HMS Royal Oak 80 Survey

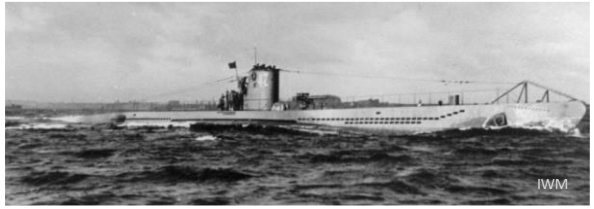
Ordnance, Munitions & Torpedo Damage

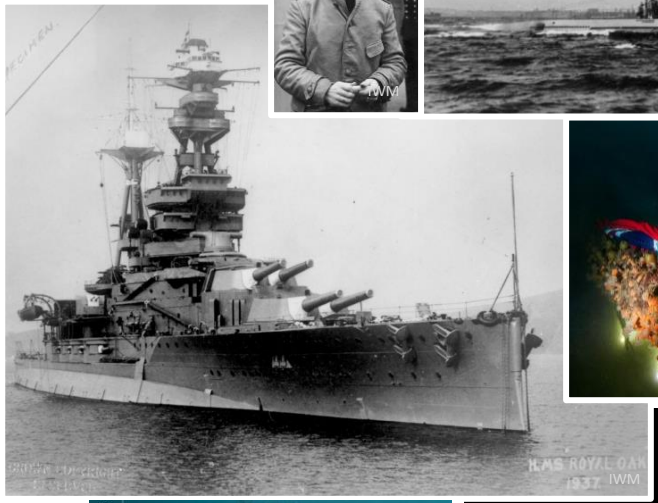
David Crofts MSc CEng FRAeS

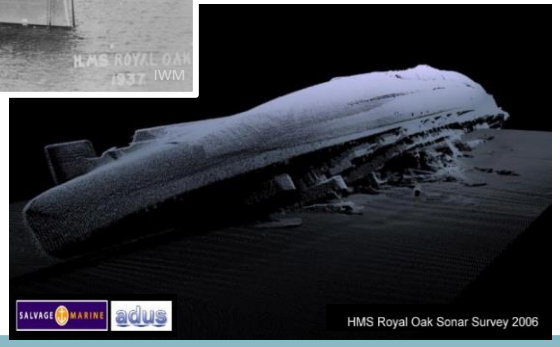
HMS ROYAL OAK

80 Years Underwater 1939-2019

Overview







- During the late evening of October 13th 1939 the ***German submarine U 47*** commanded by ***Gunther Prien*** entered the Scapa Flow naval anchorage in Orkney, Scotland and torpedoed the ***British battleship HMS Royal Oak***.
- 835 sailors lost their lives, 424 survived, and the wreck has been designated a **war grave and protected site**. It is visited annually by the Royal Navy Northern Diving Group for commemoration.
- **Fuel oil** has been removed from the wreck in recent years to lessen the environmental risk.
- HMS Royal Oak lies almost inverted on her starboard side in ~34m of sea water within sight of Orkney's principal town Kirkwall. She still contains her out-load of ammunition, and the torpedoes fired at her have not all been accounted for.

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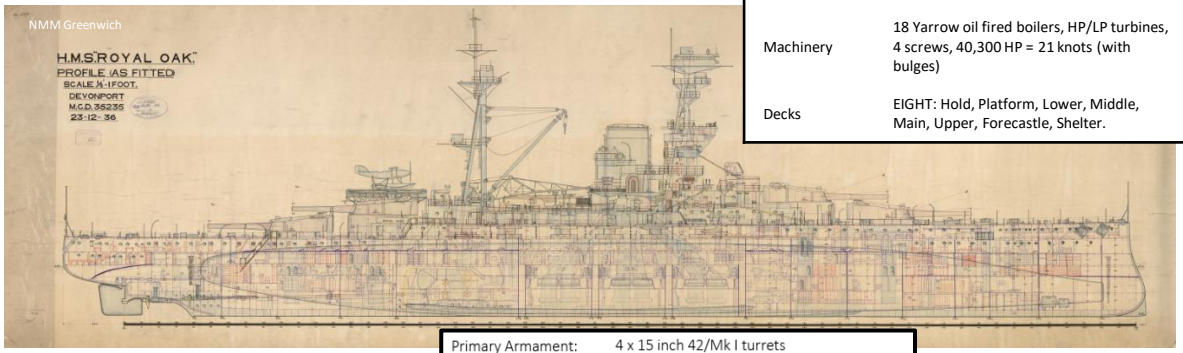
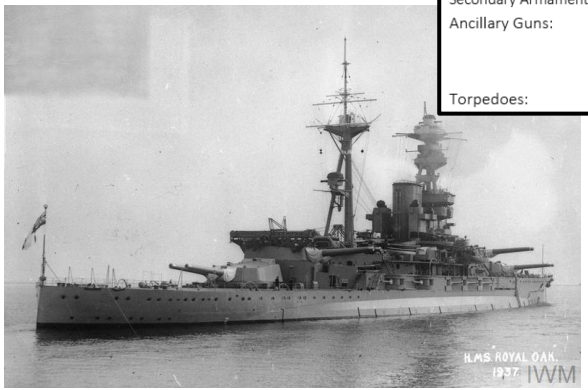
HMS ROYAL OAK
80 Years Underwater 1939-2019

HMS Royal Oak

Displacement	29,350t (standard), 33,500t (full)
Dimensions	189m L, 31m W (with bulges), 8.7m D
Machinery	18 Yarrow oil fired boilers, HP/LP turbines, 4 screws, 40,300 HP = 21 knots (with bulges)
Decks	EIGHT: Hold, Platform, Lower, Middle, Main, Upper, Forecastle, Shelter.



Primary Armament:	4 x 15 inch 42/Mk I turrets
Secondary Armament:	12 x 6 inch 45/BL Mk XII casemate guns
Ancillary Guns:	○ 4 x Twin 4 inch 45/QF Mk XIV anti-aircraft guns ○ 2 x 2-pdr (40mm/39cal) QF Mk VI Octuple Pom Pom ○ 2 x Quad 0.50 Vickers MkIII machine gun mounts ○ 4 x 3-pdr guns
Torpedoes:	4 x 21-inch torpedo tubes



- Revenge / Royal Sovereign Class super-Dreadnought Battleship.
- Eighth “Royal Oak”; named after Charles II refuge following Battle of Worcester 1651.

- Built Devonport from Jan 15th 1914,
- Launched Nov 17th 1914,
- Commissioned May 1st 1916.

- Fought at Jutland May 31st – Jun 1st 1916.
- Served in Grand Fleet, Atlantic Fleet, Mediterranean Fleet and Home Fleet.

