Modelling the last of the “Movies”: discussion and digital survey of the Eothen formerly ML286

Virtual Archaeology Review, **12**(25): In Press, 2021
https://doi.org/10.4995/var.2021.14543

Received: October 27, 2020
Accepted: January 8, 2021

MODELLING THE LAST OF THE "MOVIES": DISCUSSION AND DIGITAL SURVEY OF THE EOTHEN FORMERLY ML286

MODELADO DEL ÚLTIMO DE LOS "MOVIES": DISCUSIÓN Y LEVANTAMIENTO DIGITAL DEL EOTHEN ANTERIORMENTE CONOCIDO COMO ML286

Pablo Rodríguez-Navarro[a,*], Eliott Wragg[b], Giorgio Verdiani[c], Teresa Gil-Piqueras[a]

[a] Universitat Politècnica de Valencia, Valencia, Spain. rodriguez@upv.es; tgil@ega.upv.es

[b] Thames Discovery Programme. Museum of London Archaeology. London, UK. elbalaclavo@hotmail.com

[c] Dipartimento di Architettura. Università degli Studi di Firenze. Florence. Italy. giorgio.verdiani@unifi.com

Highlights:

- The "mosquito fleet" has a specific page in the WWI naval wars. Based on a specific ship, it is missing detailed documentation, the survey of the last one can highlight that episode.
- The digital survey of the Eothen has a strategy aimed to allow the full documentation of the shipwreck in a very difficult environment, managing floods, mud, vegetation and reflections.
- The drawings and the 3D model, accessible from a free platform allow complete access to this ruined ship, a contribution to knowledge and a base for possible intervention hypothesis.

Abstract:

The research presented here puts together different direct and/or physical operations all aimed to enhance the knowledge and produce advanced dissemination of the very last ship from the "Mosquitos' Fleet" which operated during the World War I and in some operations even during the World War II. The exploration of the valuable remains along the Thames River in London, the intervention with archaeology strategy, the use of digital survey procedures, the investigation of the references about the fleet, the digital modelling and drawing and the final online sharing of the 3D model, brought together to a specific digital heritage creation of an element with a high risk of getting lost. An international team worked together on the poor shipwreck of the Eothen (the last name assigned to this ship by its last owner). The intervention was operated in very odd operative conditions, with the hull invaded by the mud, the very wet environment and the daily flood of the area, such a mix of difficult conditions were a special challenge for the survey operations, which were optimized and accurately planned to allow the best and efficient result in terms of coverage and level of details. The following post-processing aimed to the production of a classic set of 2D drawings and an interactive 3D model, accessible in a real-time visualization from the sketchfab.com platform creates an excellent base for a possible following restoration/musealisation intervention, or, at least, allow digital preservation of a rich dataset of the remains of this interesting piece from the naval history of the first half of the 20th century.

Keywords: motor launch; World War I (WWI); digital survey; 3D modelling; 3D laser scanner

Resumen:

La investigación que aquí se muestra reúne diferentes operaciones directas y/o físicas, todas orientadas a mejorar el conocimiento y producir una puesta en valor del último barco de la "Flota de Mosquitos" que operó durante la Primera Guerra Mundial y en algunas operaciones incluso durante la Segunda Guerra Mundial. Presentamos la exploración de los valiosos restos a lo largo del río Támesis en Londres, la intervención con estrategia arqueológica, el uso de procedimientos de levantamiento digital, la investigación de las referencias sobre la embarcación, el modelado y dibujo digital, y el intercambio final en línea del modelo 3D, reunidos en una aportación de patrimonio digital específico de un elemento con alto riesgo de perderse. Un equipo internacional , trabajaron juntos en el naufragio del Eothen (nombre asignado a este barco por su último propietario). La toma de datos se realizó en condiciones operativas muy complejas, con el casco invadido por el limo del rio, el entorno muy húmedo y la inundación diaria de la zona; esta mezcla de condiciones difíciles fueron un desafío especial para llevar a cabo las operaciones de levantamiento, las cuales fueron optimizadas con el objetivo de obtener el mejor y más eficiente resultado en términos de cobertura y nivel de detalle. El siguiente posprocesamiento estuvo dirigido a la obtención de un conjunto clásico de dibujos 2D, así como de un modelo 3D interactivo, accesible en una visualización en tiempo real desde la plataforma Sketchfab.com. Así se ha creado una base excelente para una posible intervención posterior de restauración/musealización, o, al menos, para obtener la

* Corresponding author: Pablo Rodríguez-Navarro, rodriguez@upv.es

preservación digital de un rico conjunto de datos de los restos de esta interesante pieza de la historia naval, de la primera mitad del siglo XX.

Palabras clave: caza-submarinos; Primera Guerra Mundial; levantamiento digital; modelado 3D; escáner láser 3D

1. Introduction

In 2014, in connection with his work for Historic England on the East Coast War Channels (Firth, 2014; 2015a; 2015b), Antony Firth of Fjordr Ltd. contacted the Thames Discovery Programme (TDP), a volunteer project recording the archaeology of the Thames foreshore in Greater London hosted by Museum of London Archaeology (MOLA), regarding the possible presence of a surviving WWI Motor Launch (ML), often known as the "Movies", at B.J. Wood's boatyard on Isleworth Ait, West London. The vessel had started life as ML 286 but had been converted into a domestic cruiser and was now known as *Eothen*. An initial site visit early in 2015 confirmed the presence of the much-degraded vessel and this was followed by three annual, week-long, cleaning and recording sessions from 2015-17 (Fig. 1). In 2018, the initial cleaning, vegetation removal and, photogrammetry and 3D laser scanning were performed, the latter by a team from the Universitat Politècnica de València and the Università degli study di Firenze.

It is believed that this is the last surviving ML of almost 600 serving with the Royal Navy in WWI. While significant enough as the last known survivor of this class of vessel, it would appear that no detailed plans of these crafts are known to exist (Fisher, 2018: 9; Andrew Choong Han Lin pers. comm.) and thus the work of recording her is of great importance. Moreover, *Eothen* also served as one of the 'little ships' at Dunkirk adding more laurels to her earlier career with the RN.

While the volunteers of the TDP have provided sterling service in recording the outside of *Eothen,* her significance requires full excavation, recording and conservation of those elements not already too badly degraded, is a task sadly beyond the capabilities and resources of the TDP alone. As a result, a joint venture between TDP, MOLA, Fjordr Ltd., the National Museum of the Royal Navy (NMRN) and the Coastal Forces Heritage Trust (CFHT) has been formed to achieve this aim via a joint TDP volunteer/MOLA professional excavation with conservation and display to be undertaken by NMRN and CFHT. Funding is currently being sought to enable this project. In the meantime, the background and significance of the vessel along with the methodology and results of the 3D survey are presented in this paper.

2. Genesis of the "Movies"

In 1915 the British Admiralty faced an unprecedented crisis. The mercantile marine on which the survival of the British Isles and the Allied war effort depended was being ravaged by an enemy campaign that hardly anyone had foreseen. Before the war, German U boats (and all submarines for that matter) had largely been seen as a delicate coastal craft, able to sink warships if they attempted to operate in inshore waters, while the more modern, larger boats might be able to ambush a chasing (British) fleet pursuing an inferior (German) fleet. Whilst some senior officers such as Admiral Lord Charles Beresford were happy to ignore the threat and dismiss submarines as "toys", more cerebral Admirals understood the potential of these strange new crafts, particularly in coastal waters. This followed upon the alteration in 1908, largely due to the threat from torpedo boats and mines, of the traditional policy of "close blockade" whereby battle fleets would blockade enemy harbours, to one of "distant blockade" whereby the Grand Fleet based on Scapa Flow would control access to and from the North Sea, while older battleships, cruisers and flotilla craft would defend the narrow waters at the eastern end of the English Channel. The threat that submarines posed to merchant ships and Britain's Atlantic lifeline, while recognised, was largely discounted as being beyond the pale of civilised warfare, First Sea Lord (1912-14) Admiral Prince Louis of Battenberg claiming that such operations would amount to barbarity. Only the visionary former and future First Sea Lord (1904-10 and 1914-15) Admiral Sir John Fisher amongst senior officers had begun to divine the potential danger, writing in 1913 that a submarine,

"[…] cannot capture the merchant ship; she has no spare hands to put a prize crew on board […]. She cannot convoy her into harbour…. There is nothing else the submarine can do except sink her capture […] (this) is freely acknowledged to be an altogether barbarous method of warfare […] (but) the essence of war is violence, and moderation in war is imbecility"

having much earlier pointed out, in 1904, that starvation rather than invasion was the mortal threat facing Britain (Aspinall-Oglander, 1951: 84-5; Friedman, 2004: 42; Gordon 2005: 23; Lambert, 2008: 306-7, 310, 316-9; Morris, 1995: 76, 123, 161, 164, 215; Terraine, 1999: 4-6).

