened and/or Declining Species. Of the shellfish species found in the vicinity of James Bay, both longlegs and slipper lobster are also listed as being of 'Least Concern' and 'Data Deficient', respectively. Based on observation data only, it is likely that the shallow waters of James Bay are important nursery and/or spawning grounds for many of the species in James Bay, including endemic species.

233. With respect to commercially important fish and shellfish species, the principle fishery is the skipjack but large tunas, wahoo (barracuda), jack and conger are also important. To a lesser extent, cavalley, bullseye, mackerel and marlin also form part of the annual commercial landings.

234. St Helena has large resident populations of the pan-tropical spotted dolphin and also smaller populations of bottlenose dolphin, both of which are spotted regularly in James Bay. Other cetaceans, including rough-toothed dolphin and humpback whale are considered to be infrequent visitors.

235. Several seabirds are frequently sighted in the James Bay area, including the white tern, the brown noddy, the black noddy and the red-billed tropicbird.

Oil Spill Modelling of an Acute Spill

236. Oil spill modelling using a hypothetical oil spill value of 1800 m3 of marine diesel oil released into James Bay over a period of 3.5 days indicated that, in a worst-case

scenario (i.e. calm conditions) the maximum thickness of oil at the surface in offshore areas would generally be less than 0.5 mm, with localised maximums of between 5 mm and 10 mm closer to the shore. The modelling suggests that after a month, the oil will have largely dispersed offshore in a north/northwest direction. However, the prevailing wind in James Bay is south easterly and as such, under more realistic conditions, would disperse the oil offshore more rapidly in an north westerly direction, with little onshore beaching. The added influence of South Atlantic drift would also likely carry the oil further east.

Risks to Environmental Receptors from an Acute Spill

237. Intertidal habitats are typically highly vulnerable to large oil spills due to the likelihood of oil beaching, resulting in the smothering of marine organisms. Many of the species present are likely to suffer mortality in the event of an acute oil spill, as has been demonstrated by the findings of other oil spills, although recoverability of these species and communities is predicted to be high.

238. The likelihood of oil released from the wreck settling on the seabed is lower than the likelihood for oil to be washed ashore. However, the natural breakdown and sedimentation of oil may affect subtidal benthic communities. The majority of the benthic communities and species present throughout James Bay are likely to have high vulnerability to, but high recoverability from, hydrocarbon contamination. The most highly diverse benthic communities of the maerl beds have current biodiversity value and also potential future conservation value. These communities are highly sensitive to disturbance of any nature, but particularly smothering. They are also slow growing and, as such, the likely recoverability from an acute oil spill is uncertain.

239. The shallow water fish and shellfish assemblages of James Bay are likely to be adversely impacted by an acute oil spill, and mortality of a proportion of the populations would be expected. Shallow water communities have been shown to be vulnerable to historic oil spills. In addition, the eggs and larvae, as well as the early developmental stages of fish are known to be highly vulnerable to hydrocarbon pollution. It is unlikely however, that offshore commercial fisheries stocks will be severely affected.

240. Marine mammals are unlikely to be significantly affected by an acute oil spill event due to their high mobility and the fact that James Bay is likely to form only a small part of their foraging grounds. Additionally, there is little evidence from previous oil spills to suggest that they are adversely affected by large spills.

Risks to Socio-Economic Receptors from an Acute Spill

241. In the event of an acute oil spill, the modelling predicts that 12 fishing grounds to the north, northeast and southwest of James Bay could potentially be affected. Where this is the case, the Fisheries Corporation is likely to put a restriction on the use of these areas, and fishing would take place to the west and to the south for the duration of the event.

242. Diving and short boat trips operating out of James Bay will likely be affected for the oil spill duration but this will recover once the plume has dispersed. With the airport being built, the purpose of which is to enable St Helena to become more financially independent through the development of new businesses and tourism, there is the potential that investors in marine tourism will consider the existing chronic oil leak and the possibility of an acute oil spill as being a risk to their future business investments.

Environmental Risk Assessment Results

243. An environmental risk assessment was conducted using the results. The assessment considered risks associated with the existing chronic oil leak and risks with an acute oil spill event. For the chronic oil leak, 11 risks were identified that can affect the local environmental and socio-economic receptors. Out of the 11 risks, 4 were assessed as being medium and 7 assessed as being Low. There were no high risks identified. The medium risks were associated with water quality, and effects on fish, shellfish and benthic fauna.

244. For the acute oil spill event, 17 risks were identified and of these 3 were assessed as being high risks; 11 were assessed as being medium risks and 3 assessed as being low. The high risks were associated with short term water quality and lethal toxicity to fish and shellfish, and the short term closure of commercial fishing grounds. The medium risks were associated with sublethal effects on fish, shellfish and benthic fauna, including the viability of fish eggs and survival of fish larvae. Other medium risks were associated with sea birds, the contamination of commercial fish stocks and current and future prospects of tourism.

245. The results demonstrate a need for short term and long term mitigation measures. Especially, with the advent of a new airport being built; the purpose of which is to attract new businesses and tourism.

Mitigation Measures/Recommendations

246. A number of recommendations and mitigation measures have been proposed in view of the outcomes of the environmental risk assessment to reduce the potential for impacts to marine ecology receptors, human health and socio-economic receptors in James Bay. These include both short term and long term measures.

247. In the short term, it is proposed that an exclusion zone is enforced around the wreck site to prevent further damage to the wreck, which may result in a large oil spill and also a precautionary warning against recreational fishing in the immediate vicinity of the wreck site to protect human health. It has also been recommended that, as a precaution against any large spills or the existing long term leak increasing in the near future, MARPOL oil response kits are installed on the harbour side and a management plan, including training for harbour and environmental staff is implemented.

248. To mitigate for the potential adverse effects associated with an acute oil spill, long term mitigation measures, include the removal of the oil from the *Darkdale*. It is recommended that once the oil is removed, a fish and shellfish monitoring plan is

implemented, so that the continued risk to human health can be assessed before the fishing restrictions are lifted.

Risk Assessment

249. The risks for the wreck are considered in the table below. The risk has been assessed against the risk assessment matrix included at Annex 1.

250. The definition of the risks are as follows:

A – Intolerable. Cannot be tolerated – unable to be signed off/endorsed unless there are exceptional reasons. Must be authorised by higher authority.

B – Undesirable. Can be tolerated – A full safety justification and As Low As Reasonably Possible (ALARP) argument must be provided, including safety assessment to justify the risk. Any residual Class B risks are to be approved, on a case by case basis, by the Project Safety Committee and authorised by the Team Leader.

C – Tolerable. Can be tolerated provided ALARP status is reached. The record of ALARP status is to be provided in the Hazard Log.

D – Broadly Acceptable. Can be tolerated (no need to demonstrate ALARP status, nevertheless there is a duty to reduce risk if reasonably practicable).

251. For the purposes of this risk assessment, the quantity of oil remaining is taken as 4952 tonnes; the worst case scenario for the quantity of oil remaining onboard.

Risk ID.	Risk Description	Accident frequency	Impact	Category	Comments
1	Catastrophic structural failure of the wreck leading to complete discharge of oil to the environment.	Probable	Critical	Intolerable	Structural failure is inevitable – time scale is judged to be within the next 25 years.
2	Structural failure of a single tank with discharge of contents to the environment.	Frequent	Major	Intolerable	Not all tanks are in the same condition, failure of individual tanks over time is more plausible than instantaneous complete collapse.
3	Mechanical damage to the wreck caused by visiting vessels anchor chains. Contents of one tank released to the environment.	Occasional	Major	Undesirable	Contact of anchor chains with the wreck are highly likely to lead to tank rupture. The increasing number of visiting ships raises the risk.
4	Mechanical damage to the wreck caused by visiting vessels anchors or chains. Contents of multiple tanks released to the environment.	Remote	Critical	Undesirable	Contact of anchors or chains with the wreck are highly likely to lead to tank rupture.
5	Damage to the wreck caused by recreational divers resulting in release of oil to the	Highly Improbable	Major	Broadly Acceptable	Wreck is regularly dived but it is unlikely that any divers only looking at the wreck would cause a

	environment.				release.
6	Damage to the vessel caused by severe weather conditions.	Probable	Major	Intolerable	Release of oil has historically occurred in bad weather. Likelihood of release increases as the vessel continues to corrode.
7	Health of local population affected by release of oil.	Remote	Marginal	Tolerable	If a large quantity of oil was to be transported by currents in to James Bay, fumes could affect Jamestown. Prevailing winds offshore so probability is low.
8	Local population affected by eating hydrocarbon contaminated fish.	Improbable	Critical	Tolerable	Samples do indicate fish on the wreck site may be contaminated. Only small quantities of fish are taken from the wreck by a limited number of people.
9	Local fishing industry damaged by release of oil	Highly Improbable	Marginal	Broadly Acceptable	Alternative fishing grounds are available. Spill fate analysis shows that it is extremely unlikely that a spill would affect all fishing grounds.
10	Tourist Industry temporarily affected by an oil spill.	Remote	Major	Tolerable	Tourism is likely to grow with the opening of the airport but is not currently a large industry. Any impact is likely to be short term.
11	Tourist Industry permanently affect by an oil spill	Highly	Critical	Tolerable	Any impact of an oil spill is likely recover over

		Improbable			time.
12	Supply of fuel oil to the island affected by an oil spill	Remote	Disastrous	Intolerable	The island is supplied with fuel oil via ship to the tank farm located 1200 m from *Darkdale* . Oil in Rupert's Bay may prevent the delivery of fuel for a short period of time. Island should have sufficient reserves but increasing demands imposed by the new airport may cause supply problems with wider impacts to supply of food to the island.
13	Damage to local and visiting ships and boats	Probable	Marginal	Undesirable	Oiling of ships & boat hulls from a spill is likely. Owners are highly likely to seek cleaning costs from MOD.
14	Injury to general population by unexploded ordinance	Incredible	Negligible	Broadly acceptable	The vessel is a considerable distance from the town and explosives are all at least 30m underwater. Blast would not propagate far enough to constitute a risk.
15	Injury to recreational divers by unexploded ordinance	Improbable	Critical	Tolerable	UXO only poses a hazard if shells have sensitised and are disturbed by divers. Number of shells is low.

252. The assessment of the wreck identifies the following risks:

a. 4 Intolerable risks

b. 3 Undesirable risks

c. 5 Tolerable risks

d. 3 Broadly acceptable risks

253. The four risks identified as Intolerable are examined further below:

a. Catastrophic structural failure of the wreck leading to complete discharge of oil to the environment.

The structural decay of the wreck is inevitable. It is possible though unlikely that a single failure of the structure of the wreck could lead to a rapid chain of events causing complete structural collapse. Any structural collapse of the tanks containing oil will release their contents to the environment. There are no simple measures to mitigate against this risk.

b. Structural failure of a single tank with discharge of contents to the environment

It is unlikely that the wreck would collapse completely in a single incident, more likely is a gradual sequential collapse and release of oil. The impact is lower than complete structural collapse of the wreck due to the smaller amount of oil released but it will occur more than once until all tanks have collapsed. The recurring release of oil has the potential to be more environmentally damaging as the effects are longer term and impact the recovery of habitat more severely.

c. Damage to the vessel caused by severe weather conditions

Severe weather has been the catalyst for the previous releases of oil and unless mitigated against is likely to be the causative factor of the collapse of the structure. The exposed location of the wreck means that it cannot be protected in any way from the weather.

d. Supply of fuel oil to the island affected by an oil spill

The impact on the supply of fuel to the island is a short term effect however given the islands remote location and dependence on fuel delivered by ship, it would be a very serious impact. The building of the airport will increase the demand for fuel on the island making refuelling more frequent. The potential impact of oil spill could be mitigated against by increasing the fuel reserve held on the island.

Risk management options

254. The following options for the management of the risks are available:

Accept the liability and environmental damage

255. It is inevitable that if no action is taken, the oil will eventually leak out and cause economic and environmental damage. The value of this damage is difficult to quantify however the costs of environmental clean up can be considerable.

256. The oil spill fate mapping suggests that the majority of the oil will be taken away from the shore. This reduces the potential impact of the spill as the oil will mainly degrade at sea. It is likely that some oil will end up beaching and surrounding the island; how much depends on the wind and weather conditions at the time.

257. In 2011 the bulk carrier M.V. Oliva ran aground on Nightingale Island, Tristan De Cunha. This island group lies 1500 nm south of St Helena and is similar in its remote location and rocky shore lie. The M.V Oliva released 1420 t of heavy fuel oil causing extensive oiling of sea birds and environmental damage. The difficulty of responding to this incident was noted by the International Tanker Owners Protection Fund (ITOPF) (22). In particular the handling of the absorbent materials used for cleaning up the spill which can be several times the volume of the oil actually spilled.

258. There are no publicly available figures for the total cost of the clean-up for this incident however given the response that was mobilised, the figure will be several million pounds.

259. If no positive action is taken to remove the oil, the MoD must be prepared to mobilise a large scale response when the wreck releases the oil and bear all the costs of this action. The costs the MoD would be liable for will include:

a. Costs of chartering suitable ships and personnel to support the clean up

b. Cost of environmental clean up and disposal of the absorbent materials/oil recovered

c. Economic loss claims for the parties directly affected by the oil spill. As there are few parties that this is likely to apply to, the costs for this will be relatively low.

d. Costs of post spill monitoring and remediation.

260. The remote location of St Helena will reduce the efficacy of any response and increase the cost though this may improve when the airport opens.

261. As it is known that the wreck will leak oil, the MOD could provide the island with response equipment. This would help to minimise the impact of any leak and liabilities resulting for it. The maintaining of this provision and training of suitable personnel is likely to be problematic. The potential size of the spill means that a large provision would have to be made; this is unlikely to be cost effective in the long term.

Remove the oil from the wreck

262. Removal of the oil from the wreck is technically feasible using hot tap techniques. This technique has been used by the MoD on the wreck of *HMS Royal Oak* which lies in similar water depth to the *Darkdale*. The techniques have been effective in removing oil from the wreck with over 1500 m^3 of bunkers removed.

263. The structure of the *Darkdale* is a simple single hulled tanker making hot tapping considerably easier than on a warship. Much of the difficulty and time spent removing oil from the *Royal Oak* was due to the large number of small compartment and defensive design features such as the torpedo bulge. The *Darkdale* does not have any of these features and is laid out in a relatively small number of large compartments.

264. The remote location of the wreck and difficulty of handling the oil and any oily water mix removed from it will increase the cost of this operation considerably compared to *HMS Royal Oak*. Careful thought would need to be given to how this waste stream could be managed.

265. This option does provide a final solution to the problem as once the oil is removed; the wreck ceases to be an environmental hazard.

266. Prior to a hop tap operation, a detail assessment of the unexploded ordinance risk would have to be undertaken and it is likely that the shells lying around the wreck would have to be removed and disposed of.

267. Removal of the oil from the wreck is a high cost option especially when the exact quantity of oil remaining onboard is not known.

Conclusions

268. The island of St Helena has a small population that are heavily reliant on external aid. There is a long term plan to reduce this dependency and make the island a tourist destination. The unique location and pristine environment will be the prime attraction of the island. An oil spill has the potential to effect the growth of tourism in the short to medium term.

269. The main town on the island is Jamestown, home to the majority of the island's population and the administrative centre for the island. Jamestown lies on the coast by James Bay.

270. James Bay is a large northerly facing bay that is not heavily used by commercial shipping. The island is visited by a small number of cruise ships per year though it is hoped that this number will grow as the island develops its tourist industry. The island is currently dependant on the bay for resupply of the island by the RMS *St Helena*.

271. The wreck lies in the centre of the bay and continually leaks small quantities of oil that are seen as a sheen in the bay. The sheen is generally taken out to sea by the prevailing south easterly winds and currents.

272. The survey of the wreck showed that the vessel appears to have been hit by three of the four torpedoes launched, splitting the ship into two sections at approximately the amidships point, in the vicinity of the aft pump room.

273. The wreck of RFA *Darkdale* is in good condition for a wreck of this age and it is highly likely to contain a considerable quantity of oil. The exact quantity of oil could not be found due to the restriction of the remote location survey methods.

274. The bow section lies inverted and is in excellent condition given the age of the wreck. There is no torpedo damage to the bow section forward of the break and it appears that cargo tanks No.5 to No.9 are intact and oil tight. No.4 Tank is open to the sea though there is evidence that oil remains trapped in the structure of this tank.

275. The stern section lies on its port side and is subject to significant torpedo damage and structural collapse. All of the cargo tanks in the stern section are open to the sea and contain only small traces of oil. The stern section is known to be the source of the leak in 2010. Given the condition of this section of the hull, it is most likely this was from oil trapped in what remains of the bunker, service and settling tanks. While it is not believed that any significant quantity of oil remains in the stern, a slow leakage of residual oil from this section was observed during the course of the survey. It is believed that this slow leak is likely to continue for a considerable period.

276. After sinking, the bow section remained semi-buoyant for several days. The possible causes of this have been examined by a naval architecture review following the survey. The bow section was eventually sunk by a Royal Navy dive team but the actions they took to sink the bow and the impact on the oil tight integrity is not known; no reports relating to this event could be located.

277. Whilst the hull plating is in good condition, corrosion found in plate joints and rivets means that oil tight integrity is unlikely to be maintained for many more years as the hull deteriorates.

Unless action is taken, the oil will eventually be released to the environment, the most likely time for further release to occur is in heavy seas when the hull is subject to additional forces.

278. The survey combined with the naval architect review has produced an estimate of the oil remaining onboard. The total quantity of oil remaining on the bow section is estimated to be between 2326 and 4952 tonnes. During the onsite survey technical limitations made it impossible to penetrate the hull to make accurate tank level measurements. Consequently, this estimate cannot be further refined.

279. During the survey a sample of oil was taken from the area of slow leakage on the stern, the sample being collected as the oil seeped from the hull. This was analysed and found to be a light crude oil topped with some refined oil. The viscosity of the oil is such that at the water temperatures of St Helena, the oil will flow easily without additional heating.

280. The RFA *Darkdale* has become a locally important artificial reef supporting high biodiversity. Large populations of fish, several of which are endemic to the island and are listed as vulnerable, exploit the shelter and nursery ground provided by the wreck. The wreck is surrounded by maerl beds; an ecologically important habitat.

281. The environmental study collected water, sediment and fish samples which were returned to the UK for laboratory analysis. As there are no local standards to assess pollution by, samples were compared to the relevant European Quality Standards (EQS) which set acceptable limits for concentrations of pollutants.

282. Hydrocarbon contamination within the water column was generally found to be at low levels. Sediment samples were comparably more contaminated and levels of various hydrocarbon compounds exceeded EQS. The majority of the fish samples were found to contain low level hydrocarbon contamination, approximately 10% of the fish /shellfish sampled exceeded the relevant EQS.

283. Due to the concentrations of polycyclic aromatic hydrocarbons found within the fish samples, the independent consultants have, as a precautionary measure to protect human health, recommended that fishing in the immediate vicinity of the wreck be restricted. It must be stressed that this is a precautionary measure only and further, wider testing is required to verify the extent and level of fish contamination; it cannot be said with absolute certainty the contamination is attributable to the *Darkdale*.

284. The environmental study into the potential effects in the event of a large spill, found that there is a short term lethal risk to inshore fish species. The endemic reef fish are geographically isolated and therefore even if only a small proportion of the population is affected, the potential for recovery may be limited. Oil persisting in the environment would further hamper recovery of these species potentially causing long term sub-lethal effects.

285. Visiting ships routinely anchor very close to the wreck site and there is evidence of the wreck being contacted by anchor chain. Anchor chain could easily cause damage to the hull and result in a significant release of oil.

286. The prevailing metrological and oceanographic regime results in the majority of oil released from the wreck being transported offshore in a primarily north west direction. In the case of a larger spill, some oil will be transported into James Bay and there may be beaching of oil on the rocky coastline of the bay. Due to the location of the wreck, in the event of a spill it is unlikely that any effective recovery or containment mechanism could be implemented thus a significant proportion of the oil would be released in to the environment. The majority of this oil would either evaporate or undergo breakdown and weathering processes; however a proportion would undergo sedimentation where it would act as a potential source of persistent contamination in James Bay and the surrounding area.

287. Risk to the population from contaminated fish can be managed by prohibiting fishing, and damage to the wreck by ships anchors can be prevented by an anchoring exclusion zone however, these are short term mitigations that do not resolve the root cause. The eventual release of the oil is inevitable as the ship continues to corrode and the quantity on the wreck is large enough to cause a significant slick.

288. The socio-economic impact of an acute spill was assessed as being less than £100k. This is due to the tourist industry being in its infancy and the commercial fishing grounds being outside the area likely to be affected by a spill. The opening of an airport on the island in 2015 will mean that the economic impact of an oil spill will rise with time as the tourist industry grows.

289. The seabed surrounding the wreck was surveyed using side scan sonar and visually using a ROV as it was believed that there was unexploded ordinance on the seabed in the vicinity. A small number of shells were found on and within a few metres of the wreck however these are isolated to the wreck site. No evidence of munitions being scattered over James Bay was found, however, there are some areas within 200m of the wreck where cordite has been dispersed widely. If left in situ, this poses no risk to the general population of St Helena or vessels anchoring in the bay.

290. Removal of the oil from the wreck is technically possible, complicated only by the remote location of St Helena.

Recommendations

It is recommended that the following actions are taken to manage the risks posed by the wreck of the RFA *Darkdale*:

Recommendations for immediate action:

1. **St Helena Government is advised to impose a fishing ban over the wreck and immediate area.**

   The imposition of this ban will have no economic impact on the island's fishery but will ensure that the low risk attached to contaminated fish is mitigated.

2. **A larger sample of fish from a wider area should be taken and analysed for hydrocarbon contamination.**

   The samples size of the fish that identified the contamination hazard was very small and may not be representative of the wider fish population. A large sample should be collected to increase the certainty of the results.

3. **St Helena Government is advised to prohibit anchoring within 200m of the wreck site.**

   Anchoring close to the wreck is a significant hazard to the wreck. Setting an anchoring exclusion zone around the ship will change the custom and practice of anchoring for the *RMS St Helena* and visiting ships but the size of the bay means that other anchoring positions can be accommodated. By excluding anchoring close to the wreck, the risk of mechanical damage from anchor chains is greatly reduced.

Recommendations for action in the short term:

4. **The remaining oil on the wreck is removed.**

   Removal of the oil is the only practical solution to the threat of environmental damage. Release of oil due to the constant corroding of the wreck is inevitable unless the oil is removed.

   Removal is technically possible complicated only by the remote location of the wreck.

   It is recommended that due to the fragile nature of the wreck and the history of leaks, this work is carried out as soon as possible.

5. **A programme of fish and environmental monitoring is set up**

   If the larger sample of fish shows that there is a risk posed by contaminated fish, a programme of long term monitoring should be set up to assess the impact of any oil removal from the wreck and establish when contamination levels have dropped sufficiently to make the fish fit for human consumption without risk.