- Modernisation 1922 – 1936
  - **Anti-torpedo bulges** added
  - High Angle Control System (**HACS**) added to formast and mainmast.
  - **Anti-aircraft gun mounts** added; 4x twin 4 inch QF, 2x Octuple 2pdr (40mm) Pom-Pom, 2x Quad 0.5” Vickers
  - **Torpedo tubes** moves to Upper Deck Forward of A turret
  - **Aircraft Catapult** added to X-turret.
  - **Bridge** Structure & **searchlight** platforms modernised and extended.

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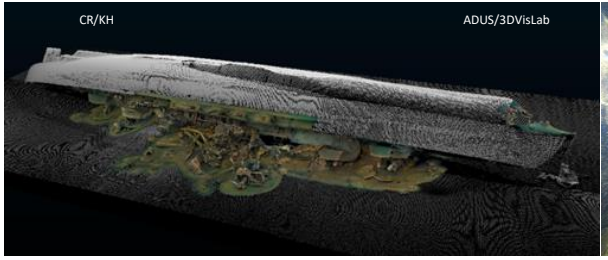
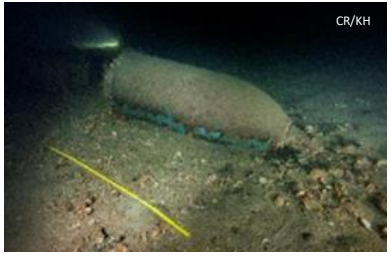
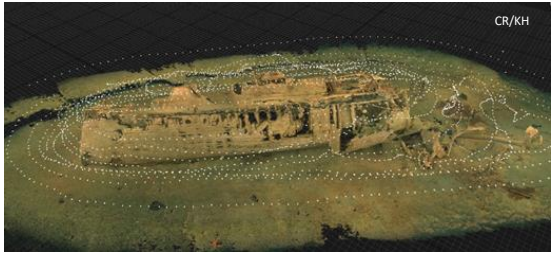
Overview







- The ***HMS Royal Oak 80 Survey*** was conducted between November 2018 and November 2019 under special licence from the Secretary of State for Defence.
- ***Purpose*** to document the war grave at 80 years underwater for the historical record, and disseminate to non-divers and future generations in memory of those lost.
- A volunteer team of 22 ***free swimming divers*** surveyed the wreck-site using videography, still photography and 3D photogrammetry.
- The survey has included detailed examination of the ***exposed munitions*** on the site, and the torpedo damage to the ship, which is the focus for this presentation.

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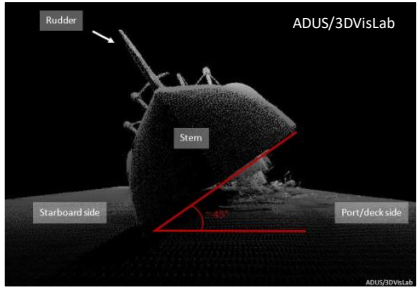
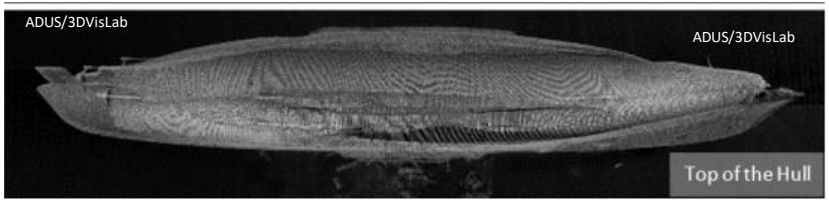
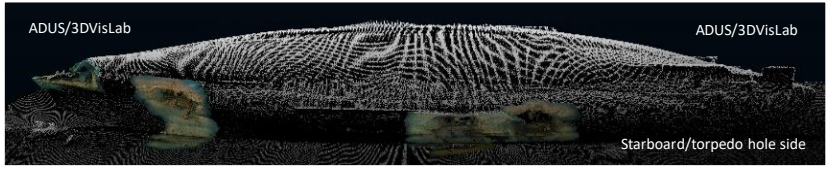
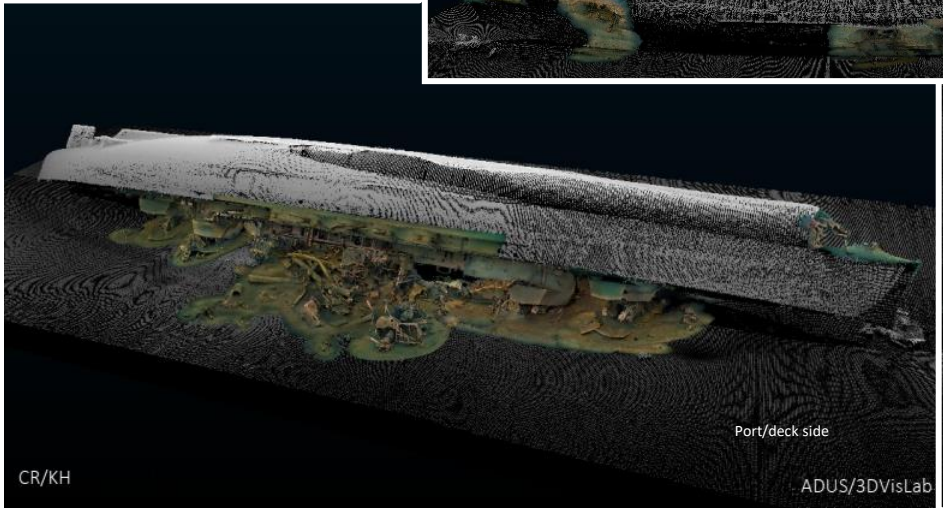
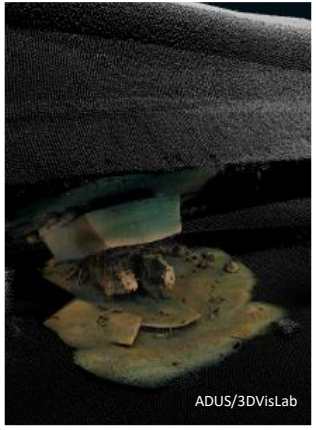
HMS Royal Oak Today











- HMS Royal Oak lies in the seabed of Scapa Bay, Scapa Flow, Orkney, upturned on her starboard rail, main deck at ~45° to the seabed in a water depth ~34m, ~6m to the top of the hull.
  - Crushed superstructure keeps hull above the seabed.
  - Bow forefoot has fallen to the seabed due to torpedo damage.
  - Four torpedo holes clearly visible starboard side.
  - Masts and other debris lies on the seabed
  - Main gun turret roofs lie on seabed revealing gun breaches & interior of the turrets
- **ADUS Multibeam Sonar Survey** of the wreck was undertaken May 2006.
  - ADUS - University of St Andrews & University of Dundee. Survey undertaken for Ministry of Defence Salvage & Marine Operations
- Sonar images were used for orientation on the wreck site.
- University of Dundee 3DVisLab has combined Sonar and Photogrammetry images.

