

<b>Institution:</b> University of Dundee		
<b>Unit of Assessment:</b> UoA 32 Art and Design: History, Practice & Theory		
<b>Title of case study:</b> 3D Sub Sea Visualisation		
<b>Period when the underpinning research was undertaken:</b> 2001-2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>  Chris Rowland John Anderson	<b>Role(s) (e.g. job title):</b>  Professor in 3D Visualisation RA / Sr RA / Sr Research Fellow	<b>Period(s) employed by submitting HEI:</b> 2001-to date 2010-to date
<b>Period when the claimed impact occurred:</b> 2015 - 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> Y		

### 1. Summary of the impact

Advances in 3D Visualisation techniques have improved methods for capturing data from underwater sites of historical or environmental significance. The visualisations embody the creative and aesthetic, rather than purely technical, to enhance the understanding of complex data by a multitude of audiences in different contexts. The impacts include:

- Informing Government policy on recording the condition of protected war-grave shipwrecks, e.g. HMS Royal Oak, HMS Vanguard.
- Supporting the recovery of remains of airmen lost in the Mediterranean Sea during WWII in partnership with U.S. Government Defence POW/MIA Accounting Agency (DPAA).
- Providing virtual access for the public to maritime heritage sites.
- Supporting international salvage operations.

### 2. Underpinning research

Rowland and Anderson developed the underpinning research, which focussed on methods for creating aesthetically driven 3D visualisation of data captured from underwater sites. Initially the processes used multi-beam sonar as the method for capture. This produces accurate topography of the overall shape and scale of wrecks. The team developed novel techniques to add Locally Oriented Colour Ramps to the data and occlusion objects which improves the viewer's understanding of the data by highlighting details and obscuring rear facing data [R6]. Key examples include the Deepwater Horizon oil rig in the Gulf of Mexico (2010) and the Costa Concordia which sank off the Italian coast (2012).

Since 2014, the methodology has been expanded to include 3D photogrammetry (Structure from Motion, SfM) to add fine detail and real-world colour to the visualisations e.g. HMS Hampshire (2016) [R1, R4], HMS Royal Oak (2018-20) and WWII aircraft wrecks around the Maltese coast. Although the use of SfM to capture heritage sites is becoming accepted practice, there are specific problems inherent with underwater sites, where lighting and visibility are significant challenges to data capture.

The team's research established a robust method for capturing lens based underwater data for photogrammetry in environments at depths of >50m and/or visibility reduced to a minimum (<5m). This involved the design of underwater lighting rigs (up to 300,000 lumens) to illuminate

features of the wrecks at close range and adapted cave-diving techniques to eliminate the risk of “silt-out” further destroying visibility on site.

The Scapa 100 project (2017-19) provided an opportunity to develop these techniques using the WWI German High Seas Fleet scuttled in 1919 (Scapa Flow, Orkney). The wrecks were used by the team to develop the data capture techniques and to research methods of combining multibeam sonar of the wrecks with SfM data captured by the survey team. The use of ambient occlusion was developed during this project to replicate self-shadowing on the wreck data; this had the effect of highlighting fine details in the 3D models. The early results were presented at public events during the 2019 commemorations and later at conferences [R3, R5].

In 2017 The University of Malta invited the team to collaborate with their Underwater Heritage Project. This involved the 3D visualisation of several historic military wrecks (HMS Olympus, HMS Osprey – L72) and WWII aircraft lost at sea. This led to our work on the recovery of the remains of air crew from a sunken B24 Liberator on behalf of the U.S. Government Defence POW/MIA Accounting Agency (DPAA).

The SfM process was further developed during the Ministry of Defence (MoD) licenced survey of the wreck of HMS Vanguard (2017) which exploded at anchor in 1917. The remains of the ship are broken up and only large features such as the Bow, Stern and turrets are easily recognisable. This project allowed us to fine tune the low visibility capture methods (often <3m) and produce high-resolution 3D images as part of the MoD report [R2].

Further development continued with the MoD licenced HMS Royal Oak 80 survey in 2018-20 from which high-quality multi-beam data from 2006 was combined with 3D photogrammetry models to produce our most detailed and accurate results to date.