Bibliography

1. **Gurr, Governor Andrew.** Letter to Secretary of State for Defence requesting for assistance. 14 April 2010.

2. **Lloyds Register of Shipping .** *Navires A Vapeur Et a Moteurs 1944-1945.*

3. **Foreign and Commonwealth Office.** *White paper - The Overseas Territories; Security Success and Sustainability.* 2012.

4. **UN General Assemby.** *Paper St Helena.* s.l. : United Nations, 2009. A/AC.109/2009/5,.

5. **United Kingdom Hydrographic Office.** *Environmental Briefing - St Helena.* 2012.

6. **Master, Harbour.** *St Helena Harbour's Masters Record August to November 1941.* 1941.

7. *Log book of M/T Egero 23rd August to 30 October 1941.* s.l. : The National Archives of Norway.

8. Convoy Web. [Online] http://convoyweb.org.uk/hague/index.html.

9. M/T Nyholm. [Online] http://www.warsailors.com/singleships/nyholm.html.

10. U68. *Uboat.net.* [Online] (http://www.uboat.net/boats/patrols/patrol_480.html) .

11. **Merten, Korvettencapitain.** *U68 Log, Translated by Paul Arnold.*

12. **Young, Captain Rodney.** *Discussion on history of leaks from Darkdale and local conditions in James Bay.* April 2012.

13. E Mail: G.Proctor (MCGA)to A.Liddell (MoD). 2010.

14. **Fugro ERT.** *report no.2574 for the Maritime Coast Guard Agency.* 2010.

15. **Department for Energy & Climate.** *Extended guidelines for the use of the Bonn Agreement Oil Appearance Code (BAOAC). .* 2003.

16. **Salvage and Marine Operations.** *RFA DARKDALE - Desk based assessment.* 2011.

17. **RPS Group.** *Marine Environmental Impact research for RFA Darkdale.* 2012. RPA/RFA8975/TR/2.

18. *Corrosion rate trajectories of Concreted iron and steel shipwrecks and structures in sea water - The Weins Number.* **Johnson, D L, et al., et al.** 12, s.l. : Nace International, 2011, Vol. 67.

19. **Naval Design Partnership.** *RFA Darkdale Sinking Analysis.* 2013.

20. *Plans for arming Dale Class Tankers.* ADM 1/9762 Enclosure N.S.02002/38/2903.

21. **Lt. Colonel H.C. Gould, Commanding Officer British Forces, St Helena.** *An appreciation of the defences of St Helena.* August 1941. National Archives reference C0 820/50/20 St Helena Local Forces.

22. **Laruelle, Franck.** *Responding to spills in Remote Locations: Gulser Ana (Madagascar) & Oliva (South Atlantic).* s.l. : ITOPF, 2012.

23. **Foreign & Commonwealth Office.** *The Overseas Territories. Security, Success and Sustainability.* s.l. : HMSO, 2012.

Acknowledgments

The survey of the *Darkdale* was carried out by Salvage and Marine Operations supported by RPS Consultants.

The MOD survey team was:

Andy Liddell	Project Manager
Matt Skelhorn	Assistant Project manager/Researcher
John Semple	ROV pilot-technician
Gordon Vickers	ROV pilot-technician
Robert Coombes	ROV pilot-technician
Kim Purchase	Environmental Consultant

The RPS team was:

Neil Thomas	Principal consultant
Jon Ekhert	Senior consultant
Anna Prior	Senior consultant

The survey would not have been possible without the help and support of the local Government and community on St Helena. The team received help from many individuals however special thanks must go to:

Sanda Sim	Manager of Governor's Office for assisting in setting up the survey
Kerry Yon	Solomon Shipping, for helping with local support and logistics
Keith and Craig Yon	Skippers of "Starlight"
Jonny Herne	Skipper of "Seahorse"
Barry Williams	Harbour master
Derek Kaye	Andrew Weir Shipping, for his help in arranging the shipping of all the equipment and samples.

Master and crew of the *RMS St Helena* for providing useful local knowledge and for an enjoyable journey to and from St Helena.

Hazel Wilmot and all the Staff at the Consulate hotel for looking after the team during our stay on the island.

Jo Crewdson, Defence Maritime Geospatial Intelligence Centre for providing metrological and Oceanographic data.

Matt Howard from the Naval Design Partnership for the work on the naval architecture review.

Lucy Caesar, St Helena Museum for historical information and photographs

Photogrammetry and Computer Modelling – Defence Geospatial Intelligence Fusion Centre for modelling work.

Chris White, Historical RFA Website for assistance with background information.

Commanding Officer and Crew of HMS PROTECTOR for the multibeam images.

The Riksarkivet – The National Archives of Norway – For assistance with the *Egero* Log books

Deutsches U-Boot Museum – for the log book of U-68

Wurttembergische Landesbibliothek Stuttgart – for the torpedo log of U-68

The National Archives

Naval Historical Branch

Annexes

Contents

Annex 1 –Desk based assessment

MINISTRY OF DEFENCE

Preliminary risk assessment for the wreck of

RFA *DARKDALE*

Date of assessment	13 October 2010
Assessed by	Andy Liddell, Staff Officer Wreck Management, Salvage & Marine Operations

Contents

Desk based wreck risk assessment explanation

This risk assessment is a desk based assessment using the best available information at the time.

This assessment is to inform the Ministry of Defence whether any further survey work is required on the wreck in the interests of environmental protection or public safety.

The assessment is split in to a number of key factors each with a High, Medium or Low ranking; the final classification of the risk is based on an assessment of these factors and rated as shown below.

The overall risk of wreck is to be classified on the following scale;

A	Intolerable – the risk can not be tolerated, an on site survey is required to allow a more detailed risk assessment and inform any further actions.
B	Undesirable – the risk can be tolerated but wreck management plan is required
C	Tolerable – the risk can be tolerated but "as low as reasonably possible" (ALARP) status is to be demonstrated.
D	Acceptable – the risk can be tolerated, no requirement to demonstrate ALARP status

Executive Summary

Risk rating	A – Intolerable
On site survey required?	The risk can not be tolerated, an on site survey is required to allow a more detailed risk assessment and inform any further actions.

The RFA *Darkdale* was a fleet tanker and became a casualty of World War Two when she was sunk by *U-68* in 1941. The wreck lies off the remote South Atlantic Island of St Helena.

The position of the wreck is in James Bay; the only commercial anchorage for the island, 600m from the shore and the principal town of Jamestown. There are a limited number of large vessel anchorages in the bay and one of these is only 160m from the wreck.

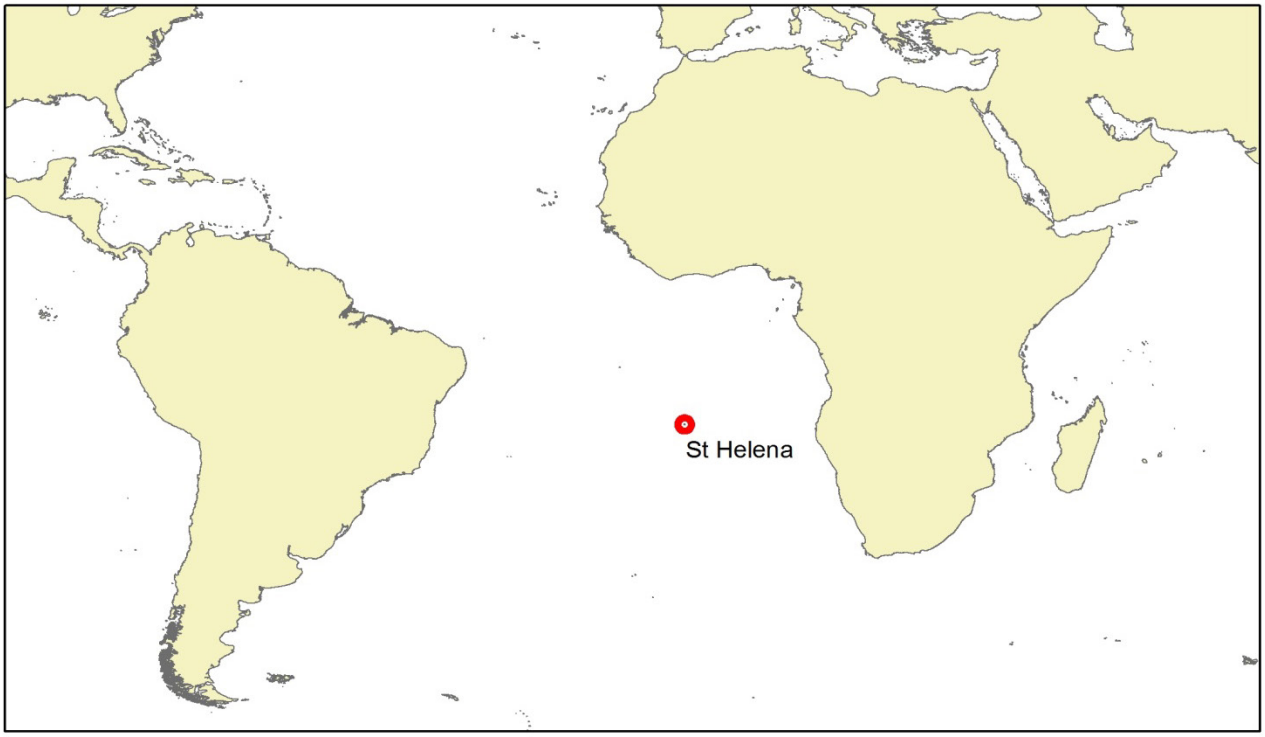
The ship was hit by up to four torpedoes, splitting the vessel into two sections. Despite the significant damage, the subdivision of the ship means it is highly likely that there is a significant quantity of oil remaining onboard. From this preliminary risk assessment, it is estimated that there could be up to 7745 tonnes of oil remaining on the wreck.

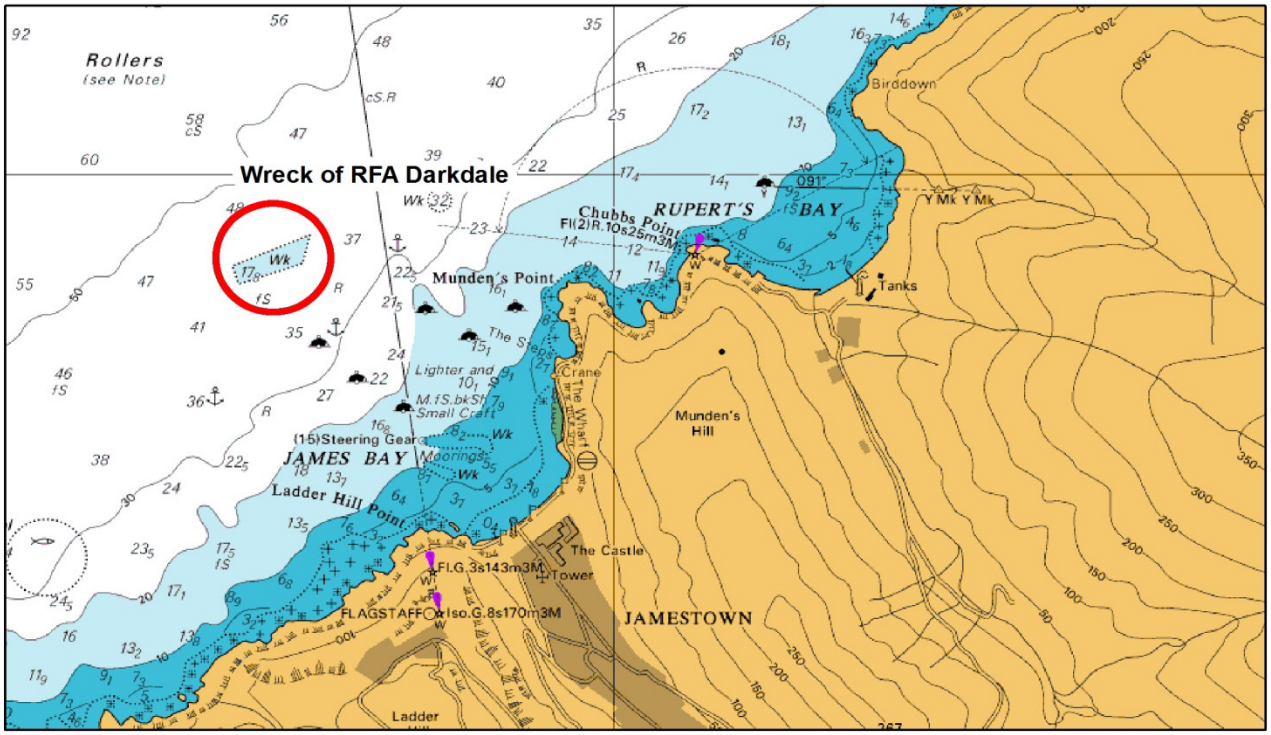
The wreck of the RFA *Darkdale* is known to have been slowly leaking oil since the time of sinking; the rate of leakage has historically been low. A larger release of oil occurred in March 2010 following a period of bad weather suggesting the structure of the wreck is significantly deteriorating and further releases may occur.

There is known to be a munitions hazard associated with the wreck but the scale of this problem is uncertain. There are munitions on the hull of the vessel and it is believed that there are also munitions scattered around James Bay.

It is recommended that an on site assessment is carried out to allow a fuller understanding of the wreck, the munitions and the potential for oil leakage. The impact on the local environment and potential impact on the food chain should also be assessed.

Location of the wreck





Vessel details

Vessel type	RFA Oiler
Vessel length	141.2m
Vessel beam	18.65m
Vessel tonnage	8145t
Date of construction	1940 (by Blythswood, Glasgow)
Propulsion type	Diesel

Vessel Image

(note: photo believed to be of a sister ship)

Latitude	15 55.1S	Longitude	005 43.4W

Description of position	James Bay, St Helena. 600 meters from the shore in 45m of water
Date sunk	22 October 1941
Fatalities	41 fatalities
Protected wreck site	No
History of sinking	RFA *Darkdale* left the UK in ballast on a convoy to Curacao in June 1941. She took on a full cargo of oil and Avgas in Curacao then sailed to St Helena, arriving on the 4th August 1941. She was then stationed as the Fleet tanker at James Bay, St Helena[1]. In the early hours of 22 October RFA *Darkdale* was attacked by *U-68* commanded by KorvettenKapitän Karl-Friedrich Merten. Extract of the War Diary of *U-68*[2]: *'0142 To firing position, course 148°, tanker bow on the left, heading 80-100°, distance 500m, 56m of water, distance to 15cm battery 1800m, small battery 2000m. Boat must be seen at any moment… Therefore decide definitely to hit the tanker with destructive force.* *0143 4 aimed single shots with a spread of impact points. Firstly 2 electric torpedoes, then 2 compressed air torpedoes, depth 4m.* *0144 Port diesel, emergency speed ahead veered off hard to starboard.* *After 32 seconds all 4 eels detonate at intervals of 1-2 seconds.* *1st hit: aft superstructure* *2nd hit: midships* *3rd hit: forward third* *4th hit: midships* *After 3rd detonation flames flare up, after 4th, one single huge sheet of flame. Nothing more can be seen of the tanker; but the water on fire with flames 20-30m.'* Although Merten states that all four torpedoes hit the *Darkdale* an on-site survey of the wreck is required to confirm this. Regardless of the number of hits the torpedoes caused a series of explosions that split the vessel in half. The stern section sank quickly but the bow remained partially afloat. Oil burned on the surface of the water for several hours after the attack.

Wreck History

At the time of the attack, it is believed that eight members of the ship's crew, including the Captain, were ashore on St Helena and survived. Only two members of the crew who were actually onboard when the ship was torpedoed were picked up, the remaining forty one crewmen were lost with the vessel.

Following the attack, the Captain submitted a report detailing the loss of his ship[3]. The Captain recorded that he was first alerted to the attack at 0040 on 22 October by two loud explosions on the port side of his ship. On reaching the Jamestown wharf the Captain observed his ship blazing furiously from end to end with the sea round about also on fire. The Captain noted that the ship continued to burn and that by 0400 two-thirds of the fore part of the vessel was still above water while the after part was completely submerged. According to the report, at around 0530 the *Darkdale* blew up and sank within five minutes. However, a photo of what appears to be the memorial service held on the wharf at Jamestown on the 25 October clearly shows part of the bow of the *Darkdale* still afloat at that time[4]. It should be noted that the Captain's report that he heard only two explosions may contradict Merten's assertion that all four of *U-68's* torpedoes struck the *Darkdale*. In addition, a report submitted by the Jamestown Harbour Master to the Government Secretary on 23 October 1941 notes three explosions occurring on the vessel. Whether these were from the actual torpedo strikes or occurred subsequently is not clear[5].

Some explosive clearance work on the wreck was undertaken by Royal Navy divers within two weeks of the vessel's loss but the exact details are unknown.

Vessel Assessment

Ref.	Criteria	High Risk	Medium Risk	Low Risk

1.1	Displacement of the vessel	Greater than 5000 tonnes	4999 to 1000 tonnes	Less than 999 tonnes

Vessel displacement 8145t

1.2	Condition of the wreck	Structurally intact	Moderate break down of structure	Structural collapse

The vessel is in two sections. From side scan images provided by UKHO[6], the break is roughly at amidships, likely to be in the region of the Pump Room. The UKHO side scan sonar images were taken in 1984 and are of low resolution; no further analysis is possible from these images.

Diver video provided by St Helena Government in May 2010[7] shows the bow section of the wreck to be largely structurally intact, no video was provided of the stern section.

The bow section is inverted and torpedo damage at the break point can be seen in the video. The majority of the hull appears to be externally undamaged.

There is very little marine growth on the hull and the condition of the steel and rivets appears to be good. The diver video showed only the upper parts of the hull, the condition of the hull closer to the seabed is likely to be the same.

The stern section lies on its port side approximately 10m from the bow section. There is debris from the wreck scattered around the seabed in the region of the wreck[8].

The shallowest part of the wreck is at 17m therefore it will experience pressure changes and water movement due to large swells. The recent larger release of oil may suggest that the internal structure of the wreck is significantly degrading.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
1.3	Estimated quantity of oil remaining onboard	More than 1000 tonnes	999 to 250 tonnes	Less than 249 tonnes

She had left Curacao in July with a full load of approximately 8000 tonnes of oil and had been stationed in James Bay since 4 August up until her sinking on 22 October. During this time she refuelled a number of other vessels, however, it has not been possible to establish the exact quantity of fuel transferred to these ships.

The *Darkdale* received additional fuel from the Norwegian tanker *M/T Egerø* on the 25 and 26 and again on the 28 September, this was presumably undertaken in order to extend the length of time that the *Darkdale* could remain at St Helena in her capacity as a Fleet oiler[9]. Although the log of the *Egerø* does not specifically state the quantity of oil that the vessel transferred to the *Darkdale* it notes that, prior to sailing to St Helena, the *Egerø* loaded 11095.05 tons (presumably of oil) at Abadan on 23 August. The figure probably includes bunkers for the *Egerø's* own use, though the log is not specific. The log further notes that, after leaving St Helena, the *Egerø* took on ca. 8000 tons diesel, ca. 2200 tons of fuel and eight casks with lubricating oil at Cape Town on 6 October[10]. According to the log, the *Darkdale* was the only ship that the *Egerø* refuelled between leaving Abadan and arriving at Cape Town. It is therefore believed that all of the 11095.05 tons, loaded by the *Egerø* at Abadan, with the probable exception of a quantity for its own bunkers, was transferred to the *Darkdale*.

The report submitted by the Captain in the aftermath of the attack details the amount and types of fuel that were on the vessel (presumably just prior to her loss, though this is not stated specifically.) The Captain's report notes:

> *'We had on board 3,000 tons of fuel oil, 850 tons of aviation spirit, 500 tons of diesel oil, also lubricating oil and coal.'*

Further evidence that the *Darkdale* contained a considerable amount of fuel at the time of sinking is provided by the War Diary of U-68. On 21 October, the submarine approached James Bay to conduct a reconnaissance of the harbour. The War Diary entry notes Kapitan Merten's assessment of the RFA *Darkdale's* state of loading:

> *'0536 …full of fuel, only at the bow one can see something of the waterline Colour'*

It is worth noting, however, the occasional tendency for U-Boat commanders to

exaggerate their victim's tonnage.

In addition to the oil in the *Darkdale's* tanks a considerable quantity of lubricating oil was apparently stored in drums on the vessel. The Harbour Master's report of 23 October 1941 notes that, following the loss of the *Darkdale*, 'about 130 drums have been landed' from James Bay. The exact quantity of this oil is unknown. As the drums were presumably stored on the upper deck and are likely to have either been destroyed or floated free during the attack this component can be discounted at the present day.

RFA *DARKDALE* – ST HELENA TIMELINE

4 Aug 1941 - RFA *Darkdale* arrived at St Helena

7 Aug - *HMS Orion* (Leander class light cruiser) arrived at St Helena and took on oil from RFA *Darkdale*.

The ship's log[11] for 7 Aug notes:

'0800 Hands employed cleaning ship and preparing for oiling'

'0900 Co. and spd as req. for going alongside R.F.A Darkdale'

'0938 Secured alongside'

'1000 O.C. Troops called on Captain.'

'1415 Hands employed preparing for sea'

'1438 Slipped and proceeded'

Note: There is no information from the log of *HMS Orion* on the quantity of oil taken from RFA *Darkdale* or the exact length of the oiling operation.

21 Aug - *HMS Albatross* (seaplane carrier) arrived at St Helena and took on oil from an 'oiler.'

The ships log[12] for 21 Aug notes:

'1530 Co: and speed as req: for going alongside oiler'

'1600 Secured alongside oiler'

'1925 All watches employed preparing to cast ship off oiler'

'1946 Ship proceeded to anchorage'

Note: There is no information from the log of *HMS Albatross* on the

quantity of oil taken from the 'oiler' or the exact length of the oiling operation. Although *RFA Darkdale* is not identified by name there is no information to suggest that any other oiler was present at St Helena on this date.

25 Aug - According to the Harbour Master's (HM) records[13], *HMS Cilicia* (Armed Merchant Cruiser) arrived at St Helena and took on oil from RFA *Darkdale*. However, the ship's log[14], while confirming the vessel's arrival at St Helena on 25 Aug, makes no mention of the ship receiving any fuel.

26 Aug - According to the HM's records, *HMS Jupiter* (J class destroyer) arrived at St Helena and took on oil from RFA *Darkdale*. No log from this ship for this date survives.

30 Aug - According to the HM's records, *HMS Avon Vale* (Hunt class destroyer) arrived at St Helena and took on oil from RFA *Darkdale*. No log from this ship for this date survives.

31 Aug - According to the HM's records, *HMS Eridge* (Hunt class destroyer) arrived at St Helena and took on oil from RFA *Darkdale*. No log from this ship for this date survives.