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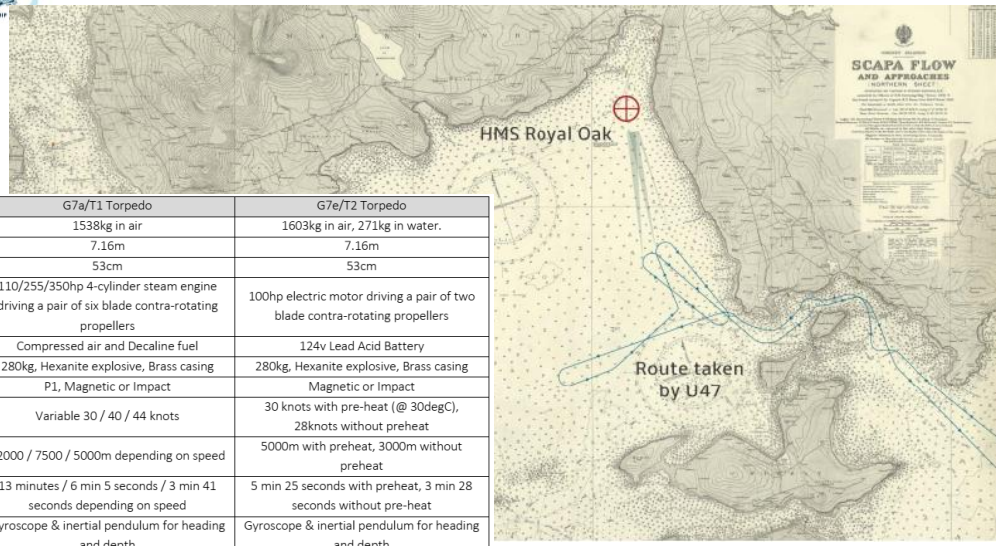
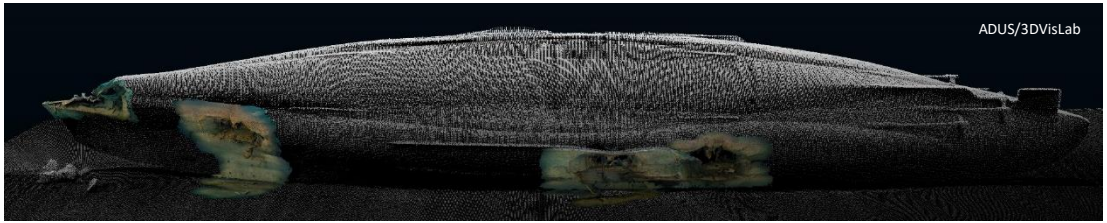
Torpedo Attack



	G7a/T1 Torpedo	G7e/T2 Torpedo
Weight	1538kg in air	1603kg in air, 271kg in water.
Length	7.16m	7.16m
Diameter	53cm	53cm
Propulsion	110/255/350hp 4-cylinder steam engine driving a pair of six blade contra-rotating propellers	100hp electric motor driving a pair of two blade contra-rotating propellers
Power	Compressed air and Decaline fuel	124v Lead Acid Battery
Warhead	280kg, Hexanite explosive, Brass casing	280kg, Hexanite explosive, Brass casing
Firing Pistol	P1, Magnetic or Impact	Magnetic or Impact
Speed	Variable 30 / 40 / 44 knots	30 knots with pre-heat (@ 30degC), 28knots without preheat
Range	12000 / 7500 / 5000m depending on speed	5000m with preheat, 3000m without preheat
Endurance	13 minutes / 6 min 5 seconds / 3 min 41 seconds depending on speed	5 min 25 seconds with preheat, 3 min 28 seconds without pre-heat
Guidance	Gyroscope & inertial pendulum for heading and depth	Gyroscope & inertial pendulum for heading and depth



Seven torpedoes fired in three salvoes

1. Three G7e/T2 torpedoes at 00:58 & ~3000m. One hit starboard side
   Frame 10 (bow beneath anchor)
2. One G7e/T2 torpedo (stern tube) at 01:02. No hit.
3. Two G7e/T2 + One G7a/T1 torpedoes at ~01:08. Three Hits starboard side
   Frame 27 (bow, beneath breakwater),
   Frame 132 (beneath boat deck, boiler room 3)
   Frame 208 (beneath mainmast, engine rooms).

In 1939 German torpedoes were unreliable.

They ran ~2m too deep & the magnetic firing pistols were unreliable.

Notable “misses” include HMS Ark Royal (Sept 1939) and HMS Nelson (Oct 1939)

To compensate, U47 fired torpedoes at shallow depth (3.5m setting, ~5.5m actual) and with impact pistols set.

Unreliability was rectified and G7a torpedo remained in production & service after 1945.

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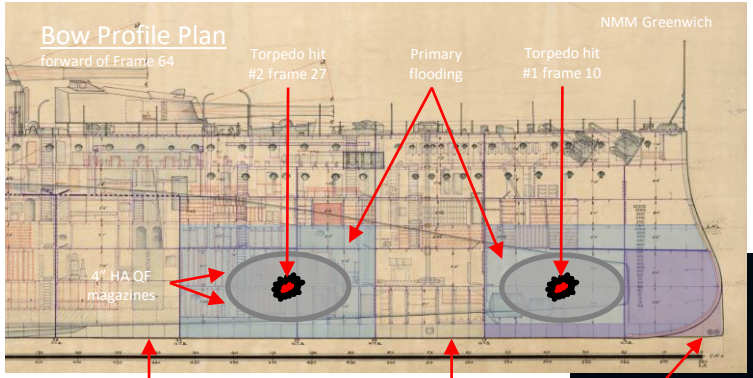
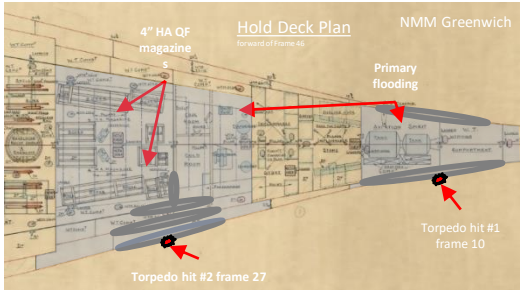
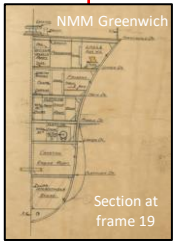
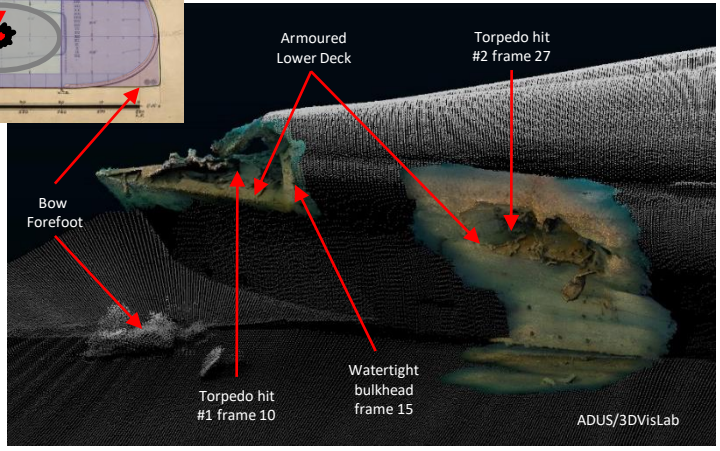
Torpedo Damage and Flooding