In 1914 submarines on both sides commenced the war intent on attacking enemy warships. The British foray into the Heligoland Bight in August 1914 was conceived by the Commodore in charge of Submarines, Roger Keyes, as a neat reversal of the pre-war fear of British Admirals- British light forces being used to draw German units into a submarine trap. While the operation was successful in sinking a number of German warships, it was the intervention of the Battlecruiser Force under Admiral Beatty rather than Keyes' submarines which did the damage. Submarines on both sides did have early successes, however; the first ship sunk by the submarine-launched locomotive torpedo was the British scout cruiser *Pathfinder*, sunk by a single torpedo from *U21* off St Abb's Head, Berwickshire, on the 5th of September. This was followed by the British *E9* sinking the German light cruiser *Hela* on the 13th of September, while *U9* sank the old cruisers *Aboukir*, *Cressy* and *Hogue* nine days later with the grievous loss of life and the cruiser Hawke on the 10th of October, again with considerable casualties. German minelaying also had success, the one-year-old super-dreadnought *Audacious* being sunk off Tory Island on the 27th of October. This was enough to see the Grand Fleet disperse from Scapa to other, more westerly bases until the former's anti-submarine defences were strengthened, and for Admiral Jellicoe (C in C Grand Fleet 1914-16) to state in writing to the Admiralty his fears of being drawn onto a submarine and/or minefield trap. The threat of both British and German submarines severely inhibited main fleet operations in the more constricted waters of the southern North Sea and almost entirely halted them from August 2016 onwards. Submarines, however, both British and German, could be vulnerable in the presence of warships. Slow and almost blind when submerged, lacking active sonar and having only primitive hydrophones, they were almost certain to be outgunned or could be rammed if caught on the surface where they had to spend much of their time recharging batteries (Aspinall-Oglander, 1951: 87, 93-5, 98; Brown & Meehan, 2002: 56-7; Compton-Hall, 2004: 62; Corbett, 1938: 163, 165, 207; English, 2004: 154; Firth, 2014: 13; Gordon, 2005: 21, 390; Lambert, 2008: 319, 350, 360; Terraine, 1999: 29-30, 696; Antony Firth pers. comm.).

Figure 1: TDP volunteers at work on *Eothen* in June 2015. Photograph Nathalie Cohen.

The historic Royal Navy concept of the blockade, whether "close" or "distant", had two fundamental objectives: firstly, to deny enemy warships access to the high seas, secondly to deny merchantmen carrying supplies access to enemy ports. The blockade would, therefore, neutralise any threat of either invasion or starvation, whilst slowly applying an economic stranglehold upon the enemy. As the war entered its second year the British had eliminated German or Austro-Hungarian warships outside of the North, Baltic, Black and Adriatic Seas and seemed to rule the waves, while merchantmen en route to Germany and neutral destinations such as The Netherlands were being intercepted by an increasingly effective patrol system. The blockade was working and was beginning to bite. The German High Seas Fleet, understanding its numerical inferiority had to adopt a strategy of "tip and run" raids on British coastal towns attempting to draw detachments of the Grand Fleet into ambush –there was no attempt to directly challenge the blockade, merely vain attempts to reduce the odds for eventual full-scale fleet action. The German High Command therefore sought to impose its own counter blockade of merchant shipping, not with surface warships but with disguised armed merchantmen slipping through gaps in the British patrols and, predominantly, with U boats which, while still just as vulnerable in close proximity to enemy warships, could simply submerge when a warship was present and then surface when the coast was clear and await its prey. On the 20th of October 1914 the first merchant ship was sunk by a U Boat, while only six days later the first was sunk without warning in contravention of the accepted rules of war. On the 4th of February 1915 the German Government announced that:

1. The waters around Great Britain and Ireland, including the whole of the English Channel, are herewith declared to be in the War Zone. From February 18th onward, every merchant-ship met with in this War Zone will be destroyed, nor will it always be possible to obviate the danger with which passengers and crew are thereby threatened.

2. Neutral ships, too, will run a risk in the War Zone, for in view of the misuse of neutral flags by the British

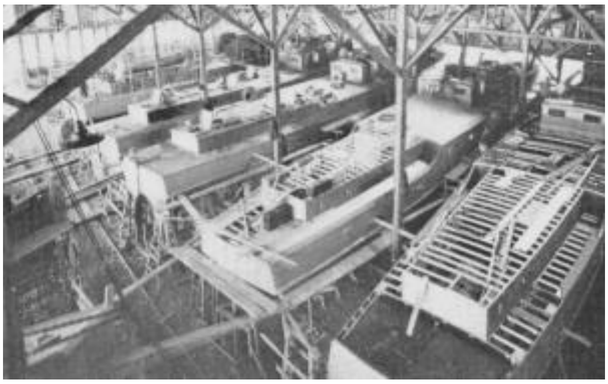
Government on January 31st, and owing to the hazards of naval warfare, it may not always be possible to prevent the attacks meant for hostile ships from being directed against neutral ships.

As predicted by Fisher, submarines could not take prizes, simply sink ships, and could not take prisoners, abandoning the crews and passengers to their lifeboats. At this time merchantmen generally sailed singly as in the balmy days of peace along "patrolled lines" into the Western Approaches, while safer "swept channels" such as the East Coast War Channel was established from August/September 1914 along portions of the coasts of Britain and Ireland. These channels were constantly swept for mines and patrolled by an array of regular and auxiliary warships, while British mines were also laid to protect them. The problem with the ineffectual "patrolled lines" was that when a patrolling warship was sighted the U Boat submerged and waited for it to patrol elsewhere before coming back to the surface to sink the next unescorted merchantman to come along, a system likened by a distinguished WWII escort commander to "...a single rifleman trying to protect a caravan in the Sahara by strolling at random to and fro along the route". In 1915 U Boats sank a total of 1307996 tons of shipping of which 855721 were British. The Admiralty at this stage incorrectly believed the ancient and proven system of convoy impracticable in the modern days of steam, and, therefore, had no further answer except to arm merchantmen with guns, deploy heavily armed decoy ships ("Q" ships) and vastly increase the number of patrol craft. The problem was that the Admiralty had already requisitioned all suitable civilian craft to form the Auxiliary Patrol, the Royal Navy Motor Boat Reserve and the Yacht Patrol, engaged not only in anti-submarine warfare but mine-sweeping and harbour and coastal patrol. Britain's shipyards were working full out and there was no further building capacity, where then would these extra patrol crafts come from and what form would they take? (Brown & Meehan, 2002: 54; Firth, 2014: 1-3, 11, 14; Fisher: 2018, 2; Gordon: 2005, 20, 393; Lambert, 2008: 319, 328; Terraine, 1999: 8-10, 41-2, 44, 51-3; Spitfires of the Sea webpage).

In February 1915 Henry R. Sutphen, chief of the Electric Launch Company (ELCO) of Bayonne, New Jersey, was (in his own words) approached by a "well-known English shipbuilder and ordnance expert", actually Sir Trevor Dawson, managing director of Vickers, in a New York hotel and a discussion of the U Boat problem ensued. Sutphen claims to have suggested a lightly armed "mosquito fleet" of small c. 80 ft (24 m) vessels in numbers large enough to patrol the waters of the British Isles and undertook to produce fifty such craft in a year using "complete standardisation". However, it seems much more probable that Dawson and his team already had Admiralty approval to procure the "mosquito fleet" before they left Britain, indeed that that was one of the purposes of their visit. Nonetheless, on the 9th of April 1915 the contract was signed for fifty 75 ft (c. 23 m) MLs and less than four weeks later "the master, or pattern boat was in the frame" to a design by Irwin Chase.

On the 1st of May Sutphen's contact sailed for home, Sutphen having told him that he could build as many boats as the Admiralty wanted at the rate of a boat a day. Sailing the same day was the *Lusitania*, within in a week to be sunk- the Admiralty promptly ordering another 500 "Sutphens" as the MLs were code-named, a new contract being signed on the 9th of July 1915. US neutrality laws ensured that only part-fabrication could take place at Bayonne and completion of the boats had to take place at Quebec and Montreal in Canada before the MLs were shipped across the Atlantic. Nonetheless, in an astonishing achievement, 550 MLs were built in 488 days. A further 30 MLs were built for the RN while 52 served with the French Navy and 110 with the Italian Navy (Fig. 2). While there were inevitable variations, the bulk of Royal Naval MLs (51-550) had the following general characteristics (Fig. 3):

- Length 80ft (24.38 m)
- Beam 12ft 3in (3.74 m)
- Draught 4ft (1.22 m)
- Propulsion Two 220 hp Standard Motor Company petrol engines
- Speed c. 19 knots
- Armament One 3 pdr gun: Up to ten depth charges



(a)

(b)

Figure 2: ML's under construction. a) Construction process. b) Finished units. From William Washburn Nutting "The Cinderellas of the Fleet", 1920.

MLs were also armed with Lance Bombs, Lewis guns, rifles and revolvers and carried hydrophones which were only effective while the MLs were drifting with the engines stopped (Fisher, 2018: 2-6; Maxwell, 1920: 51, 54; Ross, 2004: 124-5, 138; Sutphen, H.R., 1920: 1-4, 9; Terraine, 1999: 29; Spitfires of the Sea webpage).

3. The "Movies" in Action

On arrival the MLs, soon widely known as the "Movies", were quickly introduced to their raw crews and just as raw RNVR Officers, a brief education for the latter based on old cruisers such as HMS *Hermione* deemed enough for weekend rowers and amateur yachtsmen to command ships of war. Those who had amateur yachtsmen as officers were lucky, one ML included the following crew members:

[…] skipper- dentist; second-in-command- bank clerk; two petty officers- motor mechanics; coxswain- a butcher; myself- a cinema projectionist; cook- a clerk; first seaman- overlooker in Lancashire mill; second seaman- an inshore fisherman.

As in submarines of the period, there seems to have been a closer relationship between upper and lower deck in the MLs than on regular warships although the seven ratings occupied a similar space forward as did the two officers aft. For their size they were relatively seaworthy although liable to sheer in a high following sea, nonetheless, in any sort of weather the crew would get thoroughly soaked (Brown & Meehan, 2002: 84; Maxwell, 1920: 13-15, 51-3, 69-72, 131).