17 Sep - *HMS Eagle* (aircraft carrier) arrived at St Helena and took on oil from RFA *Darkdale*.

The ships log[15] for 17 Sep notes:

'1120 Oiler 'Darkdale' secured'

'2225 Completed fuelling'

The ships log for 18 Sep notes:

'0012 Oiler 'Darkdale' cast off'

Note: There is no information from the log of *HMS Eagle* on the quantity of oil taken from RFA *Darkdale* or the exact length of the oiling operation.

18 Sep - *HMS Dorsetshire* (County class heavy cruiser) arrived at St Helena and took on oil from an 'oiler.'

The ships log[16] for 18 Sep notes:

'0810 Oiler secured alongside'

'1415 Cast off oiler'

Note: There is no information from the log of *HMS Dorsetshire* on the

quantity of oil taken from the 'oiler' or the exact length of the oiling operation. Although RFA *Darkdale* is not identified by name there is no information to suggest that any other oiler was present at St Helena on this date.

23 Sep - According to the HM's records, *HMIS Sutlej* (modified Bittern class sloop) arrived at St Helena and took on oil from RFA *Darkdale*. No log from this ship for this date survives.

24 Sep - *HMS Repulse* (Renown class battlecruiser) arrived at St Helena and took on oil from an 'oiler.'

The ships log[17] for 24 Sep notes:

'0725 Secured oiler alongside'

'1330 Secured for sea'

'1500 Cast off oiler'

Note: There is no information from the log of *HMS Repulse* on the quantity of oil taken from the 'oiler' or the exact length of the oiling operation. Although RFA *Darkdale* is not identified by name (and there is a possibility that the oiler *M/T Egerø* was present at St Helena on this date – see below) it is assessed that *HMS Repulse* refuelled from RFA *Darkdale*.

24/25 Sep - *M/T Egerø* (oiler) arrived at St Helena (note: HM's records give the vessel's arrival date as 24 Sep, the log book of *M/T Egerø* (LB *Egerø*) gives the arrival date as 25 Sep.)

25 Sep - *M/T Egerø* supplied RFA *Darkdale* with fuel from 1030 – 1630 (LB Egerø.)

25 Sep - According to the HM's records, *HMS Encounter* (E class destroyer) arrived at St Helena and took on oil from *RFA Darkdale*. No log from this ship for this date survives.

26 Sep - *M/T Egerø* supplied RFA *Darkdale* with fuel until 1130, note: no start time is given (LB *Egerø*.)

26 Sep - *HMS Eagle* (aircraft carrier) arrived at St Helena and took on oil from RFA *Darkdale*.

The ships log for 27 Sep notes:

'0630 ??? Darkdale astern'

'0652 oiler let go anchor and secured astern'

'0830 Commenced pumping'

'0920 Commenced petrolling'

'1600 Petrolling completed'

The ships log for 28 Sep notes:

'0050 Oiler Darkdale cast off'

Note: There is no information from the log of *HMS Eagle* on the quantity of oil taken from RFA *Darkdale* or the exact length of the oiling operation. The 'petrolling' operation probably relates to the supply of Avgas for *HMS Eagle's* aircraft.

26 Sep - *HMS Dorsetshire* (County class heavy cruiser) arrived at St Helena and took on oil from an 'oiler.'

The ships log for 26 Sep notes:

'1345 Secured oiler alongside starboard side'

'1900 Cast off oiler'

The log includes the following information on changes to the vessel's draught as a result of refuelling:

Draught

	F'D	*Mid*	*Aft*
Before oiling	*18ft*	*19¾ft*	*21½ft*
After oiling	*21½ft*	*22ft*	*22½ft*

Note: There is no information from the log of *HMS Dorsetshire* on the quantity of oil taken from the 'oiler' or the exact length of the oiling operation. Although RFA *Darkdale* is not identified by name and the oiler *M/T Egerø* was present on this date, it is assessed that *HMS Dorsetshire* was refuelled from RFA *Darkdale*.

28 Sep - *M/T Egerø* supplied RFA *Darkdale* with fuel from 0910 – 1405 (LB *Egerø*.)

14 Oct - *HMS Euryalus* (Dido class light cruiser) arrived at St Helena. According to the HM's records the ship took on oil from RFA *Darkdale* but the ship's log[18], while confirming the vessel's arrival at St Helena on 14 Oct, makes no mention of the ship receiving any fuel.

This is not assessed to be an omission as an earlier entry in the ship's log (for 8 Oct) contains detailed information of a refuelling operation

undertaken while the vessel was at Freetown, Sierra Leone.

The HM's records note that *HMS Heythrop* and *HMS Farndale* (both Hunt class destroyers) arrived on the same date. No logs from these ships for this date survive.

The log from *HMS Euryalus* suggests that the vessel was operating in company with *HMS Heythrop* and *HMS Farndale*. It is tentatively assessed that the three vessels arrived at St Helena together but only the two destroyers received oil from RFA *Darkdale*.

22 Oct - RFA *Darkdale* sunk.

02 Nov - According to the HM's records, *HMS Milford* (Shoreham class sloop) arrived at St Helena with divers to carry out an inspection of the wreck. It is believed that some explosive clearance work was undertaken to reduce the hazard the wreck posed to other shipping and also, presumably, to determine what exactly had caused the loss of the ship. A local historian has compiled information on the event but exact details are not available[19]. No log from this ship for this date survives.

RFA *Darkdale* received oil from *M/T Egerø* on 25 and 26 September and again on 28 September. After fuelling from the M/T Egerø on 28 September the available records tentatively suggest that the only ships to refuel from RFA *Darkdale* were the two Hunt class destroyers *HMS Heythrop* and *HMS Farndale* on 14 Oct. The Hunt class were small escort destroyers (displacement 1000t.) The amount of oil that these vessels took on is likely to have been comparatively small.

Based on the report on the loss of the *Darkdale* by the ship's Captain it would appear that immediately prior to sinking on 22 October 1941, RFA *Darkdale's* tanks were at approximately half capacity. However, the accuracy of these figures is questionable. The probable complete refuelling of the *Darkdale* by the *M/T Egerø* suggests that far more fuel was present on the vessel at the time of her loss and other information in the Captain's report is demonstrably wrong:

1. He states that the *Darkdale* had 50 crew members (including himself) and that 41 were missing as a result of the loss of the ship. However, he then accounts for 10 survivors rather than the 9 suggested by his initial comment.

2. He states that 'By 0400 two-thirds of the fore part of the ship was still above water and the after part was completely submerged. About 0530 the *Darkdale* blew up and sank within five minutes.' However, as noted above, a photograph, apparently taken at the memorial service for the crew held at Jamestown on 25 October (ie 3 days after the attack) shows the bow of the ship still afloat at this time.

It is possible that the figures given in the Captain's report relate to the amount of fuel on the *Darkdale* when she arrived at St Helena rather than the amount remaining

aboard when she was lost. However, this seems unlikely and the wording does not imply that this was his intention. As a result of the discrepancies noted above and because of the conflicting information gleaned from the log of the *M/T Egerø* it is assessed that, immediately prior to the submarine attack, the tanks of the RFA *Darkdale* were at, or near, full capacity.

However, a significant quantity of oil will have been lost during the sinking as the contemporary reports describe the sea burning for several hours after the sinking. The explosion when the torpedoes impacted is likely to have been the Avgas igniting, it is not anticipated that any Avgas will remain on the wreck.

The *Darkdale* is a 9 hold design subdivided in to port, centre and starboard tanks and is single skinned[20]. This large number of tanks means that despite the damage from the torpedoes, it is likely that a significant quantity of oil remains in some of the tanks. This is backed up by the length of time the vessel has been known to be leaking.

The St Helena Government arranged for samples of the oil to be collected from the sea surface and sent for analysis. These samples show the oil to be similar to a light crude or marine fuel/topped crude[21]. The closest comparable oil is an Iranian Light Crude. It has low/medium viscosity and the lab reports show it is capable of flow in the water temperatures around St Helena. The oil has not been thermally cracked and is unrefined by modern standards.

The estimated maximum quantity of bunker and cargo oil now remaining onboard is 7000 tons. It is not expected that any AVGAS remains onboard. This estimate is derived from the number and lay out of the tanks and an assessment of the damage.

As no cargo manifest is available for the vessel, this is a worst case estimate taking account of the oil received from the *M/T Egerø*. Based on this, it is estimated that the *Darkdale* had a cargo fuel loading of circa.11000 tons at the time of sinking; though there may have been significantly less oil onboard.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
1.4	History of the vessel leaking oil	History of significant leaks	Not known or history of minor leaks	No known leaks

The vessel is known to have been leaking oil slowly since the time of sinking.

A larger release of oil occurred in March 2010[22] following a period of bad weather and heavy seas. It is conceivable that further large releases of oil may occur with bad weather.

The video of the bow section shows a small steady leak of oil, the flow rate at the time the video was shot is estimated to be not greater than 100 litres per day. Local reports of this leakage rate say there is a sheen of oil over a large part of James Bay and out to sea.

1.5	Estimated quantity of munitions onboard	Greater than 100 tonnes NEQ	Not known or 100 to 50 tonnes NEQ	Less than 50 tonnes NEQ

According to the report submitted by the Captain of the *Darkdale* following her loss the ship's armament comprised:

1 x BL 4.7in gun

1 x 12 pdr gun

2 x Pig troughs

2 x Hotchkiss machine guns

2 x Marlin machine guns

2 x Lewis machine guns

Kites

Parachute And Cable (PAC) rockets

(note: 'Pig trough' was an anti-aircraft launcher comprising fourteen two-inch rockets mounted vertically in two rows of seven and fired vertically against attacking aircraft. Kites were large box kites that were used in a similar way to barrage balloons as an anti aircraft deterrent. PAC rockets comprised a single large rocket that was fired into the air in the event of an aircraft attacking the ship, the rocket was attached to a length of cable which descended slowly by parachute. If the wire fouled the aircraft it could cause it to crash.)

Determining the amount of ammunition carried by the RFA *Darkdale* is difficult. The armament of Dale class vessels varied and no document has been found which gives the quantity of 4.7 in ammunition likely to have been stowed. However, a pre-war document gives details of the number of shells provided to Dale class vessels armed with 1 x 4in BL LA gun and 1 x 3in HA gun, noting that they had space for forty eight 4in and forty 3in rounds. This may have been increased to eighty eight 4in and eighty 3in rounds. On the basis of this information, it is likely that the wreck contains a minimum of one hundred rounds of the larger 4.7 in ammunition and possibly considerably more. The same document mentions that the 12 pdr gun is likely to have been provided with ninety eight rounds of ammunition[23]. The quantity of rockets and machine gun ammunition is unknown.

Plans of the *Darkdale's* sister ship, RFA *Cairndale*[24], show that she carried her 4in gun right aft. The ships 12 pdr gun was also mounted aft, on the port side of the boat deck next to the motor room skylight. It is likely that the *Darkdale's* 4.7in gun and 12 pdr were similarly arranged. The position of the other armament is speculative although it is probably that it was concentrated in areas, such as the bridge and near the prow of the ship, affording the best fields of fire.

In addition to the ammunition carried by the *Darkdale*, the diver's video of the wreck shows shells on the upturned hull of the bow section. Given their location, it is unlikely that these originated from the ship. The quantity of munitions on the hull cannot be estimated from the video. Locally it is believed that there are also shells scattered across the seabed of James Bay[25,] the accuracy of this claim and the source of the munitions is debatable.

Until the shell types have been identified by munitions experts, the munitions should be treated with extreme caution and disturbance avoided.

The video has been reviewed by the Defence Ordnance Safety Group (DOSG) but it did not show sufficient detail for them to be able to identify the shells or advise on the specific risks posed by them[26].

It is possible that the munitions originate from the two 6in BL Naval guns that were stationed on St Helena as a defensive measure. An appreciation of the defences of St Helena written in August 1941 by Lieut. Colonel H.C. Gould, the Officer Commanding the forces on the island, notes the presence of these guns and also '2 D.E.L. H.C.D. at MUNDENS' (the nature of these has not been determined.)[27] If ammunition from the 6in guns was dumped "in deep water" at the end of war it is possible it was actually dumped on the wreck site of the Darkdale. This would explain how shells are on the upturned bow section of the vessel. Early shells for 6in guns were lyddite filled which can sensitise over time if picrate salts are formed. Later shells were filled with more stable explosive. In addition, the War Diary of *U68* notes that, besides the 6in battery, a second small calibre battery was present on the island (this may refer to the D.E.L. H.C.D. noted above.) If ammunition from this second battery was also dumped offshore at the end of the war it might explain the mix of different sized shells apparent on the diver videos of the wreck.

Although the Captain of *U-68* noted 4 hits from the 4 torpedoes fired by the submarine there remains the possibility that some may have missed their target or that not all of those that hit actually exploded. In support of this possibility it should be noted that the Captain of the *Darkdale*, in his report on the loss of the vessel, noted only two loud explosions on the port side of the ship. Although the diver videos indicate considerable explosive damage to the wreck it is debatable whether this is as severe as might be expected from the detonation of 4 torpedoes. If any of the torpedoes missed there is the possibility that they may have come to rest on the surrounding seabed. Of greater concern is that one or more armed torpedoes that failed to detonate may still be contained within the wreck.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
1.6	Hazardous material present	Hazardous material present	Not Known	No hazardous material present
	It is not known if any hazardous materials are present on the wreck.			

Site Assessment

Ref.	Criteria	High Risk	Medium Risk	Low Risk
2.1	Distance to shore	Less than 12nm	12 to 24nm	More than 24nm

The vessel is 600m from shore in the centre of the James Bay. This is the only anchorage to support the island and is frequently used by large ships.

There are several anchoring positions shown on the Admiralty chart, the closest is 160m from the wreck.

2.2	Water depth of the wreck	Less than 50m	50 to 100m	More than 100m

The vessel lies in 45m of water. The top of the wreck is at 17m.

The vessel has previously leaked during heavy seas therefore it is shallow enough to be influenced by sea state.

2.3	Mobility of seabed	Highly mobile	Moderately mobile or not known	Stable

The Admiralty chart shows the seabed in the area of the wreck to be fine sand. This is not a high current area and the seabed is believed to be stable.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
2.4	Wreck site subject to strong tides or currents	greater than 1kn	1kn to 0.5kn	Less than 0.5kn

There is a small tidal range in the bay and a current offshore around the island are north westerly at circa 0.3kn[28].

The currents within the bay are not measured however local divers report the bottom currents as negligible.

2.5	Likelihood of weather negatively affecting the wreck.	High likelihood	Moderate Likelihood	Low likelihood

The prevailing winds over the wreck site are North Westerly, which is away from the island. This reduces the likelihood of oil being driven by wind in to James Bay or on to the beaches of St Helena. This is evidenced by the drift of the oil from the release in February 2010, the oil circulated in the bay and came close to the beaches but there were no reports of oil stranding.

The closest land to the North west of St Helena is Ascension Island 670nm away. It is unlikely that oil would be wind driven to Ascension Island due to the complex winds of the equatorial region.

2.6	Proximity to Marine Protected Areas	Less than 12nm	12 to 24nm	More than 24nm

The wreck does not lie within a Marine Protected area and there are no protected areas around St Helena.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
2.7	Proximity to other areas of special environmental protection or sensitivity	Less than 12nm	12 to 24nm	More than 24nm

No information is available on the local environment.

St Helena Government was contacted for advice but no response was received.

As the island is geographically isolated and has had limited commercial exploitation, it is likely that the marine environment will be pristine. For the purposes of this risk assessment, a worst case scenario is being adopted and it is being assumed that there are sensitive areas in the region of the wreck.

2.8	Proximity to nearest major town or city	Less than 12nm	12 to 24nm	More than 24nm

The principal town on St Helena, Jamestown is 600m from the wreck site.

2.9	Proximity to significant industry or Infrastructure	Less than 12nm	12 to 24nm	More than 24nm

There is no heavy industry on the island, however the majority of the commerce of the island is in Jamestown[29], 600m from the wreck.

Jamestown is also the only port facility on the island and all supplies to the island and exports from it are sent via the port.

The fuel farm for the island is located east of the wreck site, approximately 1nm from the wreck.

The water supply for St Helena is via bore holes on the island[30]. There is no desalination plant on the island and therefore no risk of local water supplies being affected by oil leakage.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
2.10	Proximity to a tourism or leisure area	Less than 12nm	12 to 24nm	More than 24nm

Tourism is an important industry for St Helena, it accounts for 3% of the GDP of the island[31]. This is a relatively small percentage but as 70% of the island's income is from UK subsidy, this percentage is very significant.

The majority of the tourist visits to St Helena occur via cruise ships or the Royal Mail Ship St Helena. These anchor in the bay within 400m of the wreck site and are taken ashore by small boat.

A small number of tourists also visit by yacht, anchoring in the bay.

The St Helena Government sustainable development plan is aiming to increase tourism, however a major spill in the bay could seriously impact the tourist industry in the short term.

2.11	Proximity to sites of cultural interest eg. World Heritage Site	Less than 12nm	12 to 24nm	More than 24nm

There are no World Heritage Sites on St Helena.

There is the historic wreck of a Dutch East India Company vessel within the bay. The wreck is the "*De Witte Leeuw*" (White Lion) and is owned by the Dutch Government who wants the wreck "preserved in place"[32]. In addition, prior to the construction of the Suez Canal, St Helena was an important mid-Atlantic stop for ships travelling to and from India and the Far East. There is evidence to suggest that several other vessels were wrecked around the island, most notably during a storm in 1846[33]. It is unlikely that these wrecks will be affected by oil leaking from *Darkdale*.

Ref.	Criteria	High Risk	Medium Risk	Low Risk
2.12	Fisheries value of the wreck site area	High economic value	Medium economic value	Low economic value

Fishing is an important industry for St Helena with exports representing a significant income for the island[34].

The main commercial fishery for St Helena is deep water pelagic, this is unlikely to be affected by any oil leakage from *Darkdale*[35].

Shore and boat fishing does take place in James Bay. The shallow water fish and shell fish in this area may be contaminated with polycyclic aromatic hydrocarbons that are contained in the oil emanating from *Darkdale*. If consumed, the human body metabolises these compounds into carcinogens.

There is no aquaculture on St Helena.

2.13	Area subject to offshore development	Large amount of development	Moderate amount of development	No development

St Helena is a volcanic island with very steeply shoaling bathymetry. The seabed drops to over 1000m within 1.5 nautical miles of the shore. This means it is unsuitable for offshore development using current technology.

2.14	Is the wreck used for recreational Scuba diving	Frequently used	Occasional use	Rarely or never used

The site is regularly dived by the local scuba diving company and visiting tourists, however compared with many UK dive sites, the number of visitors is low.

The lack of a recompression chamber means that diving around St Helena is normally shallow diving only.

Analysis of the wreck risks

The RFA *Darkdale* was an 8000 ton tanker that sank sixty nine years ago as a result of up to four torpedo strikes from *U-68*. The vessel broke up in to two parts as a result of the strikes and the two sections now lie roughly 100m apart. From the information available, each appears to be structurally intact and in good condition for a vessel submerged for sixty nine years.

There is very little marine growth on the wreck allowing a good view of the shell plating. There is wastage of the steel, which appears to be worse in the areas of torpedo damage but the amount of wastage is unknown. Typical steel wastage rates for ship wrecks in temperate waters are in the region of 0.1 to 0.3mm per year; it would appear that *Darkdale* is at the lower end of this range.

Since the time of sinking the vessel has been slowly leaking oil proving that there was a significant quantity of oil remaining on the wreck after sinking. There is no formal record of when leaks have occurred, however local anecdotal reports suggest that the leakage is continuous but that the rate is variable. Periods of heavy weather with large seas cause the rate of leakage to increase.

From the diver video it is apparent that there is at least one leak from the bow section of the wreck but no video was taken of the stern section. It is unknown if there are any leaks from this section.

The vessel suffered up to four torpedo strikes, one of which hit close to the bow in the region of the forepeak/deep tank or no.9 cargo tank (the furthest forward cargo tank.) The large explosion seen by the submarine and from shore is most likely the aviation spirit tanks exploding and is probably what caused the vessel to split in two. There were two sets of aviation spirit tanks, located immediately forward and aft of the forward accommodation block. The size of the two sections of the wreck would suggest that the explosion of no.4 tank of aviation spirit caused the spilt. The explosion of at least one set of aviation spirit is likely to have caused adjacent tanks to rupture.

The location of the remaining torpedoes is unknown. However as the war diary states that *U68* approached the ship on the surface whilst the *Darkdale* was at anchor, it is likely that they also hit the target. This will, however, have to be confirmed by an on-site inspection of the wreck.

The vessel is subdivided in to twenty seven cargo tanks with each cargo tank having a capacity of roughly 300m^3 plus bunker tanks totalling approximately 600m^3. From what can be seen in the video, the vessel was not structurally destroyed by the torpedoes and it is known that the bow section stayed afloat for some time after the attack showing that some of the tanks were intact and providing buoyancy. If the empty tanks could provide buoyancy, it is logical to assume that any full cargo tanks would also remain oil tight. It is likely that there is still a significant quantity of oil remaining in the undamaged tanks.

The condition of the wreck will degrade with time and the larger release oil in March 2010 may be an indication that the structure of the vessel is beginning to fail.

The type of oil onboard the *Darkdale* is a similar to a light crude oil with a low/medium viscosity and is unrefined by modern standards. It is capable of flowing in the water temperatures of St Helena as shown by the leakage. The unrefined nature means that it contains more impurities than refined oil and is therefore more damaging to the environment.

The oil pollution is unlikely to affect the commercial fishery however it may affect the fish caught recreationally or shell fish collected from the shore. These fish are more likely to be contaminated than the fish from further offshore caught by the commercial boats. Contamination by polycyclic aromatic hydrocarbons is damaging to human health.

St Helena has a fragile economy and receives a large subsidy from the UK Government which accounts for 70% of the national income. There is a development plan for the island which aims over time to make the island more self sufficient; this identifies tourism as a key area for growth. Any negative effects of an oil leak from the wreck will have far greater impact in this location than they would on a developed economy.

The position of the wreck close to the principal town on the island means that the wreck could have a significant impact on the local population if a large release of oil was to occur. The likely impact on the local population is a loss of fishing revenue and tourism; however this impact is likely to be relatively short term as the principal currents and prevailing winds will take the oil to the North West. Some oil would undoubtedly be taken into the bay which could impact the re-supply of the island in the short term.

The fate of the oil after it has drifted clear of St Helena is not known but as the oil is a heavy grade, it will take a significant time to degrade in the marine environment.