Torpedo Hits #1 and #2









Hit #1 opened the flammables & aviation fuel stores to the sea (~230 tons flooding) and caused a hole from starboard to port side.

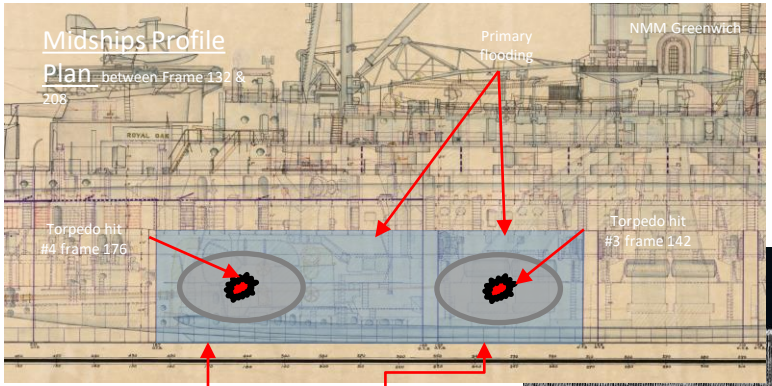
- Since the sinking the bow forefoot has broken off and fallen to the sea bed.
- The crew mistook the torpedo hit to be an accidental explosion in the flammables store.

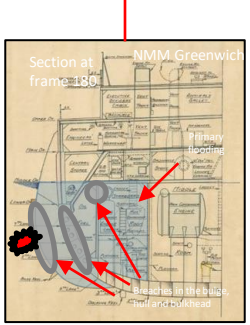
Hit #2 opened 4" HA QF magazine refrigeration store and torpedo head magazine to the sea (~1670 tons flooding) and breached the torpedo bulge & longitudinal armoured bulkhead.

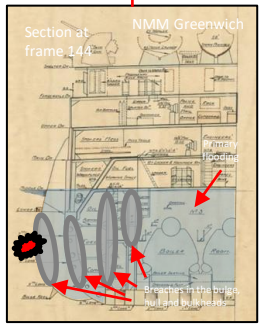
- Damaged 4" HA QF ammunition boxes can be seen inside the magazine through the cracked bulkhead.
- Robust construction of ammunition prevented catastrophic explosion.

Torpedo Damage and Flooding

Torpedo Hits #3 and #4

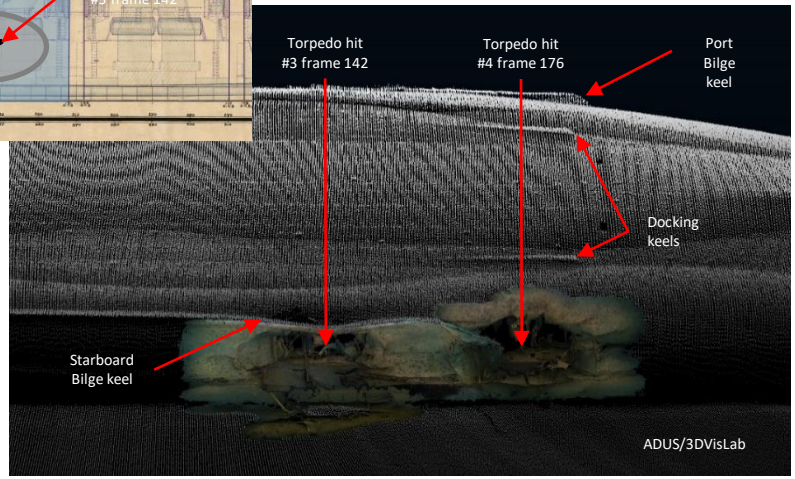






Hit #3 breached the torpedo bulge, hull side, fuel tank divisions and armoured bulkhead, opening boiler room 3 to the sea (~2830 tons flooding).

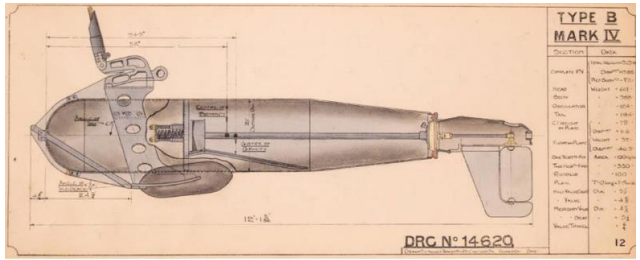
- Flooding would have taken less than 2 minutes.
- Ventilators, uptakes, open hatches and cracked plating vented blast & flash onto mess decks above.
- Fuel oil would have been released into the sea.

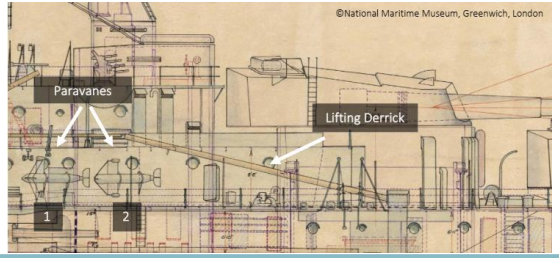


Hit #4 breached the torpedo bulge, hull side, fuel tank divisions and armoured bulkhead, opening starboard wing engine room to the sea (~1470 tons flooding).

- Flooding would have taken less than a minute and caused an immediate lit to Starboard
- As with Hit #3 blast & flash would have vented onto mess decks above, and fuel oil released into the sea.

Mine Sweeping Paravanes





ROYAL OAK equipped with Paravanes to protect her from seabed moored sea-mines.