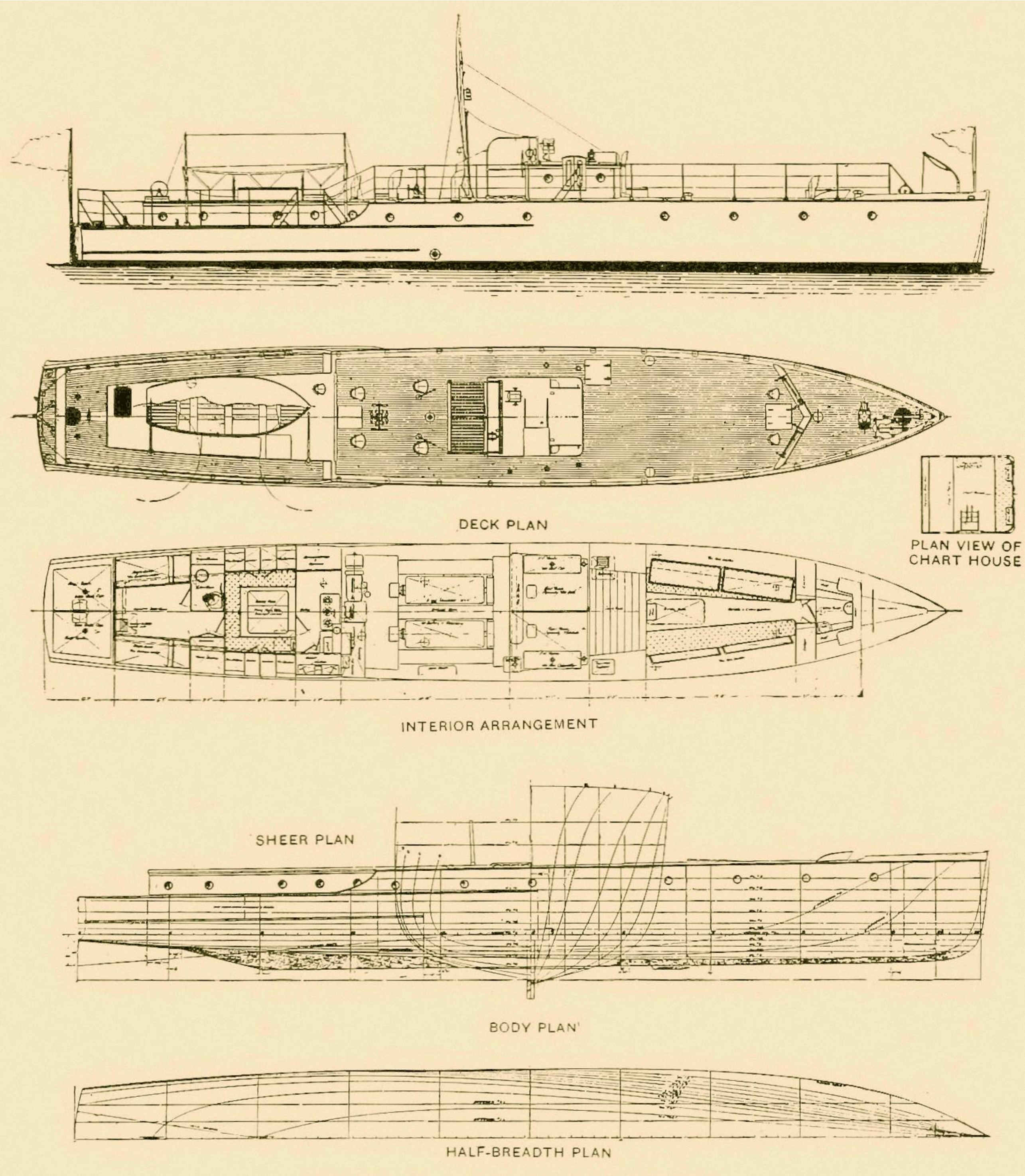


Figure 3: Technical drawings of the whole ship and its hull, from William Washburn Nutting "The Cinderellas of the Fleet", 1920, 172.

On patrol, MLs could be occupied in searching for U boats using their hydrophones, if located the aim would be to keep contact, "sitting on a submarine", hoping that the U boat's batteries would run out. While not necessarily resulting in a "kill", more likely the U boat would slowly creep away, such work ensured that it was in no position to attack Allied shipping. Sinking floating mines by rifle or machine-gun fire was also a common occurrence, as was rescuing torpedoed survivors or the grisly task of recovering the dead from the sea. At night, patrolling up the coast of Belgium out of Dunkirk, German motorboats might be engaged, while on encountering enemy destroyers the MLs had no option but to flee, firing Very lights and rocket signals to attract support. Another frequent service off the Belgian coast was to lay smokescreens screening monitors bombarding German positions ashore. With the introduction of the euphemistically titled "controlled sailings" of colliers from February 1917, and the gradual introduction of a more general convoy system from April, escort duties added to the ML's already heavy workload (Fig. 4), while in the same year further new employment was found serving as a plane guard off the quarter of capital ships now starting to launch their own aircraft. An idea of the perils of service in the "Movies" is given by a crew member of a Scapa based ML:

Our first skipper(an Australian) had been thinking things over and announced to the occupants of the bridge –the sub-lieutenant, coxswain and myself (signalman) that "This is a small boat, made of wood. We carry 5,000 gallons of petrol, plenty of paraffin, a magazine crammed with explosives, depth charges full of TNT. A cigarette end or an absent-minded cook could easily start a fire and what would be left of us? And who would know? So, I've decided to train ourselves to perfection in the most necessary thing of all- I mean abandoning ship." (Brown & Meehan: 2002, 81-3; Maxwell, 1920: 54-5, 63, 158-9, 163-4, 229; Terraine, 1999: 54-5, 58).

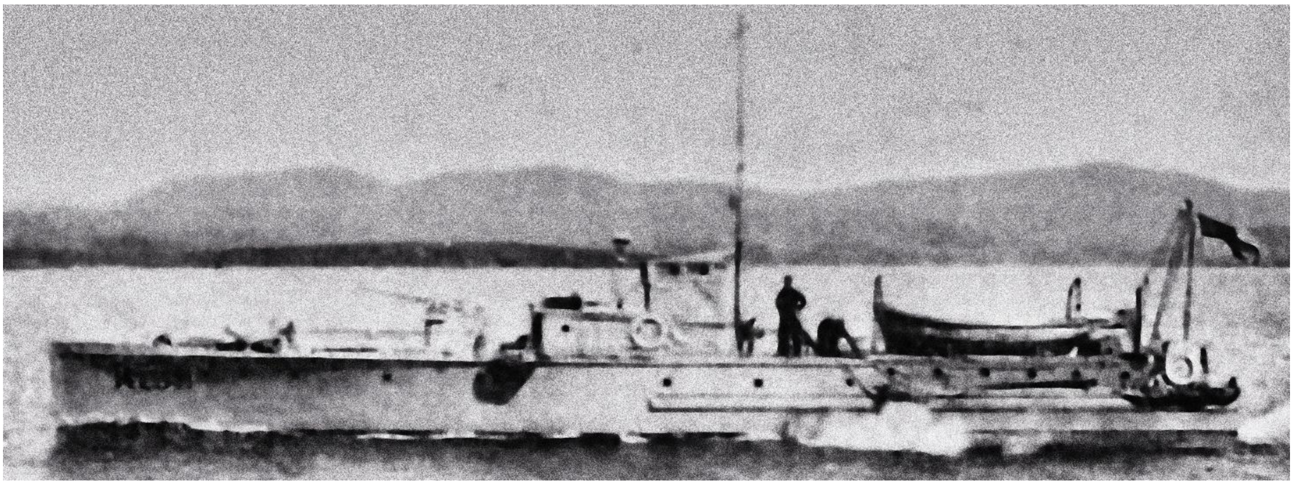


Figure 4: An ML in calm inshore waters, from Janes Fighting "Ships of WWI".

As well as around the coasts of the British Isles, MLs served as far afield as the Caribbean, Eastern waters and the Mediterranean. In the latter theatre, as well as the usual patrol (particularly of the Otranto barrage attempting to block egress from the Adriatic, the entrance to the Dardanelles, and of the Straits of Gibraltar) and escort duty, MLs might be called upon to perform unusual tasks, especially during the Turkish retreat northwards up the Levantine coast during 1918. These included the "capture" of Alexandretta by an ML landing party- the Turkish garrison would neither fight nor surrender yet the Union Flag was raised, and (with other vessels) a decoy landing near Gaza of members of the Egyptian Labour Corps as a ruse to make the Turks think that they faced an attack in their rear. Happily, those put ashore were re-embarked before the Turkish army arrived. MLs were also engaged in clandestine work, the landing and recovery of agents on the Levantine coast (Maxwell, 1920: 208-13, 226-8).