Risk Rating A - Intolerable

[1] RFA *Darkdale* - http://www.historicalrfa.org/rfa-darkdale - last accessed 30 Jun 2011

[2] Kreigstagebuch des Unterseebootes "*U68*" – covering 2 Aug 1941 – 25 Dec 1941

[3] ADM 199/2138 Survivors' Report: Merchant Vessels - 1941 Aug. – Oct. - Report of an interview with the Master, Captain T.H. Card. R.F.A. "*Darkdale*"

[4] The loss of RFA *Darkdale* - http://www.historicalrfa.org/archived-stories/856-the-loss-of-rfa-darkdale - last accessed 28 Sep 2011

[5] Re: Loss of RFA *Darkdale* – Report from the Harbour Master to the Government Secretary dated 23 Oct 1941 – Copy held in the St Helena archives, Jamestown

[6] United Kingdom Hydrographic office - Survey by *HMS Herald* 1984

[7] Video shot by Local Divers for the Governors Office. Sent to MOD by FCO 11 Mar 2010

[8] Telephone conversations A.Liddell and local divers, Aug 2010

[9] Log book of Norwegian oiler *M/T Egerø* for the period 23 Aug – 30 Oct 1941 – details provided in a letter from the Riksarkivet – The National Archives of Norway dated 3 May 2011

[10] Log book of Norwegian oiler *M/T Egerø* for the period 23 Aug – 30 Oct 1941 – details provided in a letter from the Riksarkivet – The National Archives of Norway dated 20 Oct 2011

[11] ADM 53/114826 *Orion* 1941 Aug

[12] ADM 53/113556 *Albatross* 1941 Aug

[13] St Helena Harbour Master's Record – Aug – Nov 1941

[14] ADM 53/113921 *Cilicia* 1941 Aug

[15] ADM 53/114194 *Eagle* 1941 Sep

[16] ADM 53/114137 *Dorsetshire* 1941 Sep

[17] ADM 53/114982 *Repulse* 1941 Sep

[18] ADM 53/114248 *Euryalus* 1941 Oct

[19] The story of the '*Darkdale*' – Part 2 "A Sitting Duck" - http://www.historicalrfa.org/archived-stories/1163-the-story-of-the-darkdale-part-2-qa-sitting-duckq last accessed 28 Sep 2011

[20] From plans of a sistership RFA *Dingledale* - no plans of RFA *Darkdale* can be located

[21] ERT oil analysis report no. 2574 dated 4 Jun 2010

[22] Source – St Helena Governors Office, email 5 Mar 2010

[23] ADM 1/9762 Enclosure N.S.02002/38/2903 No title – Plans for arming Dale Class vessels

[24] R.F.A "*Cairndale*" – General Arrangement

[25] Letter from St Helena Governor to MOD 4 Apr 2010

[26] Email from DOSG to S&MO 18 Aug 2010

[27] C0 820/50/20 St Helena local forces

[28] Currents from modelling provided by UKHO Maritime Geospatial Intelligence Centre for S&MO

[29] From the airport feasibility study by Atkins Consulting

[30] Communications with E.Manley, St Helena Government, 29 Jul 2010

[31] St Helena Government sustainable development plan 2009/2010

[32] Letter from Dutch Embassy to Foreign and Commonwealth Office 10 Jul 2006

[33] F088 – Shipwrecks at James Town and the Harbour, Saint Helena - http://www.nmm.ac.uk/collections/prints/viewPrint.cfm?ID=PAI0414 last accessed 04 Jul 2011

[34] Report to the UN General Assembly, A/AC.109/2009/5

[35] Emailed advice from CEFAS to St Helena Government 3 Aug 2010

Annex 2 - Pre survey assessment of possible oil content

Pre survey assessment of possible oil content

Date	Vessel	Ship disp	Estimated Quantity discharged (M3)	FO ROB *Darkdale*	
Departure condition				15727	based on all tanks being 90% on departure load port
07 August 1941	*HMS Orion*	7215	700	15027	
21 August 1941	*HMS Albatross*	4000	400	14627	
25 August 1941	*HMS Cilicia*	11000	100	14527	
26 August 1941	*HMS Jupiter*	1690	150	14377	
30 August 1941	*HMS Avon Vale*	1340	100	14277	
31 August 1941	*HMS Eridge*	1340	100	14177	
17 September 1941	*HMS Eagle*	22790	2000	12177	
18 September 1941	*HMS Dorsetshire*	9975	250	11927	
23 September 1941	*HMIS Sutlej*	1250	100	11827	

24 September 1941	*HMS Repulse*	26500	2000	9827	
24 September 1941	*M/T Egerø*			9827	Resupply figure included in 28th Sept figure
25 September 1941	*HMS Encounter*	1375	100	9727	
26 September 1941	*M/T Egerø*			9727	Resupply figure included in 28th Sept figure
26 September 1941	*HMS Dorsetshire*	9975	250	9477	
27 September 1941	*HMS Eagle*	22790	500	8977	Resupplied 10 days previous, unlikely to have taken large fuel load
28 September 1941	*M/T Egerø*		-8000	16977	Times for *Egerø* loading not fully noted in log book however loading figures before and after Darkdale resupply indicate a ship to ship transfer of at least 8000t
14 October 1941	*HMS Euryalus*	12000	250	16727	No mention in the ships log of taking fuel however it is unlikely the vessel would miss the opportunity to refuel
14 October 1941	*HMS Heythrop*	1340	100	16627	
14 October 1941	*HMS Farndale*	1340	100	16527	
		Fuel onboard prior to attack		**16527**	M^3

After Action assessment

Loss due to torpedo attack	4500	Based on a total of 9 tanks being open to the sea
R.O.B after sunk	10300	
Estimated Leakage rate per year	36.5	Estimated on 100L per day over entire period. Current leakage rate is probably higher but there was a period when the ship leaked little oil
Leakage since sinking	2555	
Remaining onboard 2011	**7745**	M^3

Annex 3 – Post survey assessment of oil content

This assessment was carried out following the survey on the basis of what tanks remain intact and the calculated capacity. No account is taken of the buoyancy or how the bow section could end up in the attitude seen in figure 25. The figures produced by the naval architecture review are considered to be more accurate.

Tank		Contents at 90% full (m3)	Remaining onboard (m3)	Notes
1	P	503	0	Not possible to ascertain condition however given damage to the rest of the region it is highly unlikely that this tank will be oil tight or contain significant quantities of oil. Small amounts may remain in between frames/stiffeners.
	C	627	0	Severe damage, not oil tight. Internal penetration with LBV showed oil in between stiffeners in small quantities with bacterial growth
	S	503	0	Severe damage, not oil tight. Internal penetration with LBV showed oil in between stiffeners in small quantities with bacterial growth. Site of oil leak in 2010 and collection site for the sample taken during the survey. Oil may be migrating from ships bunker tanks
2	P	511	0	Site of torpedo impact, open to the sea with heavy plate deformation.
	C	616	0	Open to the Sea
	S	511	0	Open to the Sea
3	P	631	0	Hold obliterated, all plating now lies in the debris field - no oil
	C	559	0	Hold obliterated, all plating now lies in the debris field - no oil
	S	631	0	Hold obliterated, all plating now lies in the debris field - no oil

	P	581	25	Penetrated with LBV. Aft bulkhead partially missing, some oil remains but in limited quantities
4	C	700	25	Penetrated with LBV. Aft bulkhead partially missing, some oil remains but in limited quantities
	S	581	25	No penetration possible and unable to establish the condition of the aft bulkhead due to large number of fishing line tangled on wreck and discarded divers shot lines
	P	417	417	Intact
5	C	503	503	Intact
	S	417	417	Intact
	P	683	683	Intact
6	C	616	616	Intact
	S	683	683	Intact
	P	477	477	Intact
7	C	584	584	Intact
	S	477	477	Intact

8	P	491	491	Intact
	C	659	659	Intact
	S	491	491	Intact
9	P	383	383	Intact
	C	680	680	Intact
	S	383	383	Intact
		Contents at 90% full (m3)	**Remaining onboard (m3)**	
Total (m^3)		**15,727**	**8,019**	

Annex 4 – KorvettenKapitän Merten's account of the attack

25/08/2011
Translated by: Paul Arnold
Assisted by: Bob Townsend (ex RN Submariner)

Notes:

1. Quality of copies of German documents is poor in places – a lot of print through from presumable carbon copies. The figures on the detailed chart were particularly hard to read.

2. There is one handwritten annotation (p.30) which cannot be deciphered – but it does not appear to be the same hand as the submarines commander Merten.

3. I have also translated p.27, the events of 21.10 as they give some interesting background to the attack; a detailed description of the tanker, Merten's observations of the defences on St. Helena and his manoeuvring on the day (which does tally with the chart).

4. The highlighted sections (p28-30), events of 22.10 cover the attack and its aftermath; I have also translated the remaining entries for that day.

5. Almost all of the naval abbreviations used in the text have been identified (Bob found a helpful internet site). There are however a few 2-letter groups (e.g. 'rw' p27) for which likely meanings are given. These are informal shorthand for positions within a sea square used by U-boat commanders.

6. Where additional explanations are needed from the translator these are identified by [ ].

7. Merten is in no doubt that he achieved four hits with two types of torpedo. The odd personal comment in the log gives some insight into his character. Obviously he does not name the *Darkdale*.

8. Presumably your team are aware that Merten was one of the most successful and distinguished U-boat commanders. He survived the war and died in 1993. A BBC drama-documentary of a year or so ago detailed his role in the sinking of the *City of Cairo* and presented him in a fairly sympathetic light.

9. *U-68* survived until 10th April 1944 when it was sunk off Madeira with one survivor.

10. All German documents returned with this translation. I have kept a copy in case you have any further questions.

Top Secret

War Diary of Submarine *U-68*

2nd Patrol

Started 2.8.1941
Completed 25.12.1941

Commander: Korvettenkapitän (Lieutenant Commander) Merten

Distribution: 2x Naval High Command
1x Supreme Commander, Submarines
1x 2nd Admiral (?) of Submarines
1x 2nd U-boat Flotilla

21.10	South Atlantic, St. Helena	
0000	FU 2487	I intend to station myself immediately off the roadstead of Jamestown at dusk, dive and have a look at the town and harbour through the periscope. As I was in Jamestown in 1927 I will easily be able to establish whether any substantial changes have been made.
0145		2 lights of St. Helena in view, periodically disappearing in rain showers. RW [far right?], 150°, course 165° 9 sm (sea miles)
0322	FU 2735	0322-0335 set course from north of the island to a point rw 1500 5.5 sea miles off Jamestown 0716.
0400	Wind 2-3, swell 2. Slight swell, moderate visibility.	
0536	Dived, course 90°. Slow ahead. Running E until daybreak so as them to run along the length of the island in S courses. [i.e zig-zags]	Tanker made out in James Bay, confirmed. Projecting power, cruiser stern, 2 masts, bridge 1/3 length from bow, short loading mast fore and after of bridge, funnel not very tall exactly in the middle of stern superstructure. Hull painted black, superstructure yellowish-brown; at the bridge and stern superstructure extending in narrow stripes over outer decks. Funnel yellow-brown with black cap ring. Confirmed as Anglo-Saan* tanker, Daring class, approx 8100 GRT. Full of fuel, only at the bow can one see something of the waterline colour. (I) intend to blow it up this night, since by doing so there is the possibility of diverting suspicion to armed merchant men. Tanker is laying approx 600m distant from land and is swinging between 130-180° heading. It is lying immediately below the newly installed harbour battery, 3-4 15cm cannons on Munden Point, 20m above sea level. I recognise these as new. Further work is also in progress. Approx 100-150m north of the battery are 2 search lights. No other vessels apart from fishing boats discerned in the harbour. No appreciable changes in Jamestown itself. The coal store by the rocky cave north of the town did not appear to have been substantially reinforced.

(P.28)

		Oil tanks were nowhere to be seen. A fairly large barracks site has been erected South of the town on High Knoll directly by the rocky court, approx 50m high. This also encloses the earlier signal station. On the right, i.e south of the new barracks is a newly erected small calibre battery. High Knoll which was previously only sparsely settled has been greatly built up. Nothing could be observed of air force installations.
0800	FU2735 Submerged	Went 270° to move away. Half speed 4.1 sea miles
0835		
1200	FU2726 Submerged	Surfaces approx 18 sea miles off, running off in squally rain, 12 sea miles.
1324-1348		Course 270° economy drive/speed.
1428		Course 270° economy drive/speed.
1600	FU2717	Reverse course, 90°, Economy Speed.
1730		Course 90°, 9 sm.
2000	FU2719	Course 85°, 9 sm.
2200		White light on island ahead (presumable car headlights)
2220		Course 80°, 9 sm.
2303		Island in sight.
2315		Days run:
2400	FU2726 SE, Sea state 2, [or wave height] moderate swell, moderate to good visibility	On surface=111 =632 sea miles Submerged= 27 =74 sea miles
<u>21.10</u>	<u>South Atlantic</u>	
0000	FU2726 Attack on roadstead of Jamestown, St. Helena	From 0000 the outlines of the island emerge clearly so that the position of the ship can be clearly fixed by taking a bearing on the small fishing boats. The sky, previously almost completely overcast, clears completely over the island, clear starlight and thus unwontedly bright.
0002		Change to dead slow, as the next cloud bank moving up very slowly and so too bright for an attack.
0015		To action stations.
0016		With 110° both electric motors. Slow, headed towards anchorage of the tanker.
0124		Tanker in view, very oblique position. Against dark rocks, can hardly be made out, while on land apparent work in progress with lamps on the new battery – greatly blinding [me].
0125		On 170° attempt to reach tanker on starboard side, in order to reach point 90, turned around immediately, since recognised that position of bow approx 160° at that boat [i.e. U-68] coming too close to coast. In contract to [previous?] morning, tanker lying on course 20-50° approx 500m from land.

0130 0134 0142 0143 0144	Weather: ½ overcast, otherwise starry and clear. [wind] E, 1-2, wave height 0, slight swell	On 20° behind tanker switched to its port side. In doing so approached too close under 300m, therefore after swinging around again vessel off to port, backed [?] boat around. To firing position. Course 148°. Tanker bow on the left heading 80-100°, distance 500m. 56m of water, distance to 15 cm battery 1800m. Small battery 2000m. Boat must be seen at any moment, particularly from the high (point on the) coast. Therefore decide definitely to hit the tanker with destructive force. 4 aimed single shots with a spread of impact points. Firstly 2 electric torpedoes then 2 compressed air torpedoes depth 4m. Port diesel, emergency speed ahead, veered off hard to starboard. After 32 seconds all 4 eels [i.e. torpedoes] detonate at intervals of 1-2 seconds. 1st hit – aft superstructure 2nd hit – mid-ships 3rd hit – forward third 4th hit - mid-ships After 3rd detonation flames flare up, after 4th one single sheet of flame. Nothing more can be seen of the tanker but the water on fire with flames 20-30m. Since the boat must first get underway in order to turn. I am concerned about getting into the sea of flames. Boat is lit up as light as daylight, the whole coast, harbour, barracks, batteries, everything bathed in a red glow. To 310°, both [engines] to emergency speed, brought sea of flames between me and 15 cm battery which must be able to see me absolutely clearly from above and the side. Not a single shot fired. Therefore changed to ¾ speed in order to save fuel. Only after 22 minutes 2 searchlights illuminated in the 15 cm battery. They search over the boat 2-3 times but don't find it and then illuminate the fire site and SW sector. Course 310°, 12 sea miles. Crew on deck to observe the grisly-beautiful spectacle. Course 270°, 12 sea miles Course 220°, 12 sea miles Boat is picked out again by the excellent strong searchlights, but lost again immediately. Sea of fire can still be seen well. Course 220°, 12 sea miles.
0150 0207 0215 0244 0307 0322 0400	SE, 2-3, wave height 2.	

	Medium swell, moderate visibility.	Course 180°, 12 sea miles. Intend to proceed to the S sector of the operating area, as I assume I will have the best prospects of meeting the Cape town
0445		North and central American traffic. Glow from the fire & searchlights spotted for the last time. Course 180°
0545		
0700		[radio telegram]
	FU5113	FT0935/22/219
0800		"Report immediately state of traffic & fuel" Extremely unpleasant to have to send a report today of all days, since only
0919		in the evening [would] short wave and southerly trade be recognised. Intended to report only after investigating state of traffic in the southern sector. Course 180°. Economy drive.
1200	FU2743, ESE Wave height 2-3 moderate swell, good to very	
	good visibility.	Course 180°. Economy drive.
	FU5169	Course 180°. Economy Drive.
1600		
	FU5419	Radio telegram to B.d.U 2032/22/237
2000		
21.20		"Port A and surrounding area no traffic, likewise route to B. Port B last night 8000 tonner supply tanker pulverised. 150 going to S sector. Merten." Days run on surface =161 Voyage = 6553 sea miles Submerged = 0 total = 74 sea miles
	FU5449	
2400		

Annex 5 – Archaeological Assessment

Table of Figures

Archaeological Assessment

Summary

The UK Ministry Of Defence (MOD) owns approximately 2500 legacy wrecks dating from 1870 to the present and is responsible for managing all aspects of the potential environmental and safety risks posed by these vessels.

The responsibility for the assessment of these wrecks lies with the Salvage and Marine Operations (S&MO) branch of the MOD. Under this remit, S&MO undertook a survey of the wreck of the Royal Fleet Auxiliary (RFA) tanker *Darkdale* following a significant leak of oil from the remains in spring 2010. The site is located in James Bay, St Helena at latitude 15 55.1S, longitude 005 43.4W (WGS 84).

Although not the main focus of the survey, the opportunity was taken to conduct an archaeological assessment of the wreck site, this annex deals solely with this aspect of the investigation.

A non-intrusive survey of the site was undertaken by means of a Remote Operated Vehicle (ROV) between 30 April and 11 May 2012. The survey produced an accurate location for the wreck, determined the nature and location of the main elements and the extent of the debris field and assessed the wreck against the non-statutory criteria for designation.

The assessment revealed that the site consists of the substantially intact remains of the RFA tanker *Darkdale*. RFA *Darkdale* was torpedoed and sunk on the night of 22 October 1941 by *U-68* with the loss of forty one members of the crew. Examination of the wreck has revealed that the vessel was struck by three torpedoes on its port side and broke into two halves. The torpedo damage is concentrated towards the aft end of the wreck. The stern section quickly sank while the bow remained partially afloat with the aft end resting on the seabed and the stem above the surface. In this position the wreck presented a significant hazard to navigation. Within a fortnight of RFA *Darkdale's* loss Royal Navy divers operating from *HMS Milford* detonated charges on the bow section of the vessel to level this part of the wreck. The stern of the vessel now lies on it's port side while the bow lies upturned with the deck lying nearly flush with the seabed.

This annex deals with an assessment of the wreck of RFA *Darkdale* in James Bay, St Helena.

The assessment was conducted as a supplement to the main focus of the survey which was to determine the environmental and safety hazards posed by the oil and munitions remaining aboard the vessel.

The survey of the wreck site was conducted by an Observation Class ROV supported by a MiniROV between 30 April 2012 and 11 May 2012.

AIMS AND OBJECTIVES

Although the primary concern in examining the wreck was to ascertain the likely quantities of oil and munitions remaining onboard two additional archaeological questions were addressed:

1. Would examination of the wreck provide new information on what caused the loss of the vessel?

2. Could analysis of the wreck, in company with surviving eyewitness accounts, yield an authoritative account of the sequence of events surrounding the sinking?

Existing Site Data

Sidescan images of RFA *Darkdale* from a survey conducted by *HMS Herald* in 1984.

A black and white photograph showing the bow of the *Darkdale* remaining above the water in the days immediately following the attack.

Photographs of the wreck taken by members of the RAF Dive Club while on expedition to St Helena in 2002.

Video footage of the wreck obtained from local divers, taken following the storm of spring 2010 that occasioned the release of oil.

Methodology

Before commencing fieldwork a Preliminary Risk Assessment (PRA) was undertaken for RFA *Darkdale*, this document forms Annex 1. A PRA is, in several respects, similar to an archaeological Desk Based Assessment (DBA). The methodology was developed by S&MO as a means of collating the details of a wrecked vessel, the circumstances of its loss, the oil and munitions aboard it at the time of sinking and any available information on its condition at the present time. It provides S&MO with a cost-effective way of assessing the risk posed by a wreck and of determining whether an on-site survey is merited.

The research on which the PRA was based was conducted at the Public Records Office at Kew, the National Maritime Museum, Greenwich, the Naval Historical Branch, Portsmouth and via enquiries to foreign archives and by using various online resources. The PRA revealed that the wreck was

substantially intact and likely to contain significant amounts of oil and an on-site survey was planned to assess whether the condition of the wreck merited further intervention to remove the oil and/or munitions.

Once on-site, a survey of the wreck site and the environs of James Bay was undertaken using a C-MAX CM2 Digital Sidescan system. A jpeg of the wreck site derived from the sidescan formed the basis for the planning of the survey. The jpeg was geo-referenced on site in Arc 10.0 GIS software using positions derived from tracked ROV data. Thereafter, this was refined using data derived from subsequent ROV dives.

A systematic survey of the wreck was conducted using a Seaeye Falcon Observation Class ROV. In addition, a SeaBotix LBV150-2 MiniROV system was deployed into the confined break zone between the two halves of the wreck to examine the damage to the ship at this point. Although not specifically designed as an archaeological survey the footage captured from these two systems provided sufficient detail to enable analysis of the site from this perspective. It should be noted that all the measurements that follow should be considered as approximate as they were not derived from a measured survey.

A video photographic survey of the wreck was undertaken using the ROVs and stills of selected archaeological features were captured from this. In addition, higher resolution footage was captured from a Go Pro Hero2HD camera mounted on the Falcon ROV.

Although recreational diving takes place on the wreck, diving for the purpose of this work survey was not a feasible option in the absence of a suitable decompression chamber. There is no decompression chamber on the island and the transportation costs to such a remote location ruled out taking one.

Following completion of S&MO's work the Royal Navy ice patrol ship *HMS Protector* carried out a multibeam scan of the wreck while conducting a hydrographic survey of the waters around St Helena.

RESULTS

INTRODUCTION

S&MO conducted the survey between 30 April and 11 May 2012. The area under investigation varies in depth from 17m to 45m.

SITE LOCATION

The site is located within James Bay, St Helena and comprises the wreck of the fleet oiler RFA *Darkdale*, a Dale Class tanker. The site lies approximately 600m offshore of Jamestown, the main settlement on the island, in latitude 15 55.1S, longitude 005 43.4W (WGS 84).