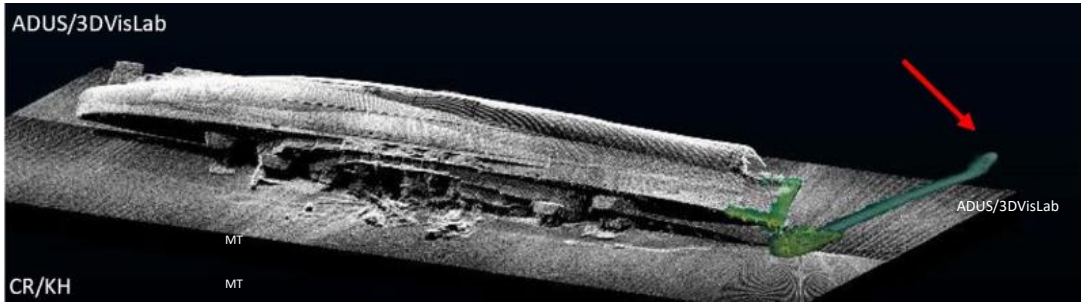
- ROYAL OAK was one of the first capital ships fitted for Paravanes with a towing 'skeg' fitted to her bow forefoot.
- Two Paravanes were stowed each side of ROYAL OAK's superstructure alongside a lifting derrick.

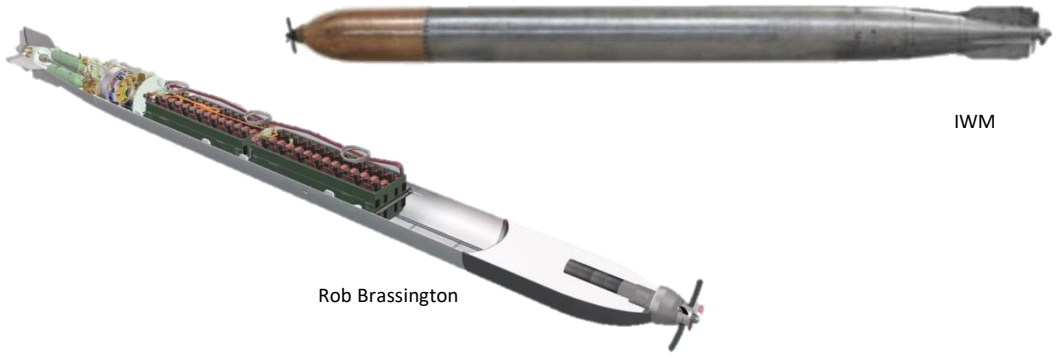
Paravanes were buoyant torpedo shaped, welded steel bodies with rudders to control water depth & position.

- In use the Paravane's were streamed out at 50° from a towing eye 'skeg' fitted to the ship's bow forefoot. The sea-mine's mooring cable would be drawn onto, and cut by a cutting device mounted on the Paravane.

Paravanes were invented during WW1 in secrecy by Commander Sir Charles Burney RN at HMS VERNON.

G7e/T2 Torpedo





IWM

Rob Brassington

The remains of a German G7e/T2 torpedo found ~60m NNW ROYAL OAK's bow.

Torpedo lies flat on the seabed, **no evidence of collision** with the ship or seabed, suggesting it missed ROYAL OAK and **sank to the seabed** at the end of it's run.

Steel casing, propeller and hydroplanes have **corroded** away, likely due to effects of **sea water** and leaking **battery acid**.

280kg Brass/Hexanite warhead & Firing Pistol, Bakelite lead-acid batteries, Stainless Steel motor & guidance section remain.

- Warhead & firing pistol was removed and destroyed December 2019 by the Royal Navy Northern Diving Group.

Small **scallop dredge** snagged on motor & guidance section.

Torpedo heading (~305°) and position (60m NNW of ROYAL OAK's bow) suggest it is the torpedo **fired from U47's stern tube** (second salvo). The range ~3000m is consistent with the maximum for G7e/T2 torpedo without pre-heat of the batteries.

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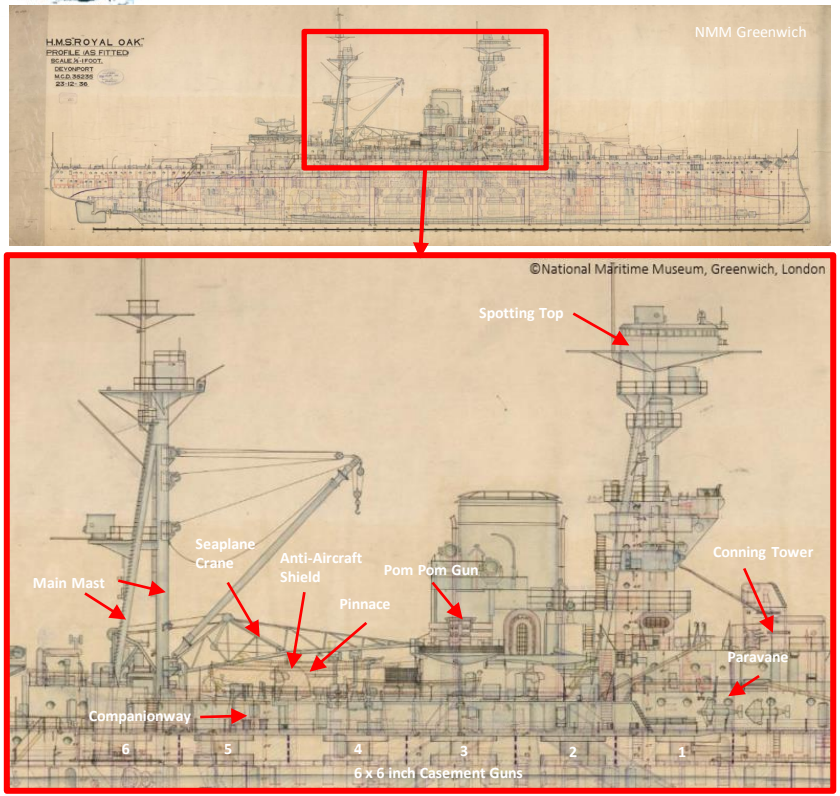
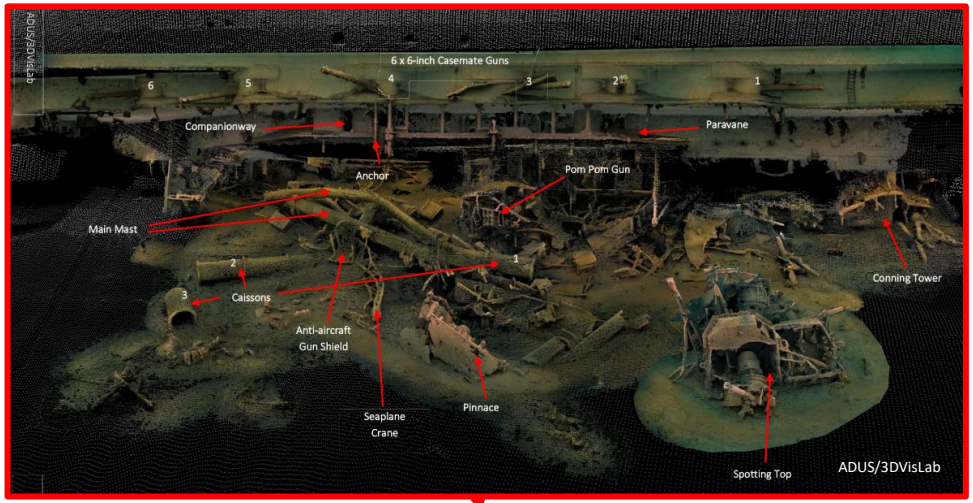
Mid-ships Debris Field