While the ceaseless patrol and escort work made a massive, if largely unknown, contribution to the Allied victory, the "Movies" hour of glory came in the Zeebrugge and Ostend raids of April and May 1918. These audacious and highly costly enterprises had a morale effect out of all proportion to their results, the valour displayed lifting the spirits of a war-weary nation (Fig. 5). On St George's Day at Zeebrugge, the main initial task of the bulk of the MLs, along with the smaller and faster Coastal Motor Boats (CMBs) was to provide a smokescreen to shield the approach of the assault vessels *Vindictive*, *Iris* and *Daffodil* and the blockships *Thetis*, *Intrepid* and *Iphigenia* which were to be sunk in the Bruges canal thus bottling up the U boats based beyond. Their other major task was the extremely hazardous one of rescuing the blockship crews once they had sunk themselves; ML 526 rescuing the crew of *Thetis*, ML 282 those of *Intrepid* and *Iphigenia*, while ML110 was sunk on the approach attempting to lay flares to guide in the blockships. On the same morning, a similar effort was made at Ostend with MLs occupying similar roles. Unfortunately, the Germans had moved a navigation buoy and the blockships *Brilliant* and *Sirius* collided and ran aground in the wrong position, ML 283 rescuing the crew of *Sirius* and ML 532 being seriously damaged in attempting to rescue the crew of *Brilliant* who were taken off by ML 276. On the night of May, the 9th a second attempt was made to block Ostend harbour, this time using the old cruiser *Vindictive*, heavily damaged from Zeebrugge, as the blockship. ML 105 placed navigation lights to help guide *Vindictive* in, whose survivors were rescued by MLs 254 and 276 (Maxwell 1920: 109-116, 133-140; Terraine, 1999: 112).

As with so many elements of both the army and navy, the signing of the armistice did not bring peace to all of the "Movies" and their crews. A flotilla of MLs was established on the Rhine until early 1926, MLs 121 and

566 sinking in the *Channel en route* from Portsmouth to le Havre on the 22nd of December 1918, while ML 229 exploded during late 1919 while refuelling at Cologne causing one fatality and a number of wounded. A further as yet an unresearched number of MLs served in northern Russian waters during the Allied intervention in the Russian Civil War up to 1919 (Motor Launch Patrol webpages).

The vast majority of the faithful survivors of the "Movies" were sold off by the Royal Navy who saw no peacetime need for them in such numbers. Four were sold to the Irish Free State in May 1922 to provide the naval arm of the embryonic government, one sinking en *route* off Lands End in July 1922. Most, however, had their armament removed and their high-performance engines replaced by lower output machinery, before being sold off for conversion to pleasure craft. One seems to have been acquired through an intermediary by the new Polish state, was refitted, re-armed and then re-entered service as the flagship of the Polish navy on the 1st of April 1921 (Association of Dunkirk Little Ships webpage, Motor Launch Patrol webpages).

Figure 5: Motor Launches engaging a Submarine, Geoffrey Alfree, IWM ART 148 © Imperial War Museum.

4. Eothen/Cordon Rouge/ML286

Little is yet known of ML 286's wartime exploits but we do know something of her crew, or at least her officers. Her first commander was Lieutenant Geoffrey Alfree RNVR, an artist who originally served with the Royal Naval Division at Gallipoli before joining ML 286 in December 1916. He was given the command of ML 338 in September 1917, later commanding ML 247 and became an official war artist in 1918; a number of his paintings depict the "Movies" –unfortunately, we do not know which, if any, show ML 286. On the 29th of September 1918 ML 247's engines failed and she drifted onto the Oar Rock and exploded, Geoffrey Alfree's body was never found (West, 2017: 97; Sarah West pers. comm).

The Navy Lists have information about other officers serving in ML 286. Sub-Lieutenant Samuel W. Salmon, a Canadian, was appointed to her in October 1916 and appears to have stayed with her after his promotion (though not in command) before getting command of ML 96 in January 1919. In September 1917 Joseph B. Marsh was appointed to HMS *Zaria*, a depot ship based at Scapa, for command of ML 286, while John Thompson was appointed to command on the 18th of December 1918 –it seems a reasonable assumption that ML 286 was based on the home of the Grand Fleet at this time. The Navy List of January 1920 shows her in commission, still under the command of Thompson but she does not figure in that of February 1920, nor subsequently (Adm. 337/121/565; Antony Firth pers. comm.; Sarah West pers. comm).

(a) (b)

Figure 6: *Eothen* in 1985 (circa): a) Bow; b) Stern. Photographs Paul Hollomby.

After decommissioning she, like most of her sisters, was disarmed and re-engined to become a pleasure cruiser under the name of *Cordon Rouge*, being renamed *Eothen* in 1930. In late May/early June 1940 she took part in the evacuation of the British Expeditionary Force from Dunkirk and was subsequently requisitioned to serve as a Thames patrol vessel before being deemed unsuitable and returned to her owners in August 1940. She thereafter continued to be a domestic cruiser on the Thames until the 1980s when her then owners took her to B.J. Wood's boatyard at Isleworth Ait for essential work (Fig. 6). As it is all too often the case with old vessels the cost of repair exceeded both the expectations and pockets of her owners and she was abandoned at the yard in her current position, her wheel and binnacle being removed and now fitted to the houseboat *Caillach*. Her rising and falling with the tide started to cause problems with the adjacent drydock and so the boatyard decided to break open her hull in the port quarter to sink her and let her sit as an inter-tidal hulk, the condition in which she still lies (Association of Dunkirk Little Ships webpage; Suzanne Taylor pers. comm.; Steve Woods pers. comm).

5. 2D and 3D survey methodologies

When approaching the survey of *Eothen*, the first priority was to establish the correct methodology, considering the size of the vessel, the level of detail required, the research aims, and site conditions. Two options were considered: photogrammetry based on SfM/IM (Guidi et al., 2015) procedures and 3D laser scanning. Photogrammetry would allow less of a logistical strain and faster survey on-site and would be cheaper, but the situation of the vessel, sandwiched between a floating drydock and an extremely overgrown riverbank overhung by trees and their constantly moving foliage, suggested that 3D laser scanning may have been the better option. This theory was confirmed by the lack of success attained by a photogrammetric survey undertaken by Juan José Fuldain of MOLA in June 2015 and an initial test photogrammetric survey undertaken by the authors in May 2018 –the problem being the constantly moving foliage around and above, and, more importantly, the constantly changing shadows they cast upon *Eothen*. The vicissitudes of the English sky, needless to say, did not help either.

As discussed above, *Eothen* lies in a sorry state indeed; breached open to the tide and thus filled by Thames silts eagerly colonised by all manner of plant life. While, over the last thirty years or so, heavy debris such as fallen trees have fallen into her, smashing her upper works and, over time, twisting her hull form by their pressure, while the planks slowly give way, start to overlap and, therefore, confuse interpretation further. The position of the vessel allows limited external hull views due to the proximity of the drydock and riverbank (both higher than the vessel), while the foreshore "surface" here, where the tidal Thames is at its upstream least volatile, sheltered between a drydock and an island, is a matter of hope- one can sink anywhere between 10 to 40 cm on any given step. Not the least of the problems was the twice-daily high tide, shifting silts and vegetation, leaving different microtopographies, and light-reflecting puddles on every visit (actually every step). In short, a quite difficult environment to undertake this sort of exercise. Of course, the same riverine silts act to preserve and protect the hitherto un-investigated and undocumented insides of the boat- until controlled excavation will allow full recording of this assumedly less damaged, and therefore probably more significant, interior.

Despite the somewhat daunting conditions, and with an awareness of the low probability of success, a photogrammetric survey was undertaken (Fig. 7a; 7b). 418 photographs were taken with a Sony α7r camera with a resolution of 36.4 MP, and a full-frame sensor mounting a Carl Zeiss lens with a focal length of 28 mm. Agisoft PhotoScan software (v. 1.4) was used and the results were as expected (Fig. 8). Only ***Eothen's*** stern and her starboard quarter, the areas most exposed and (obviously) least degraded gave better textures, appearing well modelled. It became apparent, therefore, that the greatest obstacles to achieving good results were, as expected, the surrounding vegetation causing variable shadows and higher surrounding structures/topography disallowing a suitable variance of perspective.

(a)

(b)

Figure 7: The *Eothen* in the last three years: a) Photographs of Juan José Fuldain, 2015; b) Photographs of Pablo Rodríguez-Navarro, 2018.

The way forward, therefore, was to perform the survey using a 3D laser scanner, utilising a series of specific solutions. First of all, it was preferred to use a small lightweight 3D laser scanner and tripod, this reduced the risk of the tripod slowly sinking in the mud, resulting in the failure of the scanning (to avoid the creation of point clouds altered by a possible movement of the scanner, the "shaking" sensor of the scanner was left on with the option to stop the scanning in case of even minimal position changes). To avoid the feet of the tripod sinking, various expedients were used: first of all, keeping the legs of the tripod quite open to distribute the load, then using planar elements (like metal or plastic dishes/caps or even hard cardboard sheets) to avoid direct contact of the narrow feet of the tripod with the terrain. The choice of scanner positioning was made according to the effective possibility of placing and the resulting coverage. While it was important to consider the changes between scanning positions; taking a scan of a quite small area (the vessel) in front of a quite large moving series of elements (the trees, the foliage, the muddy surfaces) may have produced misalignment issues even in front of stable and well overlapping scan stations.

The 3D laser scanner used for the survey work was a Cam/2 FOCUS[m] 70, a phase-shift measurement system (Shan & Toth, 2017) using a class one laser emitter with an operative range from 0.6 to 70 m and capable of a measurement speed up to 976000 points/s (Cam2, 2017), the nominal ranging error is about 1 mm on a normal reflective surface at a distance of 10 m. This unit has the specific features of being one of the lighter and smaller scanners in its category, with a size of 230x183x103 mm and a weight (scanner head and battery only) of 4.2 kg, it has also a sealed design with ingress protection rating class 54 (Cam2, 2017), a feature which results in it being very practical when operating in dusty and wet/muddy environments. This scanner integrates various multi-sensors: GPS, compass, height sensor, a dual-axis compensator and can be controlled via touchscreen display or with wireless remote control using a smartphone or tablet.