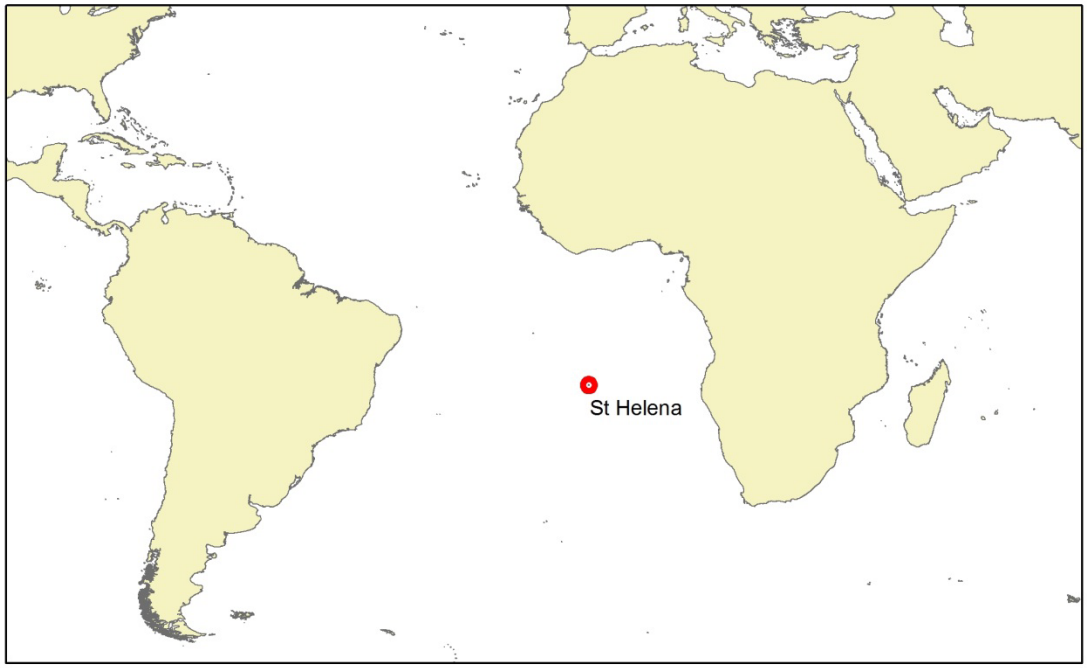


Figure 1 - Location of St. Helena

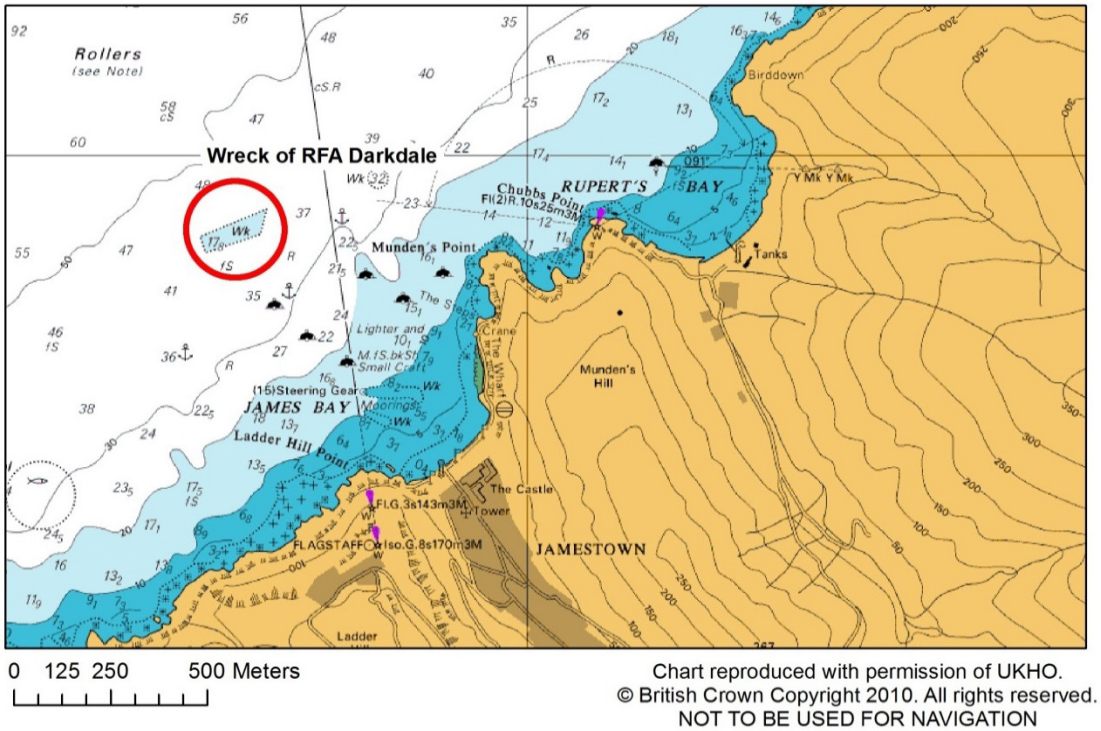


Figure 2 - Location of wreck

SEABED

The seabed in the vicinity of the wreck consists of coarse sand and varying quantities of broken shell. Full details of the nature of the seabed are contained in the environmental report conducted by RPS Consultants.

FLORA AND FAUNA

The wreck exhibits little marine growth and indeed the wider area of James Bay has surprisingly little in the way of marine flora.

The wreck hosts a notably diverse and abundant fish community which, again, forms a noticeable contrast to the limited numbers encountered elsewhere in James Bay.

Full details of the flora and fauna in and around the wreck are contained in the environmental report.

SURVEY CONDITIONS

The conditions for the survey were uniformly excellent. The weather remained sunny and dry and the sea calm for the duration of work on the site. Visibility on the wreck itself was very good, with viewing ranges for cameras mounted on the ROV typically in excess of 30m. The near absence of marine growth on the wreck enabled a good appreciation of the vessels structure to be gained from the ROV footage.

PREVIOUS WORK ON THE WRECK

Although no previous archaeological assessment has been undertaken on the wreck it is dived relatively frequently for recreational purposes. Footage from two such visits was obtained for comparison with that captured during the current survey:

- Photos taken by the RAF Dive Club in 2002 – this footage is particularly interesting as it pre-dates the oil leak of spring 2010.
- Video of the wreck taken by local divers in 2010 – this footage was taken after the leak of the spring of that year and shows oil seeping from the stern of the vessel.

THE HISTORY OF THE LOSS OF RFA DARKDALE

The following history draws mainly upon primary documentary sources supplemented by published material where appropriate. It provides an overview of events leading up to the sinking as well as a detailed account of the *Darkdale's* loss on the night of 22 October 1941. It draws together both the surviving British and German accounts of the events of that night and considers this information in light of the results of the survey of the wreck.

DOCUMENTARY RESEARCH

Extensive documentary research was carried out in advance of and following the survey of the wreck. A considerable quantity of material relating to the *Darkdale*, the historical context to and circumstances of her loss were reviewed. Copies of key material are included in the annexes.

DOCUMENTS RELATING TO THE *DARKDALE*

No plans of the *Darkdale* herself could be found. However, partial sets for two sister vessels (RFA *Cairndale* and RFA *Dingledale*) were obtained from the Ulster Folk and Transport Museum and were used to inform the planning of the survey. Basic information on the ships dimensions, displacement and other characteristics was sourced from a copy of the ship's Lloyds Registry entry obtained from the National Maritime Museum, Greenwich.

The context to the *Darkdale's* construction as part of the expansion RFA's fleet in the late 1930s and during the war itself was provided in documents held in the National Archives, Kew and from information available on the Historical RFA website (REF: http://www.historicalrfa.org/).

DOCUMENTS RELATING TO EVENTS PRECEEDING THE SINKING

Details of the period during which the *Darkdale* acted as a refuelling tanker at St Helena are contained in the Jamestown Harbour Master's log held in the island's archives. This is an important source of information on the ships that refuelled from the *Darkdale*. The details in it were confirmed by cross referencing the entries to the surviving logs of the Royal Navy vessels mentioned held at the National Archives, Kew. Unfortunately, only the logs of the larger Royal Navy ships to visit the island, those of cruiser size and above, have been preserved making verification of some of the information difficult.

While the *Darkdale* was moored in James Bay she was herself refuelled on two occasions by the Norwegian tanker, *M/T Egerø*. Obtaining further information on this was vital for determining the amount of oil likely to remain aboard the wreck today. The details of the refuelling episodes were provided by the Riksarkivet – The National Archives of Norway which hold the *Egerø's* log books.

Information on the wider context of the attack was obtained from various primary sources obtained from the National Archives, Kew. These included a series of very interesting ULTRA decrypts of signals sent to and from *U-68* in the days leading up to the attack on the *Darkdale*.

DOCUMENTS RELATING TO THE SINKING

A copy of *U-68's* log (*Kreigstagebücher* (KTB)) was obtained from the Deutsches U-Boot-Museum in Cuxhaven-Altenbruch while a copy of the boats torpedo log (*Schussmeldungen*) was provided by the Bibliothek für Zeitgeschichte in Stuttgart. These documents form important first-hand accounts of the attack on the *Darkdale* from the German perspective.

On the British side, the survivors' report submitted by the Captain of the *Darkdale* was sourced from the Naval Historical Branch at Portsmouth while a copy of the report from the Jamestown Harbour

Master was obtained from the island's archive. These two sources provide interesting, if slightly differing, perspectives on the loss of the ship.

One key document, believed to be extant, but unfortunately not obtained was the proceedings of the Court of Enquiry into the *Darkdale's* loss convened on St Helena in the days immediately following the attack. It is likely that the Royal Navy divers from *HMS Milford* would also have reported on the efforts to sink the bow section of the wreck following the attack. However, efforts to trace this important document proved fruitless.

A BRIEF HISTORY OF RFA DARKDALE

The RFA was formed in 1905 and was initially responsible for providing coal and then later oil to ships of the Royal Navy operating away from shore bases. The service expanded considerably during World War One and remained an important asset in the years following the war.

However, as the international situation worsened through the 1930s it became increasingly apparent that the RFA's existing freighting tanker fleet, composed largely of World War One vintage vessels, would be unable to meet the needs of the Royal Navy in any future conflict. Efforts to remedy this situation began in 1937 when the Director of Stores, Sir William Glick, instigated the purchase of six ships off the stocks from the British Tanker Co Ltd. These ships, based on a Shell design, formed the 'A' and 'B' Dale class tankers, they were subsequently joined by two further vessels, forming the 'C' class, purchased from the Anglo Saxon Petroleum Co Ltd

Following the outbreak of World War Two, an additional ten vessels were acquired while building from the Ministry of War Transport. These formed the 'D' and 'E' class Dales to which the *Darkdale* belonged. The *Darkdale* herself was launched on 23 July 1940 by the Blythswood Shipbuilding Co Ltd of Glasgow. Originally named *Empire Oil* she was acquired by the Admiralty and renamed *Darkdale* on 15 November 1940 (REF: ADM 1/27143 History of Royal Fleet Auxiliary (RFA) Service).

The *Darkdale's* active career lasted less than a year. Following trials the ship participated in three convoys (OB 246, BHX 104 and OB 338) (REF: http://convoyweb.org.uk/hague/index.html) and undertook several independent sailings before departing Curacao on 15 July 1941 to take over from the Norwegian tanker *M/T Nyholm* as the Fleet oiler at St Helena (REF: http://www.warsailors.com/singleships/nyholm.html)

The *Darkdale* was neither the first, nor the last, oiler to perform such a function and her presence at St Helena must be set in its wider context. The summer and autumn of 1941 saw British fortunes at their lowest ebb. With her latest ally, Russia, seemingly on the verge of collapse and America remaining neutral defeat remained a very real possibility. Britain remained heavily dependent on imports both to feed the country's population and to maintain the armaments industry but guaranteeing this supply was becoming increasingly difficult in the face of mounting U Boat successes. To date, the war against the U Boats had remained largely confined to northern waters allowing merchant vessels bringing goods from West Africa, South America and further afield to complete the greater part of their journeys in relative safety. The *Graf Spee* was two years sunk and with the prospect of one of the larger units of the Kreigsmarine breaking into the South Atlantic remote, the main threat to shipping in these waters at that time came from the small number of

merchant vessels converted to commerce raiders by the Germans. Although certain of these vessels, such as the *Kormoran* enjoyed significant success, and their activities tied down a considerable number of Royal Navy ships, they posed more of a nuisance than a serious threat to trade. The situation was about to change, however, with the arrival of U Boats in the South Atlantic. The Admiralty was alert to this threat as a consequence of ULTRA decrypts of U Boats signals traffic (REF: HW 18/312 Extracts from reports containing information about the activity of German U Boats: *U4*, *U68*, *U126*, *U148*, *U153*, *U451*, *U452*, *U503*, *U559*, *U562*, *U652*). However, the sensitivity of this intelligence made it difficult to act upon until alternative sources of information on the activities of the submarines provided the necessary plausible deniability.

The potential for this extension of the U Boat campaign to damage Britain's war effort was swiftly quantified. At a meeting with the Import Executive on 8 July 1941 the First Lord of the Admiralty raised the possibility that, under certain circumstances, it might not be possible for Britain to maintain its trade with the Iberian Peninsula and West Africa and suggested an inter-departmental enquiry to assess the impact on war production and essential food supplies of the loss of imports from these area (REF: MT 59/909 Loadings from W.Africa and South Spain – Inquiry by the Admiralty as to the effect on import programmes of a possible discontinuance of shipments from the West coast of Africa and the South Spain area for a period up to three months). The responses from the Ministries of Supply and Food were forwarded to the First Lord and the Ministry of War Transport on 22 July and made for sobering reading. Assessing the potential loss of several key commodities the report noted that imports from West Africa accounted for 10% of Britain's monthly armaments steel production requirement, 67% of the country's monthly manganese ore needs and 33.5% of her monthly tin ore requirements. Besides these raw materials, the 168,000 tons of vegetable oil that Britain imported each year from West Africa amounted to 65% of her requirements. More disturbingly, the report noted that the loss of the 170,000 tons of cocoa imported each year would lead to the disappearance of chocolate and cocoa from the country's shops. Although any shortfalls could partially be made good from alternative sources the potential for the U Boats to further damage Britain's ability to continue the war by interrupting this trade was clear. The strategic value of St Helena as a refuelling and re-supply station thus assumed far greater importance from the summer of 1941 as the Royal Navy moved to counter this growing menace.

It was against this backdrop that the *Darkdale* dropped anchor in James Bay on 4 August. Three days later she carried out her first refuelling operation when the light cruiser *HMS Orion* put in for re-supply (REF: ADM 53/114826 *Orion* 1941 Aug). The *Orion's* log notes that refuelling took place but in common with all of the surviving log books of Royal Navy ships that received oil from the *Darkdale* provides insufficient detail to determine exactly how much was taken on. After *Orion's* departure a quiet period ensued for the *Darkdale* eventually broken by the arrival of the seaplane carrier *HMS Albatross* on 21 August (REF: ADM 53/113556 *Albatross* 1941 Aug). Once again the log of *HMS Albatross* does not tell us how much fuel she received but it is probable that, besides replenishing her own bunkers, she also took on a quantity of Avgas for the seaplanes she embarked. A busy period followed beginning on 25 August with the fuelling of the Armed Merchant Cruiser *HMS Cilicia* (REF: ADM 53/113921 *Cilicia* 1941 Aug). The *Darkdale* then replenished the destroyers *HMS Jupiter* on the following day and *HMS Avon Vale* and *HMS Eridge* on the 30 and 31 respectively (REF: St Helena Harbour Master's Record – Aug – Nov 1941).

Two quiet weeks then ensued followed by a spell of intense activity in which the *Darkdale* refuelled several of the major units of the Royal Navy. On 17 September the old aircraft carrier *HMS Eagle* secured alongside the *Darkdale* to take on oil for her own consumption and, presumably, Avgas for her air complement (REF: ADM 53/114194 *Eagle* 1941 Sep). *Eagle* was at that time engaged in hunting German supply ships and commerce raiders with the heavy cruiser *HMS Dorsetshire* which anchored nearby (REF: ADM 53/114137 *Dorsetshire* 1941 Sep). On the following day the *Dorsetshire* herself refuelled to be followed on 23 September by the destroyer *HMS Encounter* and the little sloop *HMIS Sutlej*.

On 24 September *HMS Repulse* arrived in James Bay to refuel. The battlecruiser being at that time engaged in escorting a troop convoy around the Cape of Good Hope (REF: ADM 53/114982 *Repulse* 1941 Sep). Although exact calculations are impossible it is probable that by the time *Repulse* departed the *Darkdale's* tanks were seriously depleted. She had refuelled eleven Royal Navy ships including a battlecruiser, aircraft carrier and heavy cruiser and without urgent replenishment of her tanks would be unable to continue in her role.

However, the problem was realised and as Repulse left the Norwegian tanker *M/T Egerø* arrived to resupply the *Darkdale* (REF: Log book of Norwegian oiler *M/T Egerø* for the period 23 Aug – 30 Oct 1941 – details provided in a letter from the Riksarkivet – The National Archives of Norway dated 3 May 2011). On 25 September the *Egerø* supplied the *Darkdale* with fuel from 1030 to 1630 and provided further fuel to the ship the following day (no start time is given for this second operation but the *Egerø's* log notes that it was completed at 1130). *HMS Eagle* and *HMS Dorsetshire* reappeared on the 26th and it is interesting to note that the *Eagle* seems to have been receiving oil from the *Darkdale* at the same time she was herself being replenished from the *Egerø*. The *Eagle's* log is unfortunately not very exact and does not state explicitly that the 'oiler' from which she refuelled was the *Darkdale* raising the possibility that it was the *Egerø* from which she obtained fuel. Regardless, James Bay must have been very crowded by this time and *Dorsetshire* had to wait her turn before refuelling from an 'oiler' during the afternoon. After the departure of the two warships the *Egerø* carried out a third refuelling of the *Darkdale* before herself sailing from St Helena.

The *Egerø* episode is highly relevant to an analysis of the wreck of the *Darkdale* and, more particularly, to the assessment of how much oil is likely to remain aboard. The *Egerø's* log does not directly state how much oil was provided to the *Darkdale* but it does provide details of how much fuel she took on prior to sailing for her rendezvous with her and how much she loaded at her own next fuelling stop upon leaving St Helena. Crucially, the log makes it clear that the only ship that the *Egerø* resupplied between these two episodes was the *Darkdale*. On 23 August the *Egerø* loaded 11095.05 tons at Abadan prior to sailing to Table Bay and then onto St Helena. Although the ship's log does not say exactly of what, it is highly likely that this comprised both oil to supply the *Darkdale* and for use in her own bunkers. After leaving St Helena, and following a brief stop at Cape Town, the *Egerø* took on approximately 8000 tons of diesel, 2200 tons of bunker oil and eight casks with lubricating oil at Abadan on 30 October (REF: Log book of Norwegian oiler *M/T Egerø* for the period 23 Aug – 30 Oct 1941 – details provided in a letter from the Riksarkivet – The National Archives of Norway dated 20 Oct 2011). It is probable therefore that the *Egerø* provided the *Darkdale* with somewhere in the region of 8000 tons of oil during the three refuelling operations.

Based on the above, it is likely that that the *Egerø* left the *Darkdale* with nearly full tanks. After her departure only three Royal Navy ships visited St Helena before the *Darkdale* was sunk, all on 14 October. On that day the Dido class light cruiser *HMS Euryalus* arrived and according to the Harbour Master's log took on oil from the *Darkdale*. However, the log of *Euryalus*, while noting her arrival in James Bay, makes no mention of the ship receiving any oil (REF: ADM 53/114248 *Euryalus* 1941 Oct). This is not believed to be an oversight as an earlier entry in the ship's log contains detailed information of a refuelling operation undertaken on 8 October while *Euryalus* was at Sierra Leone. However, *Euryalus* was operating in company with the Hunt class destroyers *HMS Heythrop* and *HMS Farndale* and the Harbour Master records that both of these ships took on oil from the *Darkdale*. Although the logs from these vessels have not been preserved, a plausible explanation is that, while all three ships arrived at James Bay in company, only the two smaller vessels topped up their tanks. The Hunt class were small escort destroyers of approximately 1000t displacement. The amount of oil that these vessels took on, the last to do so before the *Darkdale* sank, is likely to have been comparatively small. As a consequence the oiler's tanks remained near full when *U-68* surfaced to attack in the early hours of 22 October.

THE ATTACK

U-68 departed Lorient on 11 September 1941 on a patrol of one hundred and six days that would result in the sinking of the *Darkdale* and three other ships (http://www.uboat.net/boats/patrols/patrol_480.html) In the early hours of 21 October the submerged submarine approached St Helena to reconnoitre the shipping in James Bay by periscope (REF: Kreigstagebuch des Unterseebootes "*U68*" – covering 2 Aug 1941 – 25 Dec 1941). Given the scale of recent Royal Naval activity in the harbour U-68 was perhaps unfortunate to find only the *Darkdale* lying at anchor. The submarine's Captain, Karl-Friedrich Merten, was, however, able to conduct a detailed perusal of the unsuspecting tanker which lay approximately 600m from the land swinging on a heading of between 130-180°. The entry in the KSB is interesting as it tends to confirm the belief that the *Darkdale*, after refuelling from the *Egerø*, had a considerable amount of oil aboard, "Full of fuel, only at the bow can one see something of the waterline colour. [I] intend to blow it up this night, since by doing so there is the possibility of diverting suspicion to armed merchant men." The mention that "…only at the bow can one see something of the waterline colour" is of interest. It hints at the loading of the *Darkdale*, suggesting the vessel was lying slightly down by the stern, and may have a bearing on the pattern of torpedo hits achieved by *U-68*.

In addition, careful note was taken of the recently augmented harbour defences. Merten had been in Jamestown in 1927 and so, as the entry in *U-68's* KSB states, was well placed to detect any changes to the harbour. Two years into the war the defences of James Town were substantial, Merten noted the presence of a battery of 6 in guns overlooking the *Darkdale* on Mundens Point supported by two nearby searchlights and a battery of smaller calibre guns on High Knoll. To these defences could be added the *Darkdale's* own armament meaning that any attack on the tanker would be a hazardous undertaking. Having completed the reconnaissance *U-68* withdrew to await the next nightfall.

The 21 October seemingly passed without incident for the *Darkdale*. A portion of the crew had gone ashore and though most returned to the ship during the evening a number, including the ship's

Captain Thomas H Card, her Chief Engineer and several men recovering from various complaints in the island's hospital, still remained on St Helena as *U-68* began her run in to James Bay (REF: http://www.historicalrfa.org/archived-stories/1163-the-story-of-the-*DARKDALE*-part-2-qa-sitting-duckq).

The conditions for the attack were, from Merten's point of view, not ideal. Although the moderate swell and clear starlit sky aided the approach to the target it also risked exposing the surfaced submarine. After spending some time manoeuvring into position *U-68* eventually lined up on the *Darkdale's* port side. The KSB makes it clear why the following moments were so brutal. Merten was faced with a difficult situation. His approach to the target under clear skies had left him exposed to the nearby gun and searchlight batteries, and believing he would be spotted at any moment he resolved to attack the tanker with overwhelming force to ensure a kill and, presumably, to provide cover to his escape in the subsequent confusion. At no point, however, does the KSB explain why Merten risked attacking the *Darkdale* while surfaced. One possible reason is that he was cautious of making a submerged approach to a target lying in comparatively shallow waters while the method he adopted at least made it possible for *U-68* to make a swift escape using her faster surfaced speed.