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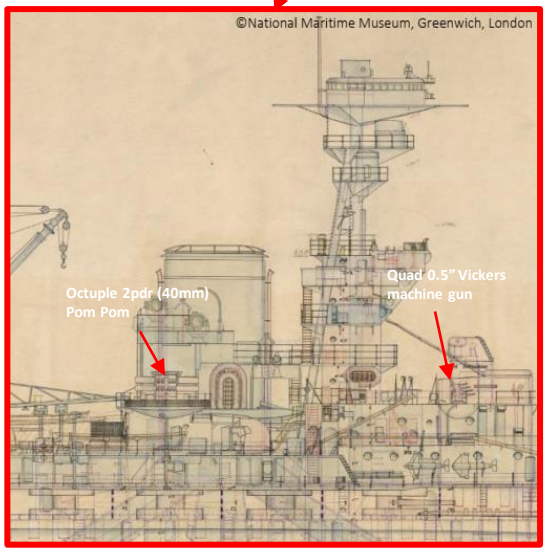
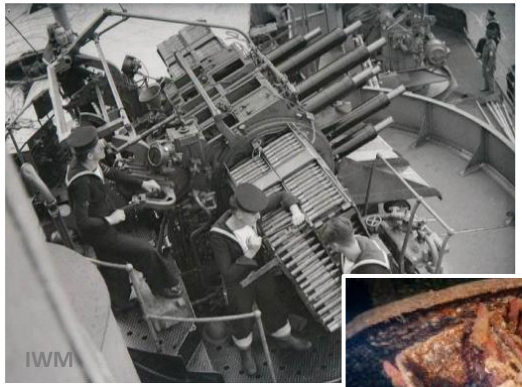
Octuple 2pdr (40mm) Pom Pom & Quad 0.5" Vickers Mk III Machine Gun

The Pom-Pom mount ammunition loading bins are virtually full, presumably in anticipation of an air raid.

The Vickers machine gun ammunition loading bins are empty, presumably because they would be quick to load and bring into action.





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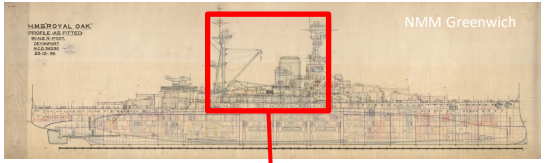
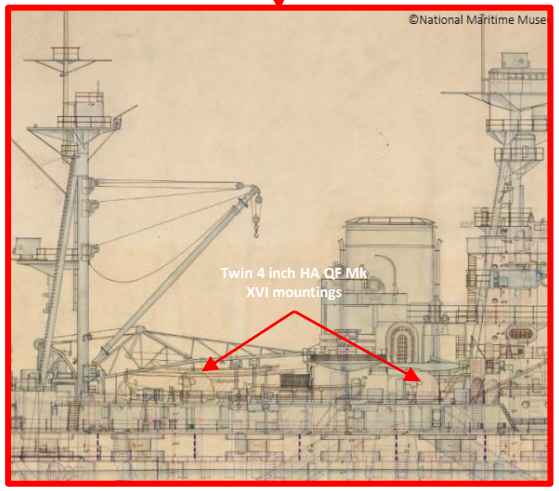
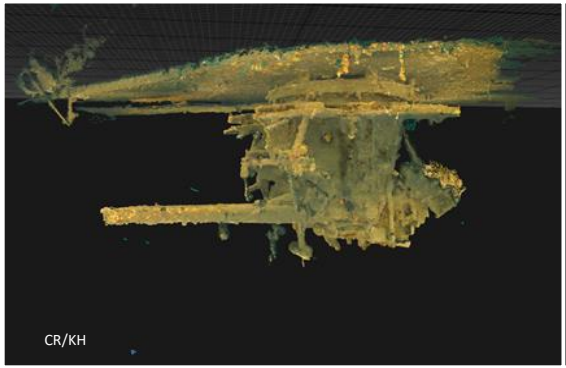
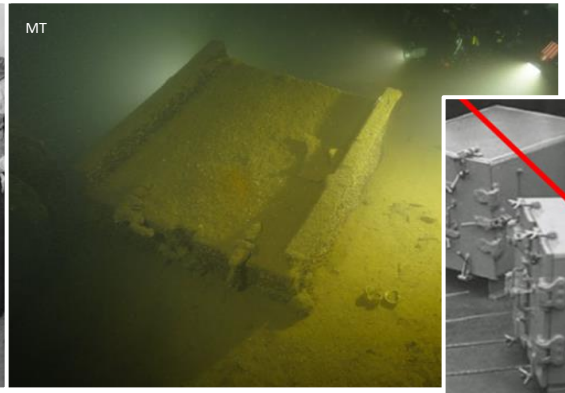
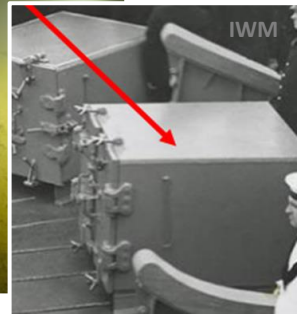
Twin 4 inch HA QF Mk XVI Gun Mounting & Ready-Use Ammunition Locker