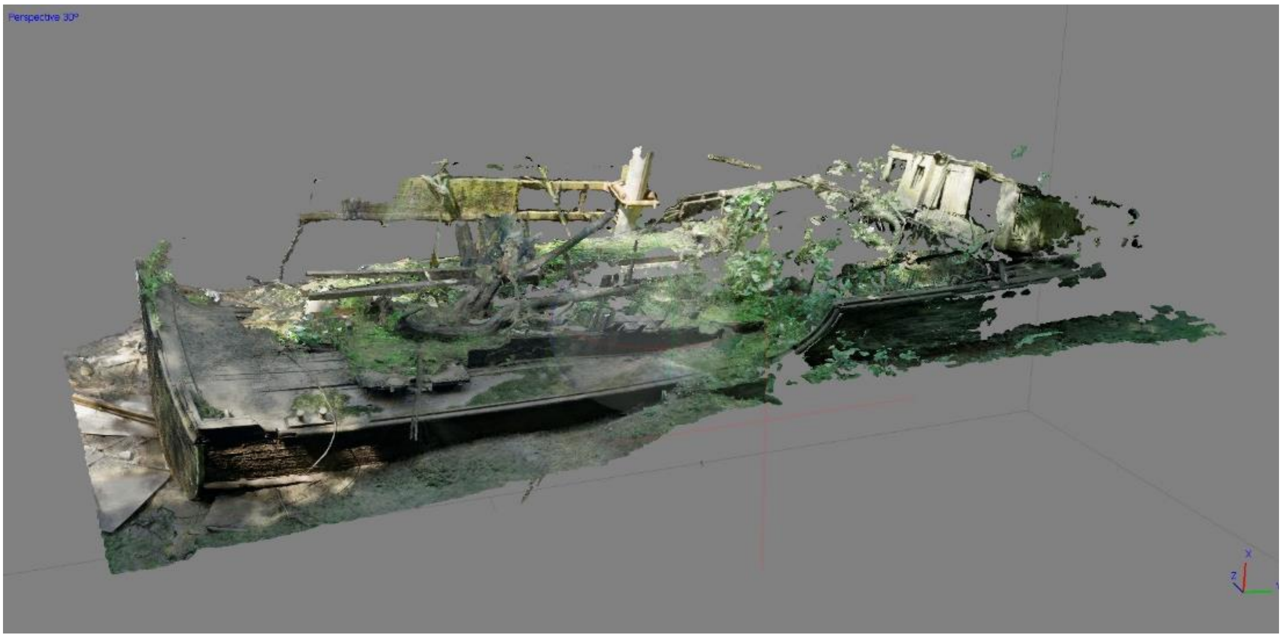


Figure 8: Photogrammetry results (Agisoft PhotoScan).

Because of the size, structure and dimension of the operative spaces, the scans operated on the vessel survey were set up according to the scanner options at a resolution of “⅛”, “⅕” and “¼” which means having up to 10.9 million points (⅛ setting), up to 28 million points (⅕ setting) and up to 43.7 million points (¼ setting), the level of quality was always set up to “4x” with a quite high level of redundancy and interpolation for each measurement, in this way the fake elements and noise produced by muddy and reflecting surfaces was significantly reduced. With these settings, each scan took 8.09 minutes (¼ setting), 5.35 minutes (⅕ setting) and 2.47 minutes (⅛ setting) plus the always quite complex repositioning of the tripod.

The planning of the survey was organized on the ground level all around the hull of *Eothen*, operating a counter-clockwise turn. These series of scans were started from the stem of the launch, the passage between the vessel’s hull and the sides of the nearby drydock were particularly complicated, because of the muddy conditions of the ground, the quite narrow passage and the presence of rubbish and various metal elements extending out from the drydock and its associated structure (Fig. 9). Once the team arrived at the stern of the launch (and of the drydock), the operations were easier, the main troubles derived from the muddy ground surface creating difficulties in positioning the tripod. When the survey around the hull was completed, a series of scans were taken from the launch itself, passing along its centre line and around the main obstacles. To complete the survey a last series of scans were taken from the side of the drydock facing the launch, this final series was the only part of the survey undertaken without standing in a deep layer of mud, thus it required particular attention, while the whole passage on the launch was susceptible to vibrations and small movements, with the attendant risk of causing the scanner to produce altered point clouds or to altogether fail to scan. The whole survey work was completed in two mornings, with an overall positioning and scanning time of about twelve hours.

The first day on site was initially utilised to allow an overall cleaning of the launch from vegetation, removing most of it and moving the more problematic areas of silt from obscuring parts of the hull. The work of cleaning was operated by a group of volunteers from the Thames Discovery Programme. The digital survey work of the first day ended when the turning tide of the Thames started to flood the area of the launch. In many cases, to enhance and simplify the alignment of the scans, a system of targets, in planar or spherical shapes, automatically or manually identified by the scan management software (Kwan Y., 2016), are placed in the survey area. But for this survey no targets were used, this was done due to two considerations: the shape of the ground topography, the vegetation, and the launch itself were all at risk of having some changes in between the two days of activity and it was not possible to cover the whole area with a single survey day, all the "stable" parts were potentially subjected to flooding. So planar and/or spherical targets were at risk of moving or being altered, the area around and the hull did not offer trustable surfaces.

(a)

(b)

Figure 9: a) Thames Discovery Programme group cleaning the surface; b) Surveyors during the scanning operations.

The solid poles in the area were not that useful, being cylindrical and thus unsuitable for hanging spherical targets for long times. For these reasons it was preferred to operate without the use of targets, increasing the overlapping of the scans and planning the sequence of scans in a way to avoid the presence of parts potentially subject to movements caused by the flooding. In this way, the first day was dedicated to taking all the scans from the stem and along/beneath the lower border of the drydock, stopping in the front of the stern, on the second day the scanning restarted from the stern, using mostly the shape of the hull itself as a morphological base of alignment. It is worth taking notice of the fact that the global alignment of the point cloud showed no misalignments in the shape of the barge, which means that the possible risk of it moving during the survey process did not in fact occur.

It is worth to say that both the photogrammetry and the 3D laser scanner survey are in themselves extremely accurate solutions for gathering a detailed digital 3D model out of reality. But they are very different survey processing, while the 3D laser scanner is an "active" tool, emitting a signal that allows the measurement itself, while photogrammetry is a "passive" solution, gathering the measurements without influencing directly the characteristic of the scene. For this reason, certain very specific conditions may reduce their efficiency accordingly to the specific features of the operative environment. In the case of the *Eothen*, the difficulties caused by the lights and shadows combined with the wet and muddy environment produced a condition extremely adverse to the creation of an appropriate photogrammetric process. In the end, the "passive" characteristics of the photogrammetry turned out as a limit in the possibility of getting the survey out of it. Even in little better condition, the narrow space between the hull of the ship and the barge would be an issue to be resolved in a sequence of pictures suitable to produce a correct 3D digital model. The intervention with the 3D laser scanner was potentially at risk of being affected by other kinds of troubles, like the difficulties of alignment between scans operated in different days after the daily flood and possible movements of the hull, but being an active sensor and the smart planning of the operations have served well the aim of getting a complete and valuable documentation of the whole relic (Fig. 10). At the same time the small size of the scanner and the minimal operative distance, solved the need about passing in narrow spaces.

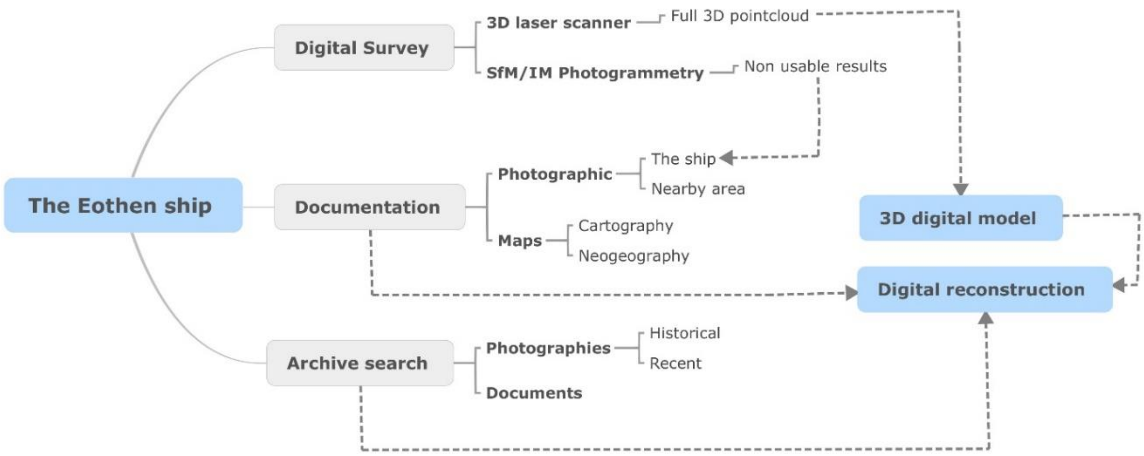


Figure 10: General workflow of the digital survey and data treatment for the *Eothen* launch case study.

6. Processing and results of the survey

The whole set of scans was made by 45 scan stations, creating a global point cloud of about 302 million points, the sub-selection defined to isolate the hull only was made by 45,5 million points. The alignment of all the point clouds was operated using Autodesk Recap Pro, exploiting its automatic registration feature (Omura Benton, 2018): being based on a proper and well-planned survey campaign the alignment process was completed without difficulties.