Regardless of the exact reasoning at 00:43 local time and at a range of 500m *U-68* fired four torpedoes set to run at 4m depth before veering off hard to starboard and increasing speed to make her getaway. The torpedo log of *U-68* reveals that the salvo comprised of two G7a and two of the less reliable G7e torpedoes (REF: Morgan, D and Taylor, B, 2011, *U Boat Attack Logs*, Barnsley: Seaforth / *Schussmeldung für Überwasserstreitkrafte und U-Boote*). The pistols on all of the torpedoes were set for contact rather than magnetic detonation and thirty two seconds after firing the KSB records that all four hit the *Darkdale* at intervals of one to two seconds. The torpedo log, which includes a sketch of the spread of impacts (figure 3), notes that the first, a G7a, hit the aft section of the tanker followed by the second, a G7e, impacting the *Darkdale's* mid-ships, the third, another G7a, hitting the forward third and the fourth, a G7e, striking again in the mid-ships area. As analysis of the wreck of the *Darkdale* now makes clear the third torpedo did not strike the forward third of the ship but in the conflagration resulting from the impact of the remaining torpedoes the mistake is easy to explain. It is possible that the third torpedo passed wide of the ship or, given the evidence that the *Darkdale* was slightly down by the stern noted above, it may have passed beneath the bow. The fate of this torpedo remains a mystery. What exactly happened to the *Darkdale* in the moments following the attack must be pieced together from the surviving accounts and an examination of the wreck.

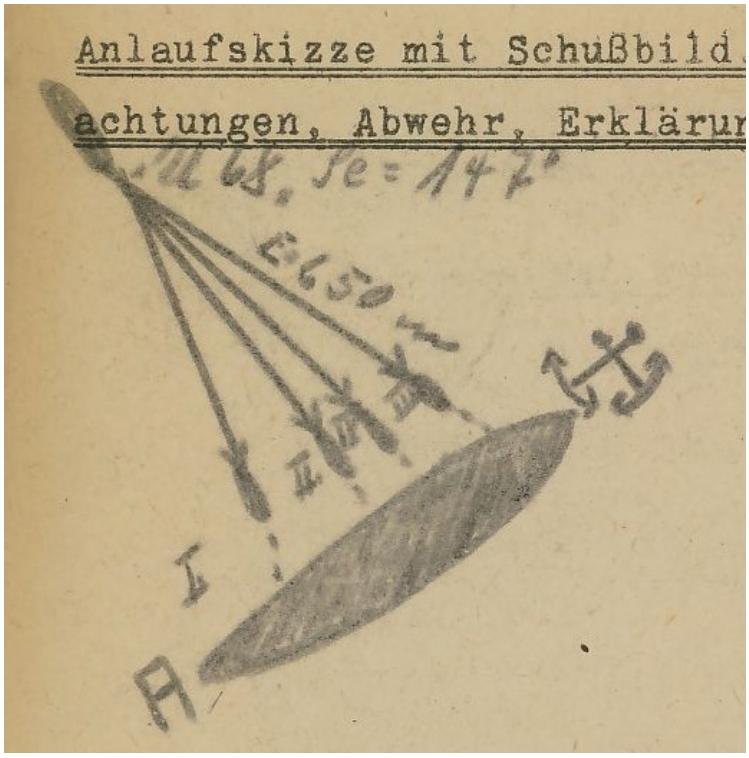


Figure 3 - Sketch of the pattern of torpedo hits on the *Darkdale* from the torpedo log of *U-68*

THE AFTERMATH

The Harbour Master provides the most detailed account of the aftermath of the attack in a report written the following day (REF: Re: Loss of *RFA Darkdale* – Report from the Harbour Master to the Government Secretary dated 23 Oct 1941 – Copy held in the St Helena archives, Jamestown). He initially heard three explosions and saw the *Darkdale* "…enveloped in flame from bow to stern" before heading to the landing steps to assist in the attempt to rescue the ship's crew. About ten minutes after the initial explosion the *Darkdale's* Captain and Chief Engineer arrived at the steps to aid the rescue. However, and despite the best efforts of all involved, only two gunners who were on the *Darkdale's* deck at the time of the attack were saved having been blown into the sea by the force of the explosions. The Harbour Master's report mentions a night watchman who witnessed the tanker turning over following the second and third explosions and states that fires continued to blaze until the ship sank at 03:30 leaving the bow projecting out of the water. The Harbour Master's report that he heard three explosions is perhaps significant in that it provides the only contemporary evidence that not all of the four torpedoes fired at the *Darkdale* actually hit.

Captain Card's report is dated 15 January 1942, nearly three months after the sinking (REF: ADM 199/2138 Survivors' Report: Merchant Vessels - 1941 Aug. – Oct. - Report of an interview with the Master, Captain T.H. Card. R.F.A. "*Darkdale*"). In it he states that there "…were two loud explosions on the port side of my ship." It is not certain that he actually witnessed these explosions but he makes the interesting statement that having arrived at the wharf and taken a launch to assist in the rescue "…the ship was now burning from end to end with the sea round about also on fire." Both the Harbour Master and the Captain therefore seem to agree that the *Darkdale*, though apparently on its side, was still intact ("…bow to stern" and "…end to end") at least ten minutes after the torpedoes struck. The Captain further notes that by 04:00 "… two-thirds of the fore part of the ship was still above water and the after part was completely submerged" before adding that at around "…05:30

the *Darkdale* blew up and sank within five minutes." Although there is disagreement between the Captain and the Harbour Master on the timings, it is tempting to assign the actual breaking in two of the ship not to the initial impact of the torpedoes but to a final explosion several hours after she was struck.

The attack resulted in a significant release of oil from the ship. Although the amount is difficult to quantify it was sufficient to leave the water around the wreck burning for several hours after the attack. Although a black and white picture, a photo of the *Darkdale's* bow above the water taken after her sinking seems to show the sea covered in oil (figure 4).

Figure 4 – The wreck of the *Darkdale* before the bow section was sunk by Royal Navy divers from *HMS Milford*

In the days following the attack a Court of Enquiry was convened on St Helena to determine the cause of the ships loss. Although the record of this has not been traced the findings are referred to in the report subsequently submitted by Captain Card. Although at least two military personnel had glimpsed the submarine on the surface during the attack their evidence was discounted and it seems the Court concluded the loss of the ship was the result of an accident.

The wreck remained undisturbed for barely two weeks. Lying in shallow water with the bow section protruding above the surface the remains posed a significant hazard to other shipping and on 2

November the Harbour Master reported the arrival of the sloop *HMS Milford* carrying divers to level the wreck and, presumably, to determine what had caused the *Darkdale* to sink. Although ULTRA decrypts had quickly revealed to the Admiralty that a U Boat was the culprit it is questionable how far down the chain of command this information had been disseminated (REF: ADM 223/103 Admiralty: Naval Intelligence Division and Operational Intelligence Centre: Intelligence Reports and Papers 1941 Oct – 1942 Feb). The diver survey therefore may well have provided the British with a useful, and non-sensitive, means of pinning the attack on a submarine. As noted, the report likely to have been produced by the divers has not been sourced. However, it is probable that they found the bow section of the *Darkdale* in much the same position as that shown in figure 4. Given the angle at which the bow protrudes it is likely that it was supported by the still intact bridge of the ship and that the easiest means of levelling the wreck was to blow the bridge off. Whether any additional charges were placed further forward to assist the sinking, as has been speculated when discussing the damage to the forecastle evident today, is uncertain. *HMS Milford* departed St Helena on 13 November, the eleven days she spent at the island perhaps hinting at the complexity of the operation to level the wreck.

The *Darkdale* was not the last RFA tanker to refuel Royal Navy ships at St Helena but after her loss the Harbour Master's log suggests they operated far more cautiously. *RFA Rapidol* arrived on 3 February 1942 and, in contrast to earlier fleet refuelling tankers which had been stationed on the island for months at a time, refuelled three ships before departing the following day. *RFA Abbeydale* put in on 5 March and, staying for slightly longer, refuelled two ships before departing on 13 March. Interestingly, however, and in line with the heightened threat of attack, the ship left James Bay each night to return the following morning.

ARCHAEOLOGICAL ASSESSMENT

RFA *DARKDALE* WRECK REMAINS

OVERVIEW

The wreck site of the *Darkdale* extends for approximately 130 m on a south-west to north-east orientation and is approximately 110 m wide at its widest point (excluding the deployed anchor chain). Analysis of the sidescan image indicates that the wreck covers an area of approximately 250 m² (figure 5).

The wreck lies broken in two sections. The bow section lies in approximately 30 m of water on a heading of 035° and is inverted with the deck lying very slightly angled to starboard. The stern lies on its port side on a heading of 056° approximately 8 m from the bow section in 40 m of water. The seabed is generally flat with a gentle slope from the bow section down to the detached stern section. Although of comparatively low resolution the multibeam survey of the wreck conducted by *HMS Protector* in late 2012 provides a useful overview of the wreck site and surrounding seabed (figures 6 and 7).

Figure 5 - Side scan sonar image of the wreck site

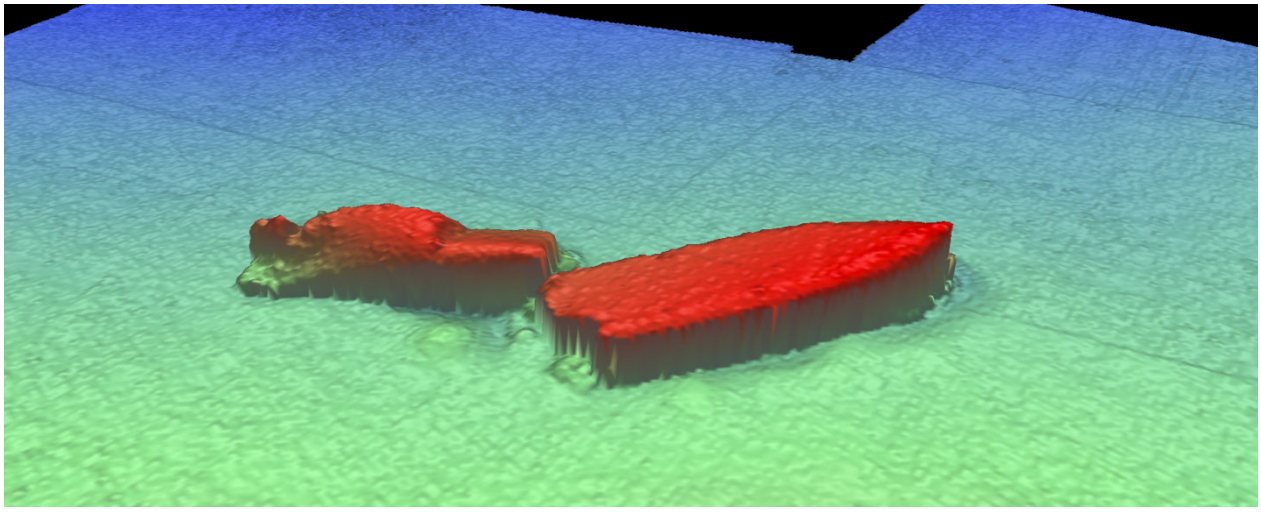


Figure 6 – Multibeam image of the wreck site looking north west, note the partial slumping of the starboard side of the aft section discussed below, the near absence of a debris field on this side of the wreck and the virtually flat seabed

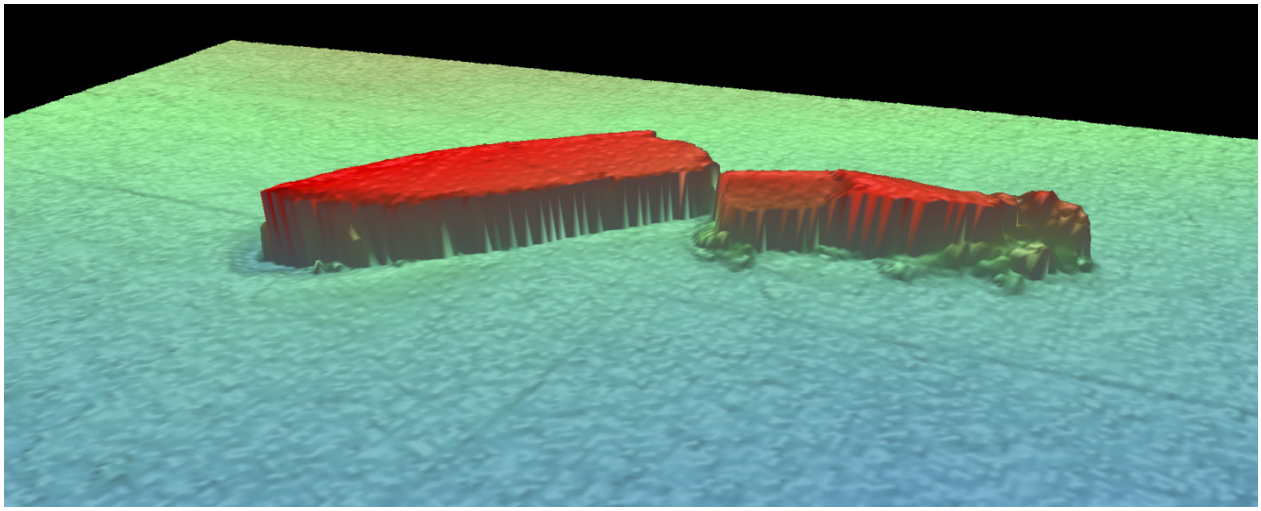


Figure 7 - Multibeam image of the wreck site looking south east, note the limited debris field adjacent to the stern section

The hull of the bow section is substantially intact and, except in the immediate vicinity of the break, shows few signs of damage. There is, however, no sign of the bridge originally situated atop the midships section of the wreck. Although this may have entirely collapsed under the weight of the upturned hull it is believed that its absence may be partly attributed to explosive clearance work undertaken on the wreck by Royal Navy divers from *HMS Milford* within a few days of the vessel's loss.

The break in the vessel occurs aft of the bridge with a portion of the ship stretching back from the aft pump room and encompassing the greater part of no.3 cargo tank no longer existing as a coherent structure. The remains of this part of the vessel, stretching for around 8m lie collapsed in the break zone between the bow and stern.

The stern section exhibits considerable evidence of explosive damage from the torpedoes that impacted in this area. The aft superstructure has largely collapsed with the funnel, ship's 4.7 in gun and assorted deck gear lying in the debris field. Although the torpedo explosions undoubtedly contributed to the collapse of the aft superstructure, anecdotal evidence from local divers suggests that it was substantially intact until relatively recently.

The debris field is largely confined to the break zone between the two sections of the wreck and the northern side of the stern section. The near absence of debris around the bow section is puzzling given both the circumstances of the ship's loss and the clearance work noted above.

There are few indications that the wreck has suffered any significant interference since the war. The only obvious damage that might be attributed to recent activity are the sections of broken bilge keel overhanging the bow in various places. The damage to the bilge keel was probably the result of

anchors dragging across the wreck. Elsewhere, clump weights, shot lines and tangles of mono filament line attest to fishing activity in the vicinity of the remains.

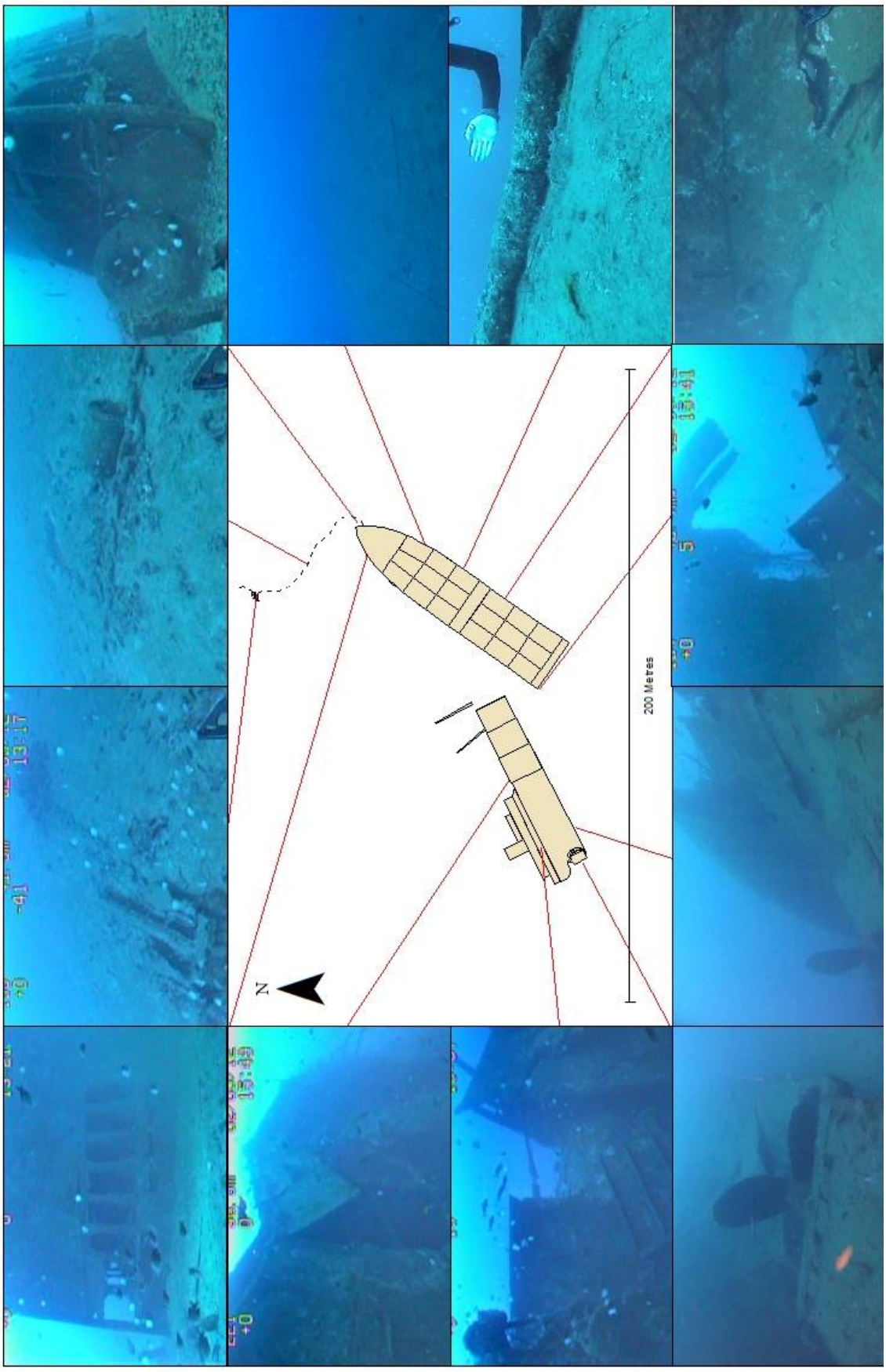


Figure 8 – Photo overview of the wreck of RFA *Darkdale*

THE BOW

The bow section is inverted and extends a distance of approximately 75m from the stem to its termination in the vicinity of frames 9A and 10A between no.4 cargo tank and the aft pump room. This is the point at which the ship was blown into two pieces and provides the only clear evidence of the torpedo attack visible on the bow. The bow exhibits a slight list to starboard resulting in a narrow gap between the port side of the ship and the seabed. However, this proved too narrow to allow even the MiniROV to gain access in order to examine the inverted deck of the ship.

The starboard bow anchor lies to the north-west of the wreck and the exposed anchor chain runs back to the upturned stem (figure 9). Four barrels lie in close proximity to the chain and it is believed these may have formed part of the cargo of lubricating oil, originally stowed in barrels on the ship's deck (figure 10). All appear to be holed and presumably sank after being damaged in the explosions and fire resulting from the attack. The anchor runs up to the stem but is no longer attached to the ship. The starboard hawse pipe is missing as is a single line of strakes on both sides of the vessel in the vicinity of the forward paint locker (figure 11). The line of missing strakes on the port side extends aft from frame 90F to frame 86F and that on the starboard side (figure 12) is slightly longer, running from frame 90F to frame 83F.

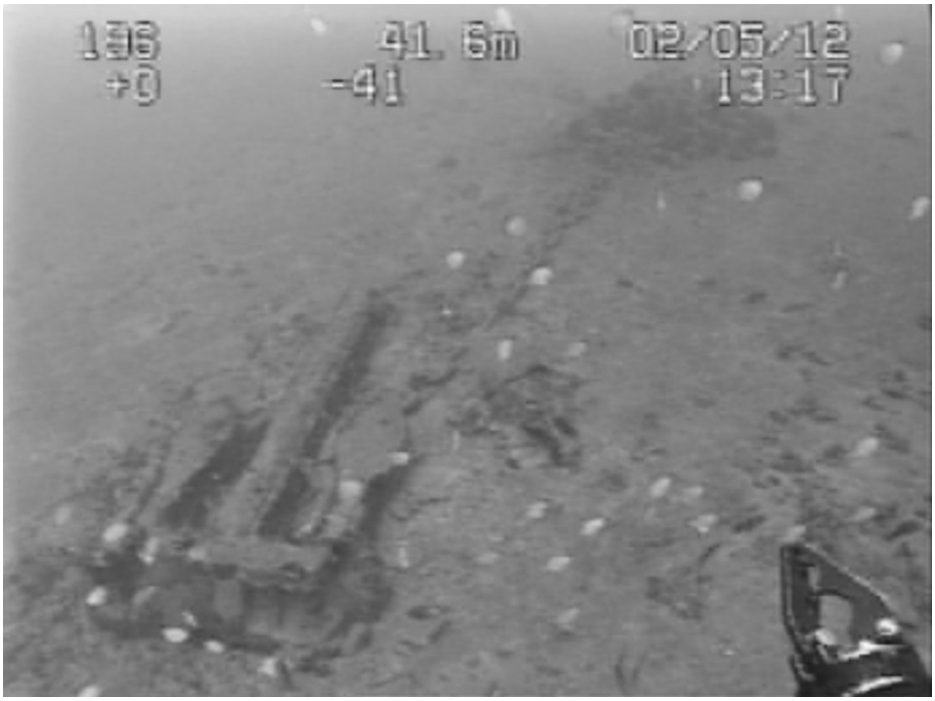


Figure 9 – The ship's anchor lying to the north of the ships bow

Figure 10 – Damaged barrel lying alongside the anchor chain – one of four lying close by and believed to have been part of the cargo of lubricating oil carried in barrels on the deck of the *Darkdale*

Figure 11 – The ship's stem

Figure 12 – The starboard side of the ship's stem showing the missing plates in the vicinity of the forward paint locker

The missing strakes on both sides of the stem form one of the few areas of significant damage to the hull forward of the break zone and require explanation. The damage was not caused by the torpedoes as the photo of the *Darkdale's* bow above the water shortly after the attack shows her starboard side with the anchor clearly attached to the ship through the hawse pipe and all of the plating in place (figure 4). The damage visible today must therefore have been caused either during the subsequent operation by *HMS Milford's* divers to level the wreck or by the crushing effect of the bow itself, either as the ship settled on the seabed or over time. It is suggested that the damage was caused as the bow came to rest on the seabed following the detonation of charges laid by the divers. Even if none of these charges were placed in the immediate vicinity of the stem, the movement of the ship to the seabed would have been quite violent with the considerable stress placed on the raised forecastle as the ship came to rest causing the strakes to burst outwards.