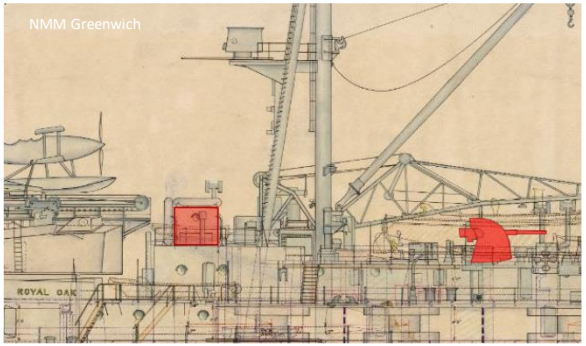


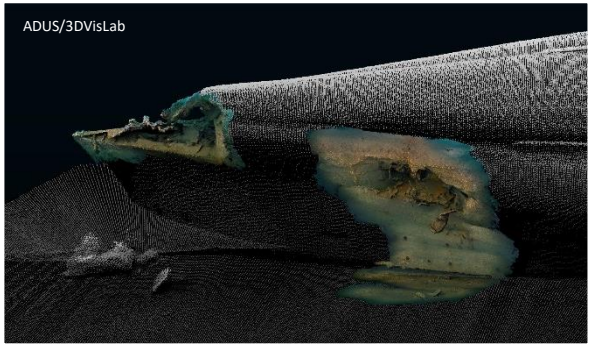


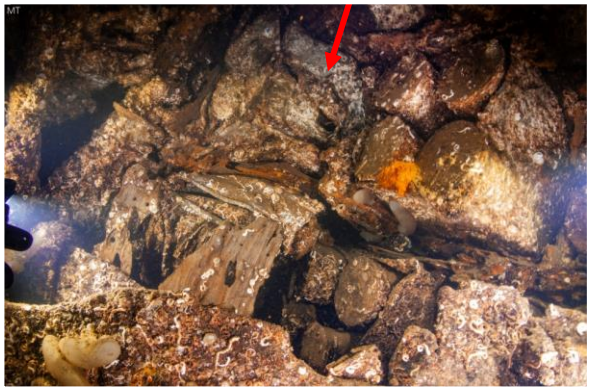




4 inch HA QF Fixed Ammunition







4 inch HA QF Fixed Ammunition for the Mk XVI anti-aircraft guns was found exposed in 2 locations:

1. Site of Torpedo Hit #2, behind fractured and broken longitudinal armoured bulkhead protecting magazine on Platform deck. Ammunition boxes showed blast damage from torpedo strike, but exhibited no sign of ammunition fire or explosion.

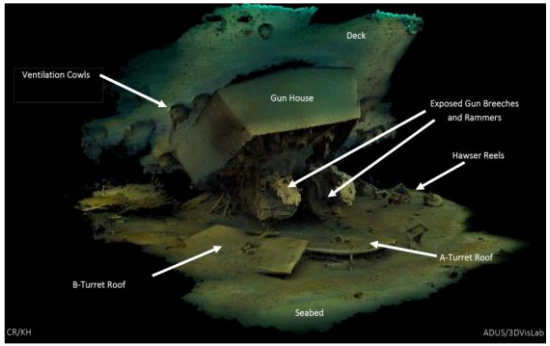
   Torpedo Hit #2 was virtually a direct hit on this magazine. It is remarkable that a magazine explosion did not occur. An even greater tragedy was averted because of the resilience of the ammunition to sympathetic reaction.

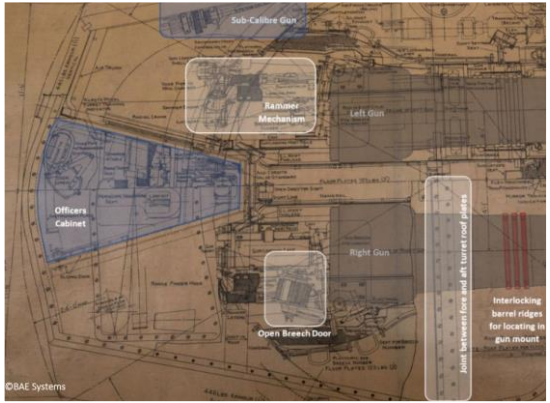
2. Deck house on Shelter Deck. Ammunition was unpacked and unrestrained. Likely this was ready ammunition temporarily stored near the gun mounts in anticipation of an air raid.

   ROYAL OAK was anchored in Scapa Bay to provide anti-aircraft protection for the radar station at Netherbutton on Mainland Orkney.

15 inch BL Mk 1 Main Armament Gun Turrets

15 inch BL Mk 1 Main Armament Gun Turrets





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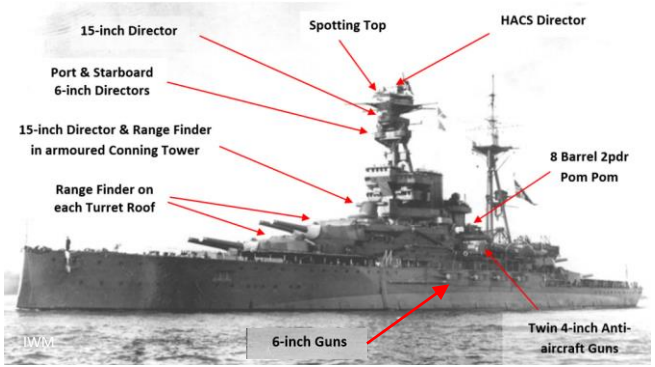
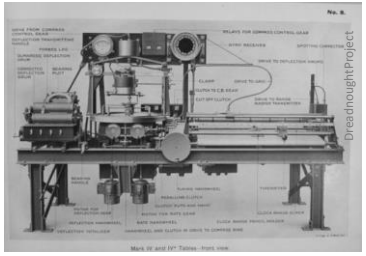
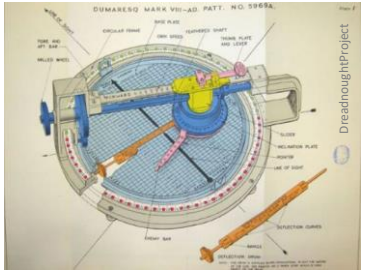
Fire Control







Gunnery Fire Control was from the Fire Control (**Spotting) Top** at the top of the Foremast with a clear view to track and report the enemy position, and to report fall of shot.

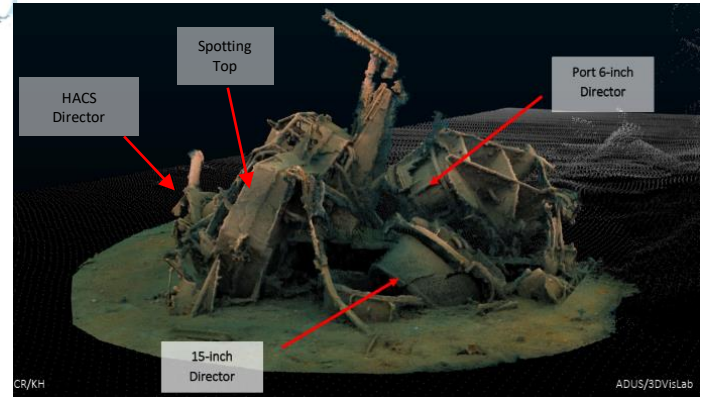
Transmitting Station deep inside the ship used mechanical computers (e.g. Dreyer, Dumaresq) to track enemy movement relative to own ship, and to relay firing solutions to the gun directors including the deflection to be applied to the gun sights.