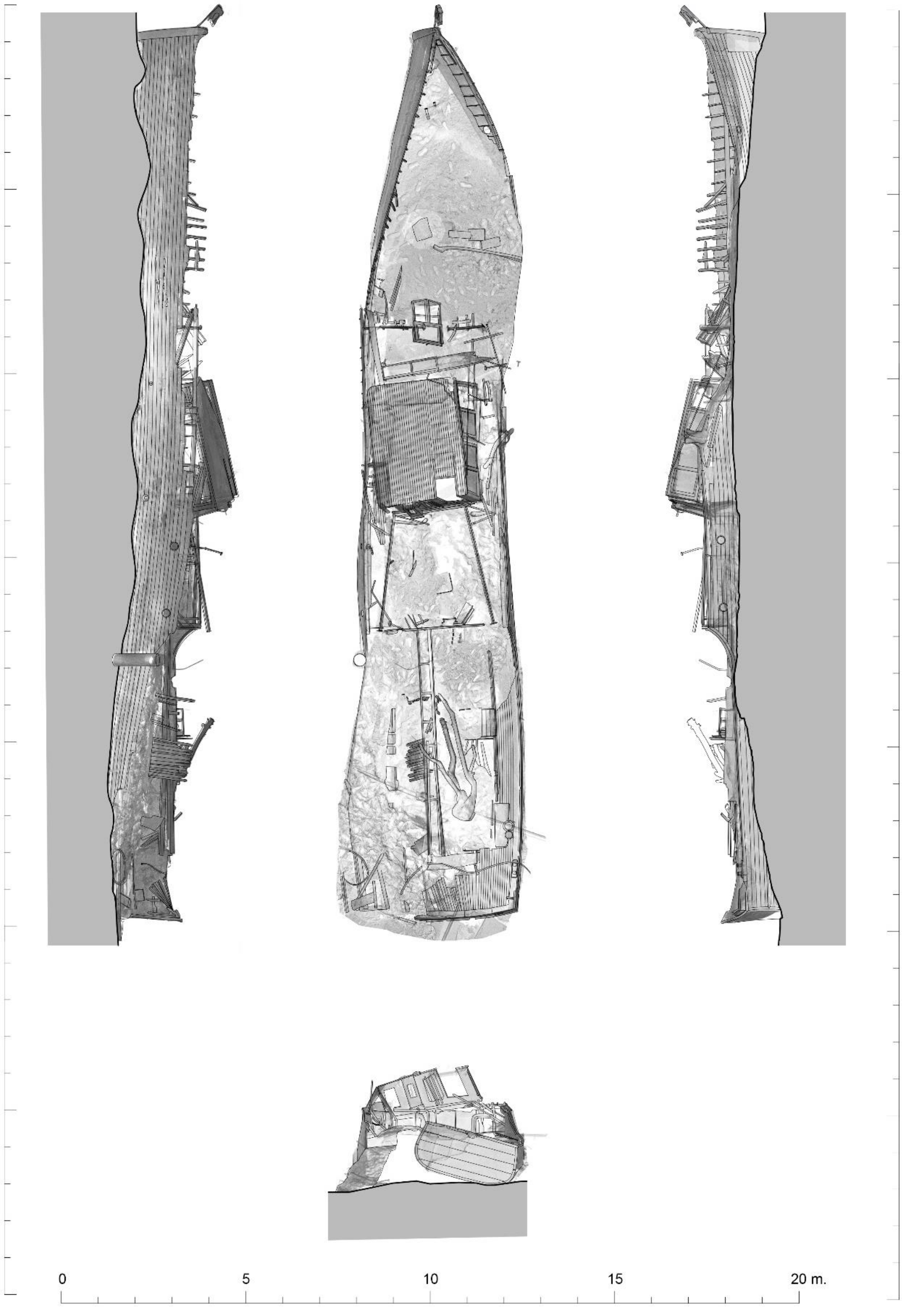


Figure 11: 2D drawings of the *Eothen*.

This produced the full aligned point cloud in the time of “importing” and “indexing” all the data plus about twenty minutes for automatic registration processing. The following elaborations were aimed to “clean” the global point cloud from some noisy parts (like ghost elements produced by reflections, and moving elements, such as branches and plants or humans in the scanning area). The large operative range of the 3D laser scanner allowed the team to also capture the whole riverbed in the nearby area and the front of the main buildings facing on the opposite side of the river. This allowed the production of a planar view and an environmental section of the launch, which was useful to fully contextualize it. Following this, a reduced version of the point cloud was produced showing just the launch itself. This last version of the point cloud was used as a base for all the drawings depicting the launch and its conditions. The redrawing operation was done working directly in Autodesk Autocad v. 2018. In fact, the complex and deformed aspect of the launch made it quite tricky to always recognize all the varied vessel elements. To avoid possible wrong interpretation, the operator taking care of the redrawing work, used a double monitor configuration, the main monitor dedicated to the CAD operations, the other dedicated to a continuous check of the 3D view of the point cloud, changing the visualization mode (colours, shaders, edge highlighting, limit box, etc.) as required to better understand the correct interpretation of each specific part. The graphic layout and treatment were defined according to simple and clear choices. On the one hand, there was the need to produce traditional and easy to interpret drawings, defined according to the classic archaeological nautical representations: lines with minimal variations in the weights, well defined schematic choices evidencing the hull, its parts, and the size and shape of all the significant elements. The production of these drawing was completely done in CAD format, using Autodesk Autocad and operating on the point cloud according to the procedures above described, the final result was optimized for representation in scale 1:20 and 1:10 (Fig. 11). On the other hand, there was the need to define a well working interactive 3D model, usable for multimedia production and usable for online and real-time visualization (Figs. 12, 13 & 14).

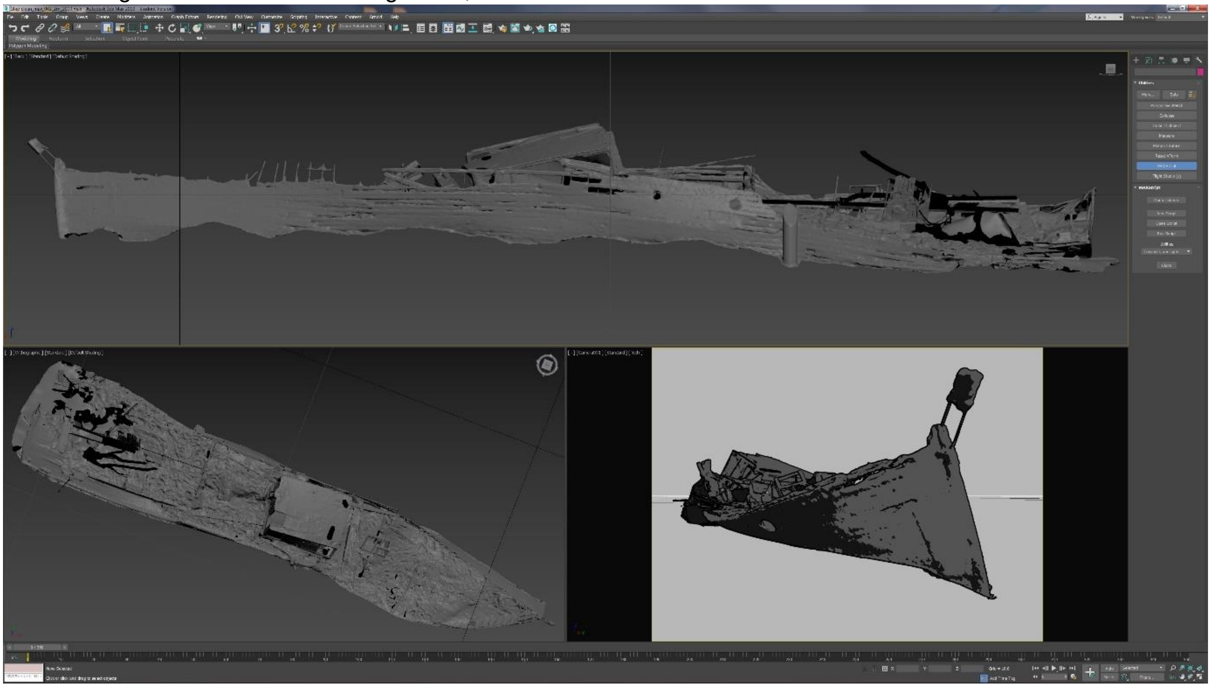


Figure 12: Modelling post-processing in Autodesk 3D Studio Max.