Adjacent to the area of missing strakes on the port side is a small debris field extending 5m from the side of the ship and extending for approximately 10m along its length. This consists of steel plates, presumably those from the visible area of damage on the port side, the port hawse pipe and what appear to be unidentified items of deck equipment. Surprisingly, there is no equivalent debris field on the starboard side of the stem to account for the line of missing plates in this area.

As noted, the virtual absence of a debris field around the bow is peculiar. It is unlikely that a formerly visible debris field in this area has become buried by sediment given the clearly visible features on the seabed in the vicinity of the nearby stern. It may be, given that the bow is shallower than the stern and so more accessible, that items have been removed from it by divers but it is hard to envisage a scenario where the area could have been swept quite as clean as it now appears. It is

probable that much of the equipment lies buried beneath the upturned wreck, but the sheer neatness of the bow and the near absence of items lying round about remains puzzling.

Moving aft from the stem along the starboard side of the ship there are no signs of damage caused by the attack until the break zone is reached. Just forward of this zone, two sections of the ship's bilge keel hang loose over the ships side and a further section lies on the seabed (figure 13). The damage to the bilge keel is likely to have been caused by boat anchors dragging across the wreck.

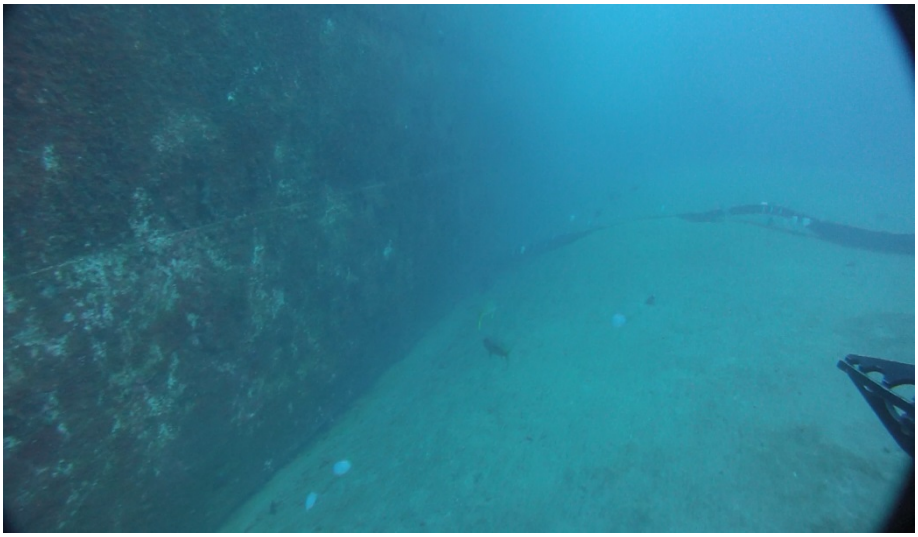


Figure 13 – Bow section, starboard side with a detached section of bilge keel on the seabed

The port side of the bow is in similarly good condition with one interesting exception. Moving aft from the stem on this side of the ship a section of the bilge keel hangs down just aft of the start of this structure. It is likely that this too is the result of an anchor dragging over the wreck. However, the most significant damage is evidenced further back where the bulwark running adjacent to the now vanished bridge lies splayed out on the seabed (figure 14) It is suggested that the damage in this area may have been caused by *HMS Milford's* divers when levelling the wreck. The angle at which the *Darkdale's* bow protruded above the surface immediately following the attack, as evidenced by figure 4, indicates that the bridge was still present and partially supporting the wreck at this time. It is therefore likely that the divers used explosives to remove the bridge as the easiest means of levelling the wreck, in the process causing the damage to the bulwark visible today.

Figure 14 – Bow section, port side showing damage to the bulwark in the vicinity of the now vanished bridge

With the exception of the damage to the bilge keels and the actual break point between the two sections the upturned bow of the *Darkdale* is in excellent condition. Although there is some localised flaking of the steel there are no signs of significant structural damage and no indication of a torpedo hit forward of the break zone. One of the most interesting features is the presence of a number of medium calibre shells lying on the bottom of the ship (figure 15). Several of these have seemingly been deliberately placed by divers in a neat line alongside the bilge keels (figure 16). Mixed in amongst these shells are several bundles of cordite rods. These are though to be the remains of the separate silk covered cartridges in which the cordite was bundled. Although the silk coverings have rotted away the cordite remains in distinct groups (figure 17).

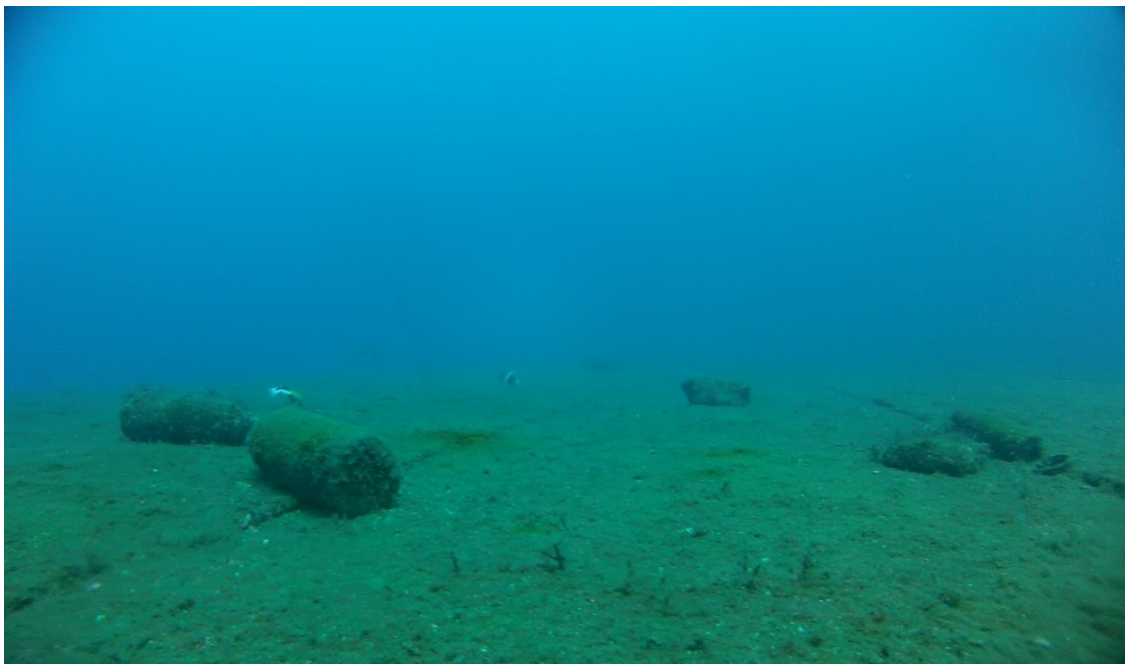


Figure 15 – Shells lying on the upturned bow section

Figure 16 – Shells lined up along the bilge keel on the upturned bow section

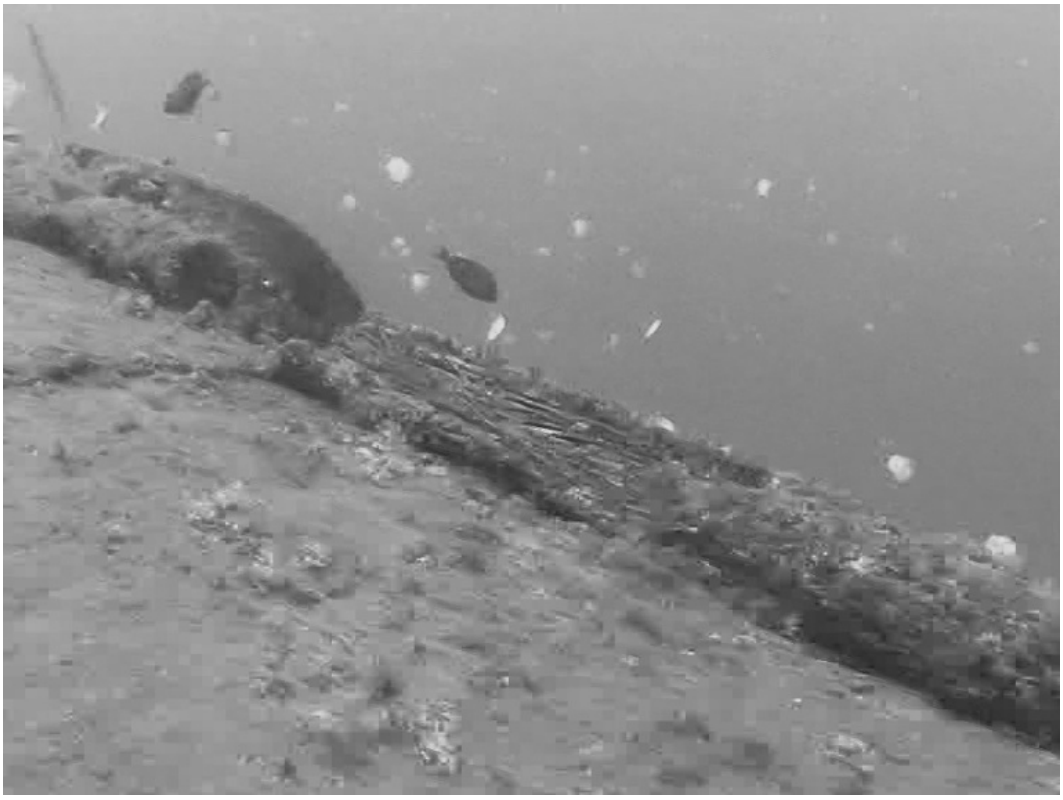


Figure 17– Bundles of cordite rods amongst the shells lining the bilge keel – believed to be the remains of cartridges

It is locally reported that these shells originated from the shore defence batteries on St Helena. These comprised one 6 in battery of naval guns and a second battery of smaller calibre guns. After the end of the Second World War the ammunition from these guns was dumped at sea and some of it came to rest on the upturned bow of the *Darkdale*. Although no measurements were taken, at least two different types of shell seem to be represented. While these probably reflect the two different calibres used in the shore batteries it is possible that some may once have originated in the *Darkdale's* own magazines and have been gathered from the wreck by divers to be placed on the ship's bottom.

The inaccessibility of the deck area on the bow is problematic. Although the sides and bottom of the ship exhibit no sign of torpedo damage forward of the break zone, it is likely that the deck was affected by the fires and explosions resulting from the attack. Indeed the barrels lying near the anchor chain may well provide evidence for explosions on this part of the ship. The barrels appear to be holed in places. If, as suggested above, they once formed part of the cargo of lubricating oil stowed on deck, it is likely that they were blown overboard by explosions on the ship before sinking to their present position. The degree to which this fire damaged the deck is, however, conjectural. It is interesting in this respect that the photo of the bow of the *Darkdale* lying above the water in the days following the attack clearly shows the handrail on the starboard side of the forecastle intact (figure 4). As a relatively weak structure it is difficult to see how this could have survived apparently unscathed if the bow had been exposed to explosions and fire for any length of time.

Although there is insufficient evidence to determine the degree of damage to the deck of the bow, the archaeological evidence provided by this section of the wreck disproves the statement in *U-68's* log that one torpedo struck the forward part of the ship. However, this also raises the possibility that an armed torpedo may lie undetected in James Bay.

THE BREAK ZONE

The break zone comprises the narrow gap between the bow and stern sections of the wreck (figure 18). The collapsed debris between the two parts most likely represents the remains of the aft pump room and the greater part of no.3 cargo tank. However, the remains are so shattered that positive identification of any of the parts on the seabed is difficult.

Although hard to quantify using just the ROV the amount of debris in the break zone appears insufficient to account for the approximately ten metres of the ship that is missing between the bow and stern sections. The most likely reason is that large parts of this section were blown out and lie some distance from the main wreck. In order to try and locate any such far flung items a series of search transects radiating out from the wreck were conducted by the ROV. Although no large items were detected during these searches *U-68's* KSB attests to debris from the *Darkdale* flying around as the ship exploded.

Figure 18 – View of the starboard side of the bow at its aft end with the plates of the ship's bottom overhanging the break zone

THE STERN

The stern of the *Darkdale* lies on its port side and exhibits signs of significant explosive damage caused by the detonation of the torpedoes. However, as these struck on the port side there was no opportunity to examine the area immediately affected by the detonation. In addition there is evidence for more recent structural collapse which, though ultimately attributable to the war time damage, attests to the current fragility of this section of the vessel. A significant debris field extends some 12m to the north of the stern section. It is primarily composed of material from the poop and boat decks that, according to local information, have undergone a significant collapse in the relatively recent past.

The stern section stretches for approximately 58m from the aft end of no.3 cargo tank which is open to the sea across its full width in the vicinity of frame 23A. As the greater part of the remains of this tank lie shattered in the break zone, only approximately 2m of the aft end of the tank survives as a coherent structure. In order to determine whether the bulkhead between this tank and no.2 cargo tank immediately aft remained intact the MiniROV was deployed into this section of the wreck. The foray revealed that the bulkhead, though still in place, is in very poor condition. It is punctured in numerous places with the result that no.2 cargo tank beyond is open to the sea. Indeed the visibility was sufficiently good to catch a glimpse right through no.2 cargo tank to the bulkhead beyond and reveal that this too is holed. The bulkhead between no.3 and no.2 cargo tanks was probably badly damaged by the nearby detonation of a torpedo during the attack. The weakening of the structure at this time likely increased its vulnerability to natural decay mechanisms resulting in its condition at the present day. Further survey of the exterior of the wreck was undertaken by the Falcon ROV.

Examination of the surviving section of the ship's now vertical upper deck revealed a large hole immediately forward of the still intact starboard ladder leading up to the poop deck. The hole lies above, and exposes, no.1 cargo tank (figure 19). The damage to this area evidenced at the present day was compared to that shown in a photo taken during the visit of the RAF Dive Club to the wreck in 2002 (figure 20). The photos were taken from near the break on the stern section looking aft towards the poop deck. They show the same hole and the line of the starboard side of the vessel. At this time the hole was noticeably 'neater' and the starboard side in its normal alignment. The current survey ROV footage reveals that since 2002 the starboard side of the ship from the break point all the way aft to no.1 cargo tank has sagged. The sagging has resulted in a very noticeable kink in the starboard side adjacent to the hole over no.1 cargo tank as well as considerable distortion to the hole itself (figure 21). The dramatic sagging in this area suggests that the stern section of the wreck is poorly supported (almost certainly as a consequence of the damage inflicted to the port side of the wreck during the torpedo attack and as the sinking ship impacted the seabed.) It is possible, given that the area appears intact in the 2002 footage, that the slumping of the wreck occurred in the spring storm of 2010 that occasioned the leak of oil from the wreck and led to the current survey. If so, it suggests that the heavily damaged stern may be vulnerable to future storm events. Determining the extent of damage to the port side of the stern, and thus its ability to support the wreck, proved difficult as the ship lies on this side and the debris field on the north side of the stern obscures any evidence to support this supposition.

Figure 19 – View of the vertically orientated stern section of the wreck taken during the 2012 survey looking aft towards the remains of the poop deck – note the hole over no.1 cargo tank and the distortion in the alignment of the starboard side

Figure 20– View of approximately the same area as in figure 19 taken during the 2002 visit to the wreck by the RAF Dive Club. Note the lack of distortion to the hole over no.1 cargo tank and the starboard side of the vessel in its correct alignment

Figure 21 – View from the poop deck taken during the 2012 survey looking forward– note the obvious distortion to the starboard side that has occurred in the 10 years since the visit of the RAF Dive Club

Moving 'up' onto the boat deck revealed that the crew accommodation has collapsed although, as noted, local divers suggest this too was a relatively recent occurrence. While the collapse of this area

cannot be directly attributed to the attack it is probable that the fire and explosions contributed to its weakening and probably hastened its decay. The side walls of the crew accommodation now lie in the debris field adjacent to the vertical deck and it is likely that they obscure other items originally mounted on the deck. It is probable, for example, that the 12 pdr gun believed to have been located on the port side of the boat deck next to the motor room skylight may lie hidden beneath the collapsed crew accommodation. Certain other distinct artefacts are, however, visible amongst the debris field including the ship's spare propeller that was originally carried on deck.

There is a large split in the deck at approximately frame 80A extending down both the deck and the starboard side of the ship (figure 22). The split forms a triangle with its widest point at the starboard gunwale, it tapers sharply down the greater part of the deck with its end point hidden by the debris field adjacent to the wreck. Visible within the split is a large cylindrical object believed to be the ship's donkey boiler. The split is likely evidence for an explosion in the ship's motor room. It may, however, have been recently widened by stresses from the probable slumping of the forward part of the stern section noted above.

Figure 22 – View of the triangular split tapering from its widest point on the starboard gunwale down the vertical deck of the stern

Plans of the *Darkdale's* sister ship, RFA *Cairndale*, show that this vessel carried her main armament, in this case a 4 in gun, on a bandstand right aft. The 4.7 in gun mounted in this position on the *Darkdale* has now collapsed but the upturned mounting has been tentatively identified lying in the debris field immediately below its former position. The gun itself is obscured by overlying debris.

Within the debris field on the northern side of the stern are several readily identifiable items of equipment including the ship's masts lying towards the front of this section. On the seabed in and around the debris field are a considerable number of what appear to be thin brown plastic rods several cm's in length (figure 23).

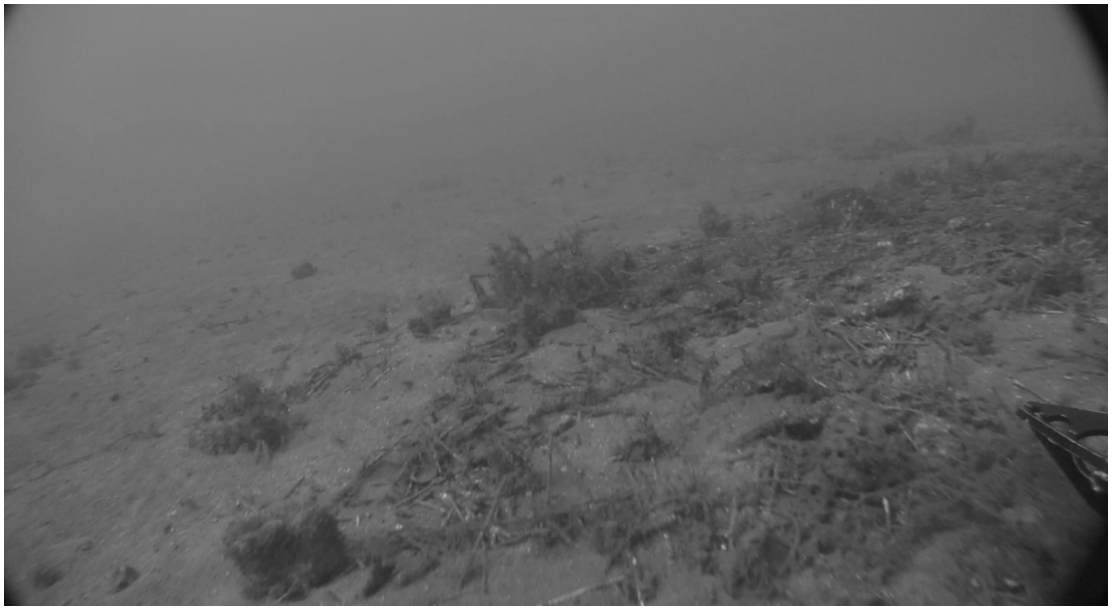


Figure 23 – Cordite rods on the north side of the stern

Given their similarity to the bundles of rods identified amongst the shells on the upturned bow it was suspected that these might also be cordite. One of the rods was recovered from the seabed to test this theory and was confirmed as this material. The presence of cordite lying loose in quite considerable quantities is interesting. Based on the position shown on plans of the *Darkdale's* sister ship RFA *Cairndale* the magazine was located on the poop deck immediately below the bandstand of the 4.7 in gun. Despite the ferocity of the explosions that engulfed the *Darkdale* there is no indication from the witness accounts that the aft magazine exploded. This is further supported by the intact condition of the stern in the area once overlain by the now collapsed magazine. The identification of the gun as of 4.7 in calibre rests on Captain Card's report and a mention in a report by the Officer Commanding the troops stationed at St Helena (REF: C0 820/50/20 St Helena local forces). However, neither of these makes the distinction of whether the gun was of the usual Quick Firing (QF) type, in which the cordite was contained in a brass cartridge case attached to the shell, or a rarer Breech Loading (BL) model with the cordite held in a silk cartridge separate to the shell (REF: Friedman, N, 2011, *Naval Weapons of World War One*, Barnsley: Seaforth) It is likely, however, that this gun was of World War One vintage or even older.

Both of the gun types are possibilities, in the first scenario the presence of dispersed cordite in the debris field may suggest that the *Darkdale* mounted a BL model. In the years following the loss of the ship it is likely that the silk bags containing the cordite would have rotted away, as appears to be the case with the munitions, believed to be derived from the shore battery, lying on the bow section. With the recent collapse of the boat and poop decks, and so therefore the magazine, the rods would have scattered across the seabed. If the gun had been a QF model the cordite would likely have remained contained in the brass cartridges and so would not have dispersed. If this reasoning is correct the 4.7 in gun on the *Darkdale* constitutes a rare survival. Most models of this calibre were of the QF variety and only two models, 4.7 in BL Mk I and Mk II, employed silk cartridges (REF: Friedman, N, 2011, *Naval Weapons of World War One*, Barnsley: Seaforth)

Conversely, the presence of shells on the upturned bow of the ship, apparently derived from the shore based batteries and dumped over the wreck after the war, raises the possibility that the ship's own 4.7 in gun was of the QF type. As noted, a number of these shells are neatly lined up along the bilge keel and this, in combination with the apparent absence of any similar shells around the wreck, suggests that divers must have gathered at least some of them from the seabed and deliberately placed them on the bow. It is certainly hard to envisage a scenario where the post-war dumping of the munitions was so accurate that the shells came to rest solely on the bow. Given that some form of undocumented clearance work has taken place it raises the possibility that the ship's 4.7 in gun was a QF model and the attractive brass cases it employed have been removed by divers who, in the process, deliberately emptied the cordite onto the seabed. Further examination of the gun would be required to determine the exact type.