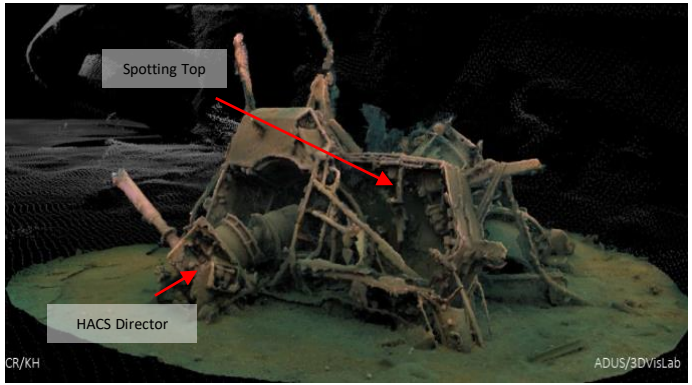
To improve accuracy and effectiveness the guns were centrally aimed and fired from **Gun Directors**.

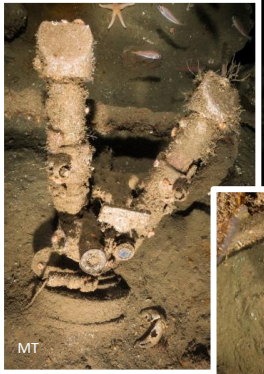
- 15” gun Directors (i) foremast, (ii) conning tower & (iii) X turret.
- 6” gun Directors (i) port & (ii) starboard on foremast.
- 4” anti-aircraft HACS Directors (i) foremast & (ii) mainmast.

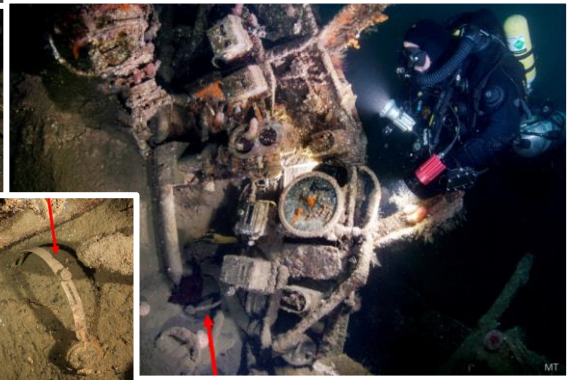
The turrets were all equipped with their own rangefinder and could be aimed and fired under **local control** if necessary.

Fire Control (Spotting) Top









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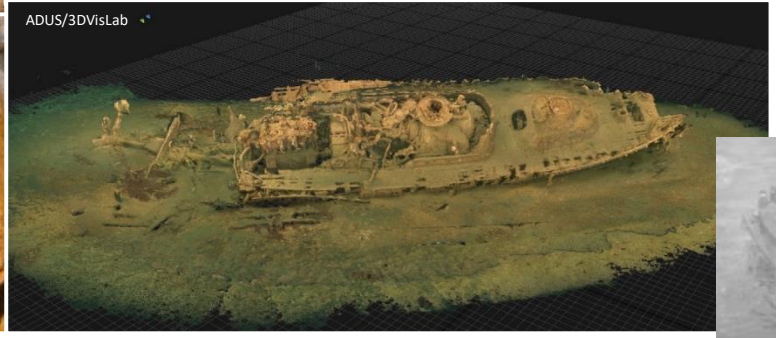
HMS ROYAL OAK
80 Years Underwater 1939-2019

50’ Steam Pinnace “jolly boat”



ROYAL OAK had two 50’ Steam Pinnace’s, known to the crew as ‘jolly-boats’. Both were built during WW1. They were utility boats when in harbour and could be armed.

One Pinnace was crushed by the Mainmast as ROYAL OAK capsized and is located in the mid-ships debris field.

The second floated away with survivors aboard, but sank when overloaded, with significant loss of life. It has been found on the seabed to the west of ROYAL OAK. It is ostensibly intact, but damaged by trawl fishing.

The survey team has recommended that the exclusion zone around ROYAL OAK be extended to include this important site.

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Conclusions & Recommendations

HMS ROYAL OAK 80 SURVEY

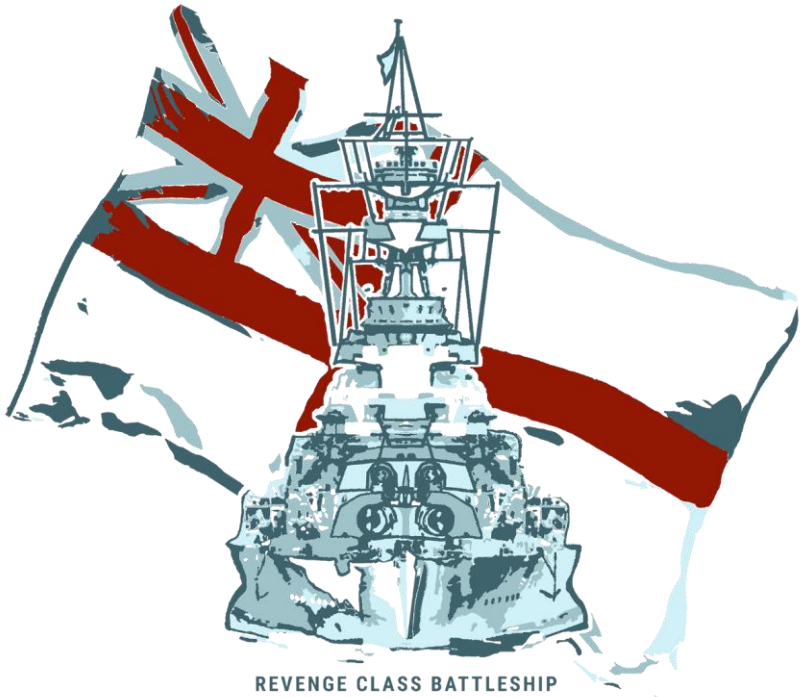
2018 – 2019

REPORT

https://www.Huskyan.com/diving/hms-royal-oak

- HMS ROYAL OAK is arguably the most complete example of a dreadnought battleship underwater today, and therefore of extreme archaeological & historical importance.
- Broad-scale sonar, videography, photography, photogrammetry and targeted diver surveys have been used in a complementary way to visualise and document the shipwreck to a most comprehensive extent.
- The survey team have been able to add significantly to the historical record, particularly with respect to the damage to HMS ROYAL OAK from the torpedoes, the condition of the wreck and the artefacts present on and around the wreck-site.
- Dissemination of the results from the HMS ROYAL OAK 80 Survey will help to ensure the loss of ship and crew retains the significance and commemoration it deserves.

- ***The FALLEN OAK documentary video can be found on U-TUBE.***
- ***HMS ROYAL OAK 80 Survey Report can be accessed via the MV Huskyan dive boat website.***



REVENGE CLASS BATTLESHIP

HMS ROYAL OAK

80 Years Underwater 1939-2019

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