This 3D model was developed in Raindrop Geomagic Studio starting from the point cloud, generating first a polygonal mesh triangulating the points and applying a series of procedure of optimization: from the classical procedures of automatic repair of the mesh to the closing of the “holes” caused by occlusion spaces and nearby narrow spaces. The resulting mesh was then simplified with a decimation procedure. The first mesh was made of about 45 million polygons, the decimated version was optimized for five and two million polygons. The two simplified models were later exported in Alias|Wavefront OBJ format and then imported in Autodesk 3D Studio Max. The two differently decimated models were kept for different purposes: the five million polygons version was intended for images and video, while the two million polygons version was aimed at real-time visualization. For this second use, it was decided to employ the online platform of sketchfab.com capable of fast and well performative interaction, with safe protection of the contents and the excellent options of embedding the 3D visualization window in other webpages and allowing the automatic generation of immersive VR environment. The use and qualities of the Sketchfab.com platform are well illustrated in a large number of case studies concerning cultural heritage digitization (Evans et al, 2014) -especially with regard to previous solutions (Guarnieri et al., 2010)- and for general 3D model uses (Management Association, 2018). In this case, it turned out to be a very good presentation solution and created a complete, optimized model of the launch at its state in June 2018. The model is accessible on Sketchfab.com at the following link: https://skfb.ly/6AZJE

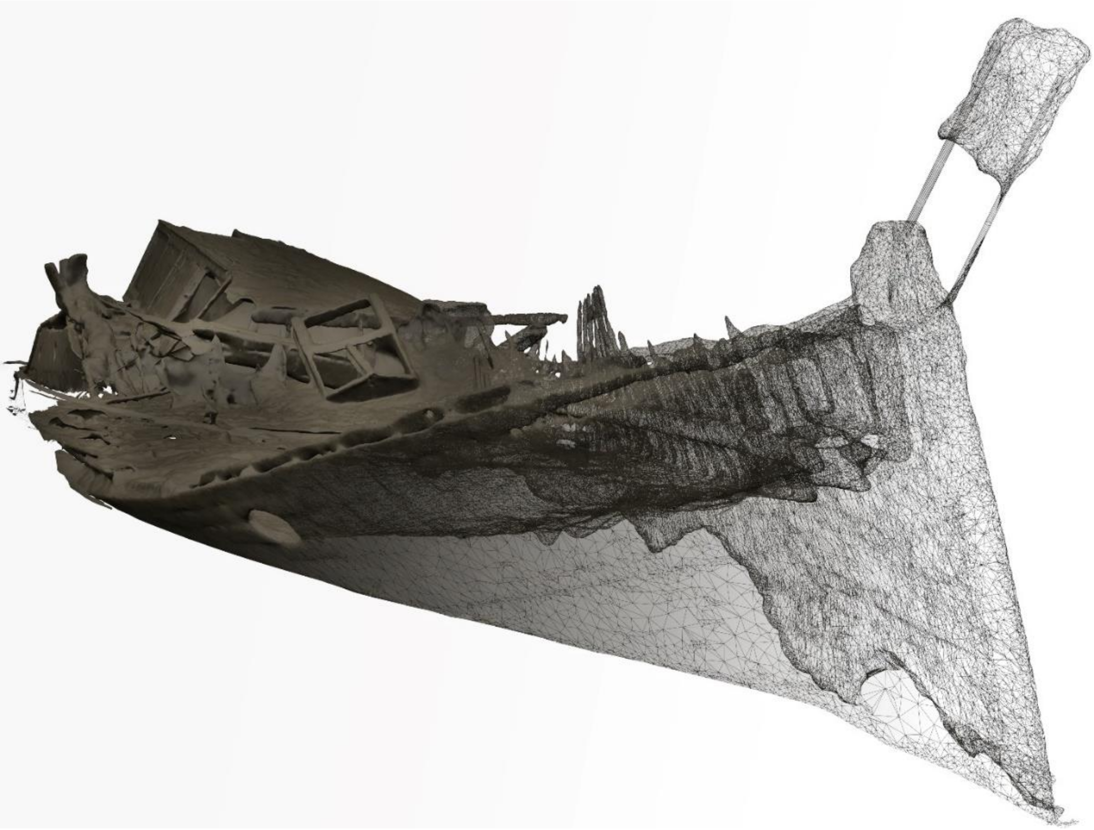


Figure 13: Rendering from the simplified 3D surface model of the ship. View from the bow.

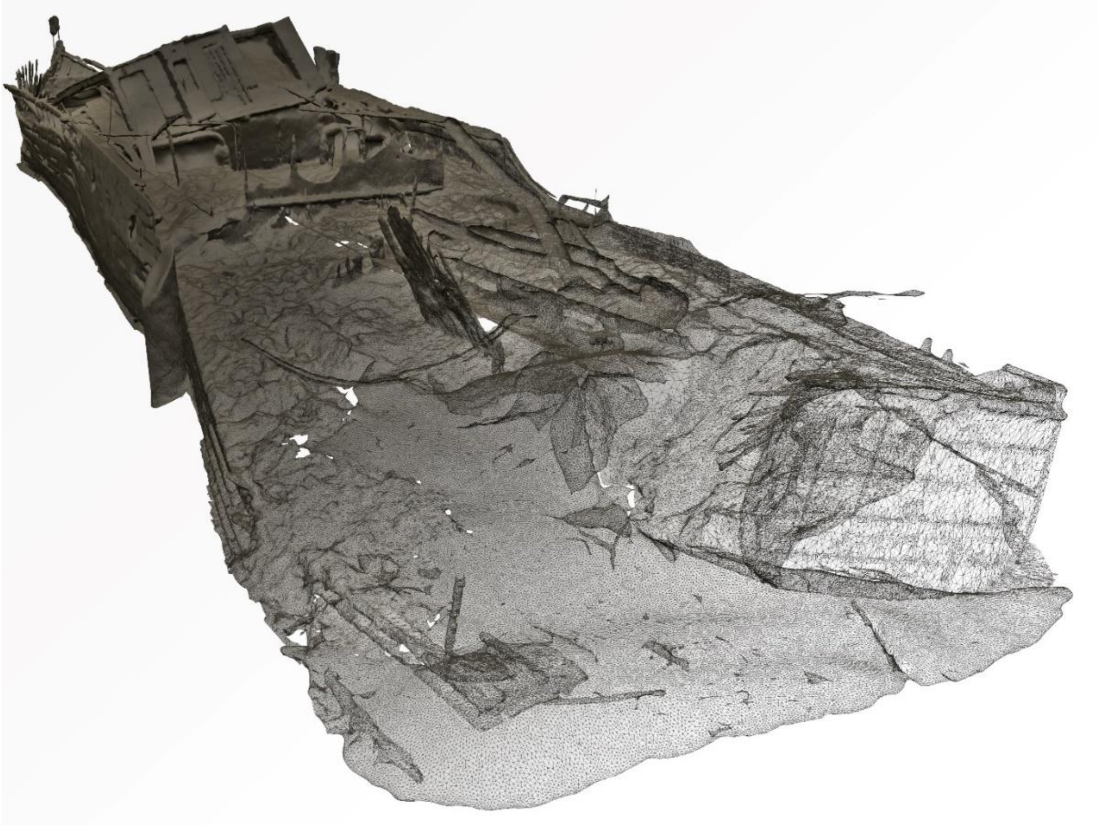


Figure 14: Rendering from the simplified 3D surface model of the ship. View from the stern.

The next steps for this survey will be both to try and integrate it with archive photographs edited as a base and reference to develop a 3D reconstruction of the original aspects of the vessel, possibly with some interactive features, and also to try and integrate it with the detailed 2D elevations and plans already made by the volunteers of the TDP (Fig. 15).

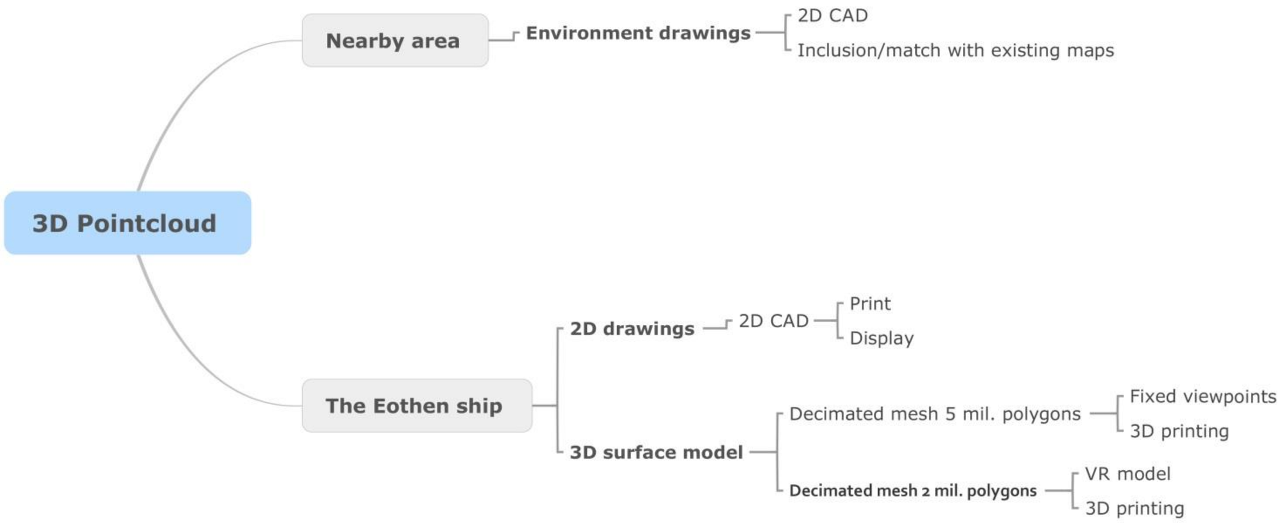


Figure 15: Workflow of the post-processing from the final point cloud to the 3D modelling and representation.

7. Conclusions

Eothen, formerly ML 286 and then *Cordon Rouge*, now lying derelict and degrading aside a drydock at Isleworth Ait would appear to be the last survivor of an integral part of the "mosquito fleet", improvised almost out of thin air to fight a novel U Boat menace, which played an indispensable role in WWI. Through interminable patrols and escort duties, the "Movies" were amongst the unsung heroes of the Great War, although they did have their moment of glory taking part in the Zeebrugge and Ostend raids of 1918. As small vessels bought in haste from abroad by the Admiralty, no detailed plans are known to survive of the almost 600 MLs serving in the RN, making *Eothen* a small boat of huge significance. Such significance enhanced by her being one of the 'little ships' serving at Dunkirk in 1940. Whilst reviewing this paper it has been very sensibly suggested to the authors by Stephen Fisher of Ronin Archaeology that the Admiralty purchase of the "Movies" may not have been entirely driven by the U Boat menace and so further documentary research into this vessel and her sisters, their genesis, procurement, development and deployment may considerably enhance our understanding not only of the desperate struggle undertaken by the small craft of WWI but also give us added insight into the thoughts of the Admiralty with regard to flotilla warfare from 1915. Further research is also required into the brave men who crewed her both in WWI and during the perilous days off Dunkirk in 1940.