By contrast, the 12 pdr gun shipped by the *Darkdale* would certainly have been of the QF type but, again, there are no signs of any brass shell cases for this gun amongst the debris field. However, assuming that these were also stored in the same, now collapsed, aft magazine as the 4.7 in ammunition, it is possible that they lie buried in the debris field or, again, have been deliberately removed.

Even though the exposed starboard side of the *Darkdale* did not bear the brunt of *U-68's* attack there is clear evidence on this side of the vessel for the ferocity of the assault and for the subsequent decay of the vessel. A few metres aft of the break point, a number of cables lie twisted around the wreck and just beyond these are two holes. Though only a few centimetres in diameter, the edges of one of these holes is sharply buckled outwards. Judging by their position it appears that an explosion inside the ship, probably occurring in no.1 cargo tank, was of sufficient force to punch debris through the starboard side.

Moving further aft, the line of the starboard side is interrupted by a sharp upwards 'ramp'. The 'ramp' is in fact the kink visible on the deck side of the wreck lying adjacent to the large hole over no.1 cargo tank described above (figure 21). Everything forward of this ramp on the starboard side has slumped downwards. At the base of the ramp two plates are buckled outwards although whether this damage was caused during the attack or, perhaps more likely, when the vessel slumped is not clear.

Moving further aft along the starboard side the damage in the vicinity of frame 80A that adjoins the triangular split in the deck noted above becomes apparent (figure 24). On this side the damage consists of a gaping hole running from the gunwale down the side and a series of misshapen and dislocated plates. Right aft, the ship's balanced rudder and propeller are in place and are both in excellent condition (figure 25).

Figure 24 – Damage to the starboard side in the vicinity of frame 80 – this adjoins the triangular split running down the deck shown in figure 22

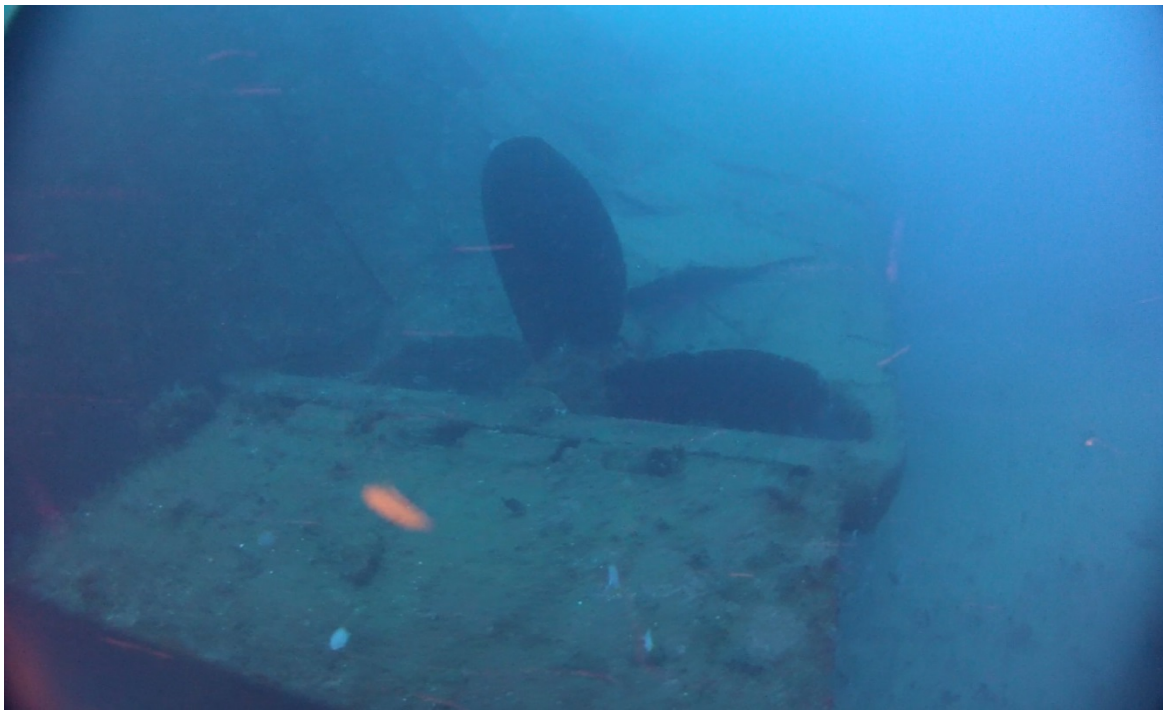


Figure 25 – The *Darkdale's* propeller and rudder

Although the survey did not encounter any direct signs of the crew, and indeed was designed to prevent any unnecessary intrusion, the damage to the stern makes it apparent why, with the exception of two gunners blown clear of the deck, there were no survivors from those aboard at the

time of the attack. With up to three torpedoes impacting in close proximity to the crew accommodation and at night when most hands were turned in there was little opportunity for escape before the ship turned over. Thereafter, the flames that took hold of the oil leaking around the wreck hampered the attempts of the islanders to mount a rescue.

WRECK SIGNIFICANCE

The archaeological and historical significance needs to be considered both in terms of the wider inventory of World War II era wrecks and its local relevance to the island and people of St Helena.

WIDER SIGNIFICANCE

The wreck is a well preserved example of a World War II era tanker. A type of vessel which played a vital role in the conduct of the war and which, as a consequence, was a prime target for Axis forces. Such vessels are well represented in the archaeological record but are comparatively little studied, in part because they lack the obvious 'glamour' of warship wrecks but also because a significant proportion remain either undetected or are difficult to access. In this respect the Potentially Polluting Wrecks Database 4 (PPWD4) maintained by the MOD and based on the UK Hydrographic Office wrecks database lists 177 tanker wrecks of all nationalities from the period 1939-1945. This is a poor reflection of the number of tankers actually lost as a significant proportion will have sunk in deep waters and have yet to be detected. The *Darkdale* is significant in this respect because, although St Helena is physically remote and difficult to reach, the wreck itself is easily accessible once on the island. There are few indications that it has been subjected to the same level of disturbance, in terms of the removal of artefacts etc, that vessels in similar situations around the UK coast have often suffered. However, it is likely that with the opening of an airport on the island in 2015 visits to the wreck will increase. If these are not properly managed there is likely to be a heightened risk of artefacts being removed from the site.

The vessel is also significant as a representative of the Royal Fleet Auxiliary. This service performed a vital function during the war but the surviving wrecks, in comparison to those of the Royal Navy or even the numerous, but poorly studied, wrecks of the Merchant Navy, have attracted little serious attention. A number of other wrecks of RFA tankers lost during World War II lie in comparatively accessible waters including RFA *War Mehtar* some 12NM off Lowestoft on the east coast of the UK and RFA *Boardale*, a sister ship to the *Darkdale*, wrecked near the Lofoten Islands of Norway.

The *Boardale*, which forms the closest archaeological parallel to the *Darkdale*, was lost after striking a rock and sank slowly over the course of several hours giving her crew ample time to escape. However, despite avoiding the brutal end visited upon her sister the wreck is believed to be in a poorer condition than the *Darkdale*. The *Boardale* has been the subject of sustained investigative work over a number of years to determine the environmental threat posed by the oil remaining aboard and in the spring of 2012 the Norwegian authorities undertook an operation to remove this oil from the vessel. The operation was successful and although the wreck was not assessed from an archaeological perspective the work has yielded some interesting details in this respect.

Surveys of the wreck undertaken in 1996 and 2000 show the vessel lying on its starboard side, partially buried in the seabed and apparently broken into three parts (REF: http://www.kystverket.no/Documents/Beredskap/Vrak/Vrakrapport_2006.pdf). Besides the actual breaks there appears to be very extensive damage to the stern of the ship in the vicinity of the engine room. The damage to this area may have been caused by an explosion, presumably of the ships boilers, reported to have taken place in the moments before the vessel finally sank (REF: ADM1/10916 – HM Ships – Damage and loss (31) – Loss of RFA *Boardale*: Report by Master). A plan of the survey results omits the vessel's superstructure, suggesting that either this has now collapsed or that it has been deliberately omitted. Despite the extensive physical damage to the wreck the *Boardale* apparently shows few signs of extensive corrosion.

LOCAL SIGNIFICANCE

The strategic importance of St Helena and its vital function as a Royal Navy refuelling stop has been detailed above. The wreck of the *Darkdale* provides the most tangible reminder of this role but also of the wider part played by the island in World War II. Although not, as yet, afforded any statutory protection the wreck site is clearly respected by the local community. The commemoration of the loss of the ship and its crew forms the focus for the island's Remembrance Day service and the very good condition of the wreck, particularly in respect of the lack of obvious pilfering from it, reflects its importance to the St Helenians.

Besides its relevance to the islands role in World War II the wreck needs to be viewed in the wider context of St Helena's maritime history. Since the first settlers arrived in the early sixteenth century the island's fortunes have been inextricably linked with the sea. The *Darkdale* is one of five wrecks that have been identified in the vicinity of James Bay. These consist of the Dutch East Indiaman *Witte Leeuw* that blew up in an engagement with a Portuguese vessel in 1613, the *Howden*, sunk as a target in 1902, the *SS Papanui* that accidentally burnt out in 1911 and the *SV Spangaried* which fell victim to a similar fate in 1920. Besides these obvious wreck sites, a recent (2012) underwater archaeological assessment by Headland Archaeology ahead of development work on the Jamestown wharf identified several additional submerged maritime archaeology features (REF: Headland Archaeology 2012 Jamestown Wharf Improvements – Phase 2 St. Helena. Archaeological Underwater Assessment). Of particular note was the identification of 27 historic anchors ranging in date from the seventeenth to the nineteenth centuries (Headland Archaeology 2012: 16). It is quite possible that additional wrecks lie as yet undiscovered in the waters around the island. In this respect a lithograph held by the National Maritime Museum, Greenwich is significant for its depiction of the wrecking of 13 vessels in James Bay during a Tsunami event in 1846 (REF: F088 – Shipwrecks at James Town and the Harbour, Saint Helena http://www.nmm.ac.uk/collections/prints/viewPrint.cfm?ID=PAI0414).

CONCLUSION

The wreck of the tanker *RFA Darkdale* is an important surviving example of a poorly studied type of vessel that made a major contribution to the allied cause in World War Two. It is also, so far as the author is aware, the only wreck of the Royal Fleet Auxilliary to be subjected to any form of

archaeological examination. At a local level the wreck is both the grave of the men who died aboard her and the most tangible reminder of the important role played by St Helena in World War Two. The *Darkdale* is therefore of considerable significance, however, the wreck faces a number of significant future challenges.

In the short term the recommendation of the wider report to remove the oil from the vessel is likely to have the biggest single impact on the *Darkdale*. This is unfortunately unavoidable if the very real environmental problems associated with the vessel are to be addressed. This work, should it proceed, will involve the hot tapping of oil from the bow of the *Darkdale* (it now being assessed that little, if any, remains on the stern section). While some damage will be unavoidable the procedure is surprisingly non-destructive and, carefully managed, should cause only minimal disturbance to the wreck. Indeed, the upturned bow aids the hot tapping process as it allows easy access to all of the tanks from which oil will have to be removed.

Safeguarding the wreck in the longer term will require careful management. To date, the isolation of St Helena coupled with the respect with which the wreck is treated by the island's inhabitants has afforded it an unusual degree of informal protection. As a result the vessel exhibits few of the signs of disturbance often found on wrecks lying in more accessible waters. The opening of an airport on the island in 2015 is likely to lead to a significant increase in both the number of visitors to the island and, by extension, the number of recreational dives on the wreck. The potential for this heightened activity to have a detrimental impact on the *Darkdale* is significant and will need to be carefully monitored.

Besides such anthropogenic threats more natural processes of decay are now increasingly in evidence on the wreck. The relatively recent collapse of part of the crew accommodation area on the ship's stern is attested locally while the nearby slumping of the starboard side in the last ten years has been discussed above. Much of the more obvious natural decay to the wreck is likely to be concentrated on this aft portion for the foreseeable future. As the section that suffered the brunt of the torpedo damage it was already significantly weakened and its side on orientation affords it perhaps less natural resistance to structural collapse than the upturned bow. Whether this natural decay will be a gradual process or intermittently more pronounced is not certain without undertaking longer term monitoring of the wreck. It has been speculated, above, that the storm event of 2010 occasioning the significant release of oil from the wreck may have been the direct cause of the slumping of the starboard side of the stern section. Such storms occur on the island every few years and careful examination of the wreck in the aftermath of any such future event will be key to better understanding the rate at which the vessel is decaying.

The survey of RFA *Darkdale*, although not intended as an archaeological examination, has yielded valuable information on the wreck in this respect. The project has facilitated a far more comprehensive understanding of the circumstances of the vessel's loss. For the first time both British and German accounts of the sinking have been compared while other documents, particularly those relating to the *M/T Egerø*, have yielded important insights into the loading of RFA *Darkdale* immediately prior to her loss. As noted this may have had a direct bearing on the spread of torpedo hits evidenced by the wreck at the present day. Physical examination of the wreck has demonstrated that any appraisal of the vessel's loss based solely on written records is flawed. The absence of any significant damage to the vessel forward of the break zone has conclusively demonstrated that the

torpedo stated in the German accounts to have struck this part of the *Darkdale* missed. This discovery should caution against over reliance on historical resources for interpreting other legacy wrecks. The case of the *Darkdale* demonstrates that on-site observation is crucial to the accurate evaluation of these vessels.

In the final analysis, and in answer to the questions posed under the Aims and Objectives section, the examination of the wreck has provided significant new insights into what caused the loss of the vessel. This information could not have been derived solely from documentary resources. Secondly, the survey, in combination with the eyewitness accounts, has now yielded as close to an authoritative account of the events surrounding the loss of RFA *Darkdale* as might reasonably be expected

Annex 6 – Post loss report of the Master of RFA *Darkdale*

from: ADM 199/ 2138 297

H.

TD/DEMS/139/1214.
15th January, 1942.

CONFIDENTIAL.

SHIPPING CASUALTIES SECTION. TRADE DIVISION.

REPORT OF AN INTERVIEW WITH THE MASTER, CAPTAIN T.H. CARD.

R.F.A. "DARKDALE". 8,145 gross tons.

IN HARBOUR. PRESUMED SUNK BY TORPEDO FROM U-BOAT ON OCTOBER 22nd, 1941.

CAPTAIN CARD:

We were at anchor off St. Helena on 22nd October and the ship was lying about 1,200 feet from the shore. We had been anchored here since 4th August, being used as a supply ship. We had on board 3,000 tons of oil fuel, 850 tons of aviation spirit, 500 tons of Diesel oil, also lubricating oil and coal. We were armed with a 4.7", 1 12-pdr., 2 Pig troughs, 2 Hotchkiss, 2 Marlin 2 Lewis, Kites and P.A.C. rockets. The confidential books were in a weighted bag in the chart room and went down with the ship. The number of crew, including myself and 4 Naval and 2 Army Gunners was 50, of whom 41 are missing.

2. I was on shore at 0040 on 22nd October, as were also 7 other members of my crew, when there were two loud explosions on the port side of my ship, which was the seaward side. The sea at the time was smooth and it was very dark but clear.

3. A Military Sergeant named Elliot and a Corporal who were on watch on the cliff heard the explosions. They both ran down to the gulley to their searchlight post and from there saw the silhouette of a submarine in the glare of the light from the burning ship. A native who was also on look-out on another part of the island stated at the enquiry that he also saw a sharp object but he could not define it or definitely state that it was a submarine.

4. I immediately went down to the Wharf where a number of people had collected and saw my ship blazing furiously. I took a launch and went off to the ship which was now burning from end to end with the sea round about also on fire. We picked up two men from the water and these were the only survivors from my crew who were actually on board at the time of the explosion.

5. We searched in the vicinity until 0245, but did not find any more survivors. By this time the ship was still blazing furiously, and I thought that in view of her cargo I had better warn the Military to clear everybody from the wharf. I telephoned to the Major in charge and asked him to clear everybody away. He did this and then I went to the hospital to interview the two survivors to see if they thought there was any chance of further survivors having got clear of the ship.

6. By 0400 two-thirds of the fore part of the ship was still above water and the after part was completely submerged. About 0530/

DISTRIBUTION:

D.T.D.
Cdr. Robertson MacDonald.
Admiral Dreyer.
C. in C. S.A.
Captain Beswick.
D.E.M.S. Section.
Commander Edwards.
D.N.C. Bath.
N.I.D. XI.
Commander Tennant.
D.A.S.W.
D.N.C. London.
D.T.S.D.
D.M.M.D.
Mr. R. Allen.
Files.

0530 the DARKDALE blew up and sank within five minutes.

7. I then telephoned to the Colonel and told him that I was sure there was a submarine around, and he replied that he could find no evidence of enemy action at all.

8. I asked him if he had made a signal to the C. in C. South Atlantic that my ship had been sunk by enemy action and he said "No" as he did not think that it was.

9. I knew that a mail boat was due in next morning, and that the C. in C. would require all possible information as early as possible.

10. The Authorities started an enquiry at 0900 the next day (22nd October). In the evidence taken from various people during the first day nothing was said about anyone having seen the submarine or anything resembling a submarine.

11. At 1400 next day, at the Enquiry, a Royal Engineer officer, Captain Scratchley, said he had new evidence to bring forward. He stated that two of his men had seen a submarine. The Colonel said "Why bring new evidence forward at this stage".

12. Sergeant Elliot and the Corporal came forward and said they were sure they had seen the submarine, and drew a diagram of the object they had seen.

13. Next day (24th October) a ship came in with two Naval Officers (Captain Bell, R.N., and another officer) who joined the Court of Enquiry.

14. Another witness came forward that afternoon. This witness stated that he Pumpman from my ship had been in his house 2 or 3 weeks before and had stated that he had seen the Bo'sun and a Greaser going on watch drunk, and that the Pumpman had said that some day the DARKDALE would be blown up. This man had a theory that the Fireman would burst a boiler and blow the ship up.

15. I am quite sure that there was no drunkenness amongst my men who were on watch at any period of our stay. One survivor said he had spoken to the Donkeyman and Greaser as they were going on watch at 2400 and that they were perfectly sober. This man also stated that he had been round the decks after 2400 and that everything was quite normal and that there was no smell of petrol or signs of fire.

16. At 0015 the last batch of shore leave men had returned to the ship and the boatman said that there was nothing to indicate that there was any trouble on board.

17. I am also quite sure that it would not be possible for anyone to have boarded the ship without being seen by the Officer or the men on watch.

18. I am firmly of the opinion that the ship was sunk by enemy action.

19. The Divers who examined the ship reported that the explosion appeared to have been from the inside of the ship outwards, and I am of the opinion that the torpedo penetrated the patrol tank, then exploded and blew a hole in the ship's side.

20. Another look-out man stationed at another part of the

island/

island reported seeing a dark shape near the ship at the time of the explosion, but he was not prepared to say that it was a submarine.

21. I am convinced that the evidence of the two Royal Engineers is correct, and that the sinking of the DARKDALE was due to a torpedo from an enemy submarine.

Annex 7 – Harbour Masters report

The Castle,
St. Helena,
23rd October, 1941.

From:
The Harbour Master,
thro' Colonial Treasurer.

To
The Hon'ble Ag. Government Secretary,

Re: Loss of R.F.A. "Darkdale".

I beg to report that on the morning of 22nd October at about 20 minutes to 1 I heard an explosion afterwards the sky was lit up and subsequently followed by two more explosions which sounded like the report of a big gun fire.

I tried to locate what had happened and could see the R.F.A. "Darkdale" which have been in this Port since the 6th August, 1941 enveloped in flames from bow to stern, no part of the ship appeared to be free.

I went on the Wharf and at the landing steps Boat No.17 owned by J. Seale and 31 owned by Isaac Williams, was taking in men to go in other boats to try and rescue the Crew who were on board.

The Captain of the R.F.A."Darkdale" and Chief Engineer who were ashore at the time arrived at the landing steps in about 10 minutes after the explosion were heard and rowed off the shore in Boat No.17.

(Boat No.17 and 31 was engaged by the Captain of this ship to row the Crew to and from the shore since this ship arrived at this port on August 5th). Other boats engaged in the rescue work were:-

Boat No.6
" " 22.
Military Gig
Motor Boat Anna.

The Complement of Crew carried in this ship was 50. Only 2 Gunners were rescued and they were picked up in the sea, landed, and removed to Hospital. Other Survivors from the ship who are:-

Captain, Chief Engineer. Chief Steward.
One seaman and 3 Seamen in Hospital. These were not on Board at the time. The total number saved are nine, the remaining 41 being lost.

Mr. Frank Flagg who is engaged by Messrs Solomon and Company as a night watchman to look after boats informed me that at the time of the explosion was first heard, the ship was lying across the Harbour bow to the East, when the second and third explosion occured the ship was seen to turn over. The fire continue to blaze until the ship sank at 3.30. When the vessel sank only the bow projecting out of the water. The submerged part of the vessel is now lying in a dept of about 20 fathoms.

Drums of Lubricating Oil were seen floating, and about 130 drums have been landed, also a boat was towed in from sea and have been landed on the Wharf.

Harbour Master

Annex 8 – Casualty list

List of RFA Darkdale Casualties

Atterbury	Philip	Cabin Boy
Bailey	Harry Harold	Able Seaman
Bain	Neil	Sailor
Bartley	Patrick	Sailor
Biggs	John Michael	Donkeyman
Borthwick	Archibald	Pumpman
Bradley	Michael	Donkeyman
Branchfield	Robert	Donkeyman
Brown	Peter McKenzie	2nd Officer
Burns	Douglas Haig	Electrician
Casement	Samuel	Assistant Steward
Clark	Jonathan	3rd Engineer Officer
Docherty	James	Donkeyman
Duncan	John	Boatswain
Gilbert	Bertram	Able Seaman
Golding	James	Chief Cook
Gosse	Charles A	Seaman
Hindson	Ronald John	2nd Engineer Officer
Irvine	James Currie	Junior Engineer Officer
Kelly	William	Donkeyman
MacLeod	John	2nd Radio Officer
MacMillan	Neil	Able Seaman
MacPherson	Archibald	Able Seaman
Maxwell	William Hastings	Sailor
McCafferty	Albert Henry	Carpenter
McClure	Ernest	Pumpman
McKenzie	Donald John	Able Seaman
McKernan	William Thomas	Junior Engineer Officer
Miller	Norman Percy	Chief Officer
Moore	Herbert William	Donkeyman
O'Connor	Robert	Deck Boy
Plews	William	Gunner
Reed	Leonard Frank	1st Radio Officer
Rodgers	George Andrew	4th Engineer Officer
Shaw	Thomas Herbert Patrick	3rd Officer
Smith	John	Steward
Sneddon	Samuel Nicholas	Cook
Stevenson	David	Ordinary Seaman
Ward	Thomas	Cabin Boy