While external elevations and plans have previously been made by the volunteers of the Thames Discovery Programme in 2D, only now has 3D laser scanning and photogrammetry successfully been employed, creating a virtual model of *Eothen* as she lies. The survey team worked under somewhat unusual conditions, the foreshore silts of the tidal Thames being treacherous underfoot, while the overhanging trees and neighbouring vegetation would just not stop moving. Nonetheless, the methodologies and processes described above have led to the clearest depiction of a "Movie" so far known. Externally she looks battered and bruised although most damage appears to have occurred to her post-service upper works –the hull seems largely intact apart from the deliberately breached port quarter; likewise, the deck aft of a post WWI deckhouse survives around the starboard side of the aft cabin. The deck forward has gone, yet the hull is largely in place. Below and behind the silts inside the hull may lie hitherto unknown details of her and her almost 600 sisters' construction. And just maybe some personal evidence of the brave men who served in her.

The authors along with the Thames Discovery Programme, MOLA, Fjordr Ltd., Ronin Archaeology, Coastal Forces Heritage Trust and the National Museum of the Royal Navy are exploring the possibility of full excavation and recording of this gallant and possibly now unique vessel with an aim to conserve and display as many elements as possible –of course 3D digital recording will play a large part in the process; the results of such work to be published in future volumes of these papers.

In the future excavation process, digital graphic surveys will be carried out with a double intention, since two possibilities are contemplated today: on the one hand, it is intended to obtain a digital reconstruction of the original boat, to be able to carry out its restoration; the second possibility is to document its exact state of conservation and transfer its remains to be exhibited. In either of the two possibilities, the digital survey is manifested as a fundamental step to obtain a rigorous and reliable work.

Acknowledgements

The authors would like to express their gratitude to the following; Steven Woods of BJ Woods and Sons Boatyard for granting unlimited access, assistance and information, Antony Firth of Fjordr Ltd for alerting us to the presence of ML286 in the first place and, along with Stephen Fisher of Ronin Archaeology, reading this manuscript and providing extremely wise guidance, information and advice –all errors herein are those of the authors alone, Andrew Choong Han Lin of the National Maritime Museum for confirming that the Admiralty did not have detailed plans of the MLs, Paul Hollomby for kindly permitting us to reproduce his photographs, Rupert Selby, owner of *Caillach*, for allowing us to mention the present location of ***Eothen's*** wheel and binnacle, TDP colleagues Nathalie Cohen, Josh Frost, Helen Johnston and Gustav Milne who assisted on site, and last but certainly not least the volunteers of the TDP who cleaned and recorded *Eothen*: Gabrielle Abbott, Liz Anderson, Angel Banks, Samantha Brummage, Paul Clabburn, Sandra Claggett, Jill Cook, Marianne Cook, Gwen Corlet, Gillian Crossan, Chis Crowley, Peter Cunnell, Margaret Daly, Vanita Eden, Russell Edgecock, David Geall, Ruth Geall, Suzie Gretz, Rachel Hozier, Rob Hutchinson, Holly Jobson, Tina Larcombe, John Layt, Steve Lee, John Lingford, Yvonne Masson, Brian Minehane, Miriam Molnarova, Theresa O'Mahony, Simon Pett, Claudia Pinci, Hilary Prosser, Olivia Swabey, Graham Strudwick, Iain Sutherland, and in particular Suzanne Taylor and Sarah West who undertook and continue to undertake further documentary research into the vessel.

Pablo Rodríguez-Navarro carried out this work with a research stay at MOLA (Museum of London Archaeology), funded by the program "Stays of professors and senior researchers in foreign centres", funded by the Spanish Ministry of Education, Culture and Sport.

References

Adm. 337/121/565. Admiralty: Royal Naval Volunteer Reserve: Records of Service, First World War. The National Archives, Kew, UK.

Aspinall- Oglander, C. (1951). *Roger Keyes*. London: Hogarth.

Association of Dunkirk Little Ships. Webpage accessed September 18, 2018, from http://www.adls.org.uk/t1/node/583.

Brown, M. & Meehan, P. (2002). *Scapa Flow*. London: Pan Books.

Cam2 Faro Technologies (2017). *Faro Laser Scanner User Manual*, online version, Faro Product Info, available from http://www.faro.com (last accessed August 2018).

Compton- Hall, R. (2004). *Submarines at War 1939-45*. Penzance: Periscope.

Corbett, J. (1938). *History of the Great War. Naval Operations,* Vol. 1. London: Longmans Green and Co.

English, J. (2004). Auxiliary Warships. In D. Brown (Ed.), *The Eclipse of the Big Gun*. London, England: Conway Maritime Press.

Evans, A., Romeo, M., Bahrehmand, A., Agenjo, J., & Blat, J. (2014). 3D graphics on the web: A survey. *Computers & Graphics*, *41*, 43-61. https://doi.org/10.1016/j.cag.2014.02.002

Firth, A. (2014). *East Coast War Channels in the First and Second World War*. Unpublished report for English Heritage. EH Project Number 6586, Fjordr Ref: 16131. Tisbury: Fjordr Limited.

Firth, A. (2015a). East Coast War Channels: a landscape approach to battlefield archaeology in the North Sea. *International Journal of Nautical Archaeology*, *44*(2), 438-445. https://doi.org/10.1111/1095-9270.12113

Firth, A. (2015b). The East Coast War Channels in the First World War: rediscovering a lost battlefield in the North Sea. *Historic England Research*, 1, 3-7.

Fisher, S. (2018). *Building the Motor Launch armada*. Unpublished document, Ronin Archaeology.

Friedman, N. (2004). The Aircraft Carrier. In D. Brown (Ed.), *The Eclipse of the Big Bun.* London, England: Conway Maritime Press.

Gordon, A. (2005). *The Rules of the game. Jutland and British naval command*. London, England: John Murray.

Guarnieri, A., Pirotti, F. & Vettore, A. (2010). Cultural heritage interactive 3D models on the web: An approach using open source and free software. *Journal of Cultural Heritage*, *11*(3), 350-353. https://doi.org/10.1016/j.culher.2009.11.011

Grussenmeyer, P., Landes, T., Doneus, M., & Lerma, J. L. (2016). Basics of range-based modelling techniques in Cultural Heritage. In E. Stylianidis*,* F. Remondino (Eds.), *3D Recording, Documentation and Management of Cultural Heritage* (Chapter 6, pp. 305-368). Dunbeath, Scotland: Whittles Publishing.

Guidi, G., Micoli, L. L., Gonizzi, S., Brennan, M. & B. Frischer. (2015). Image-based 3D capture of cultural heritage artifacts an experimental study about 3D data quality. *2015 Digital Heritage* (pp. 321-324). Granada, Spain: IEEE. https://doi.org/10.1109/DigitalHeritage.2015.7419514

Kwan, Y. (2016). *Laser Scanning, Theory and Applications*. USA: Scitus Academics LLC.

Lambert, A. (2008). *Admirals*. London: Faber and Faber.

Management Association, I. (Ed.). (2018). *Gamification in Education: Breakthroughs in Research and Practice*. USA: IGI Global. https://doi.org/10.4018/978-1-5225-5198-0

Maxwell, G. S. (1920). *The Motor Launch Patrol*. London and Toronto: J.M. Dent and sons.

Morris, J. (1995). *Fisher's Face*. London, England: Penguin.

Motor Launch Patrol. Webpage accessed November 21, 2018:

http://motorlaunchpatrol.net/history/post_war/rhine_patrol_flotilla/rhine_patrol_flotilla-2.php

http://motorlaunchpatrol.net/history/post_war/rhine_patrol_flotilla/

http://motorlaunchpatrol.net/history/post_war/

http://motorlaunchpatrol.net/history/post_war/irish_free_state/

http://motorlaunchpatrol.net/history/post_war/the_forgotten_flagship/

http://motorlaunchpatrol.net/history/pleasure_yacht/

Omura, G. & Benton, B. C. (2018). *Mastering AutoCAD 2019 and AutoCAD LT 2019*. USA: John Wiley & Sons. https://doi.org/10.1002/9781119495048

Rojas-Sola, J. I., de la Morena-de la Fuente, E. (2018). Digital 3D reconstruction of Betancourt's historical heritage: the dredging machine in the Port of Kronstadt. *Virtual Archaeology Review*, *9*(18), 44-56. https://doi.org/10.4995/var.2018.7946

Ross, A. (2004). Costal Forces. In D. Brown (Ed.), *The Eclipse of the Big Bun.* London, England: Conway Maritime Press.

Shan, J. & Toth, C. K. (2017). *Topographic Laser Ranging and Scanning: Principles and Processing*. USA: CRC Press. https://doi.org/10.1201/9781420051438

Spitfires of the Sea. Webpage accessed November 25, 2018: https://spitfiresofthesea.com/industrial-might/.

Sutphen, H. R. (1920). The building of the ships. In G. S. Maxwell (Ed.), *The Motor Launch Patrol*. London and Toronto: J. M. Dent and sons.

Terraine, J. (1999). *Business in Great Waters.* Ware, England: Wordsworth Editions Ltd.

West, S. (2017). Geoffrey Alfree 1889-1918. In N. Cohen, & E. Wragg, *The River's Tale: The Archaeology of the Thames Foreshore in Greater London*. London, England: Museum of London Archaeology.