### 3. References to the research

---

[R1] Rowland, C., Hyttinen, K., Macdonald, R., Wade, B., Turton, E., Fitzsimmons, C., Haynes, P., Crofts, D. (2020), *HMS Hampshire 100: Survey Report*. Dundee: University of Dundee DOI: [10.20933/100001133](https://doi.org/10.20933/100001133)

[R2] Turton, E., Crofts, D., Fitzsimmons, C., Rowland, C., Hyttinen, K., Kay, S., Smith, J., Anderson, B., Tynkkynen, M., Hatton, K., Porter, J., Wade, B. (2018) *HMS VANGUARD 100: Survey 2016-2017*. Dundee: University of Dundee DOI: [10.20933/100001113](https://doi.org/10.20933/100001113)

[R3] Rowland, C. (2018) 'Immersion and the Submerged: The Scapa 100 Project'. *46th International Conference on Computer Applications and Quantitative Methods in Archaeology CAA 2018: Human History and Digital Future* CAA Tübingen, Germany 19-23 March 2018. Tübingen: CAA pp. 134-135 Available at: <https://2018.caaconference.org/wp-content/uploads/sites/22/2018/03/AbstractBook.pdf> (Accessed 22 March 2021)

[R4] Rowland, C., Hyttinen, K. (2017) 'Photogrammetry in Depth: Revealing HMS HAMPSHIRE', *Electronic Visualisation and the Arts (EVA 2017)*. London 11-13 July 2017 London: EVA pp. 358-364. DOI: [10.14236/ewic/EVA2017.72](https://doi.org/10.14236/ewic/EVA2017.72)

[R5] Rowland, C., Macdonald, R. (2017) *Dive Scapa Flow*. Caithness: Whittles Publishing. Rowland provided 36 original 3D digital images of the Scapa Flow wrecks for the book.

[R6] Rowland, C., Anderson, J. (2010) 'WreckSight: revealing our submerged maritime heritage'. *VAST 2010: The 11th International Symposium on Virtual Reality, Archaeology, and Cultural Heritage*. Paris 21-24 September 2010 Eurographics Association, pp. 39-45, DOI: [10.2312/VAST/VAST10/039-045](https://doi.org/10.2312/VAST/VAST10/039-045)

#### 4. Details of the impact

---

Impacts have occurred across a range of communities, strengthened by active engagement and dissemination through outreach activities with schools and community stakeholders, public exhibitions, and technical training courses.

##### **Informing policy on recording the condition of protected war-grave shipwrecks:**

There are two specific bodies that have engaged with the research: The Ministry of Defence (Royal Navy) and the heritage agency, Historic Environment Scotland. The 3D visualisation methods developed from the research have been used in three major MoD licenced surveys of UK Naval war graves: HMS Hampshire (2016), HMS Vanguard (2017) and HMS Royal Oak (2018-19). The purpose of the surveys was to ascertain the condition of the ships after a century underwater (80 years in the case of HMS Royal Oak) and report on the location of any hazardous materials that were found. In all three surveys, large quantities of live munitions were found on the ships.

The Royal Navy's Northern Diving Group (NDG) bomb disposal unit were given access to the 3D images on site and informed of the location of munitions so they could take any immediate action they deemed necessary. In the case of HMS Royal Oak, the survey pinpointed the location of the final German torpedo that had narrowly missed the ship, and which was lying on the seabed approximately 40 metres from the wreck – the NDG removed and destroyed it with a controlled explosion within 48 hours, thus making the wreck safe. The results of the surveys were published in a series of reports [R1, R2] and in the case of HMS Royal Oak, a 25 minute documentary, "Fallen Oak" was made to further disseminate the findings of the survey to the general public [E1]. Since its launch in October 2020, the documentary has received over 10,000 views (to Dec 31 2020).

The significance of the work has been confirmed by the Deputy Head of Designations at Historic Environment Scotland:

*'In our view, the pioneering visualisation work... has significantly helped efforts to investigate and protect the wrecks of Scapa Flow... This work has helped us to understand what survives on the seabed, to record threatened artefacts, and to take decisions in relation to the protection of these sites... [It] has also enabled observations to be drawn on the degree of survival of the wrecks, and the extent of deterioration in their condition over time. This information is of key importance in helping us to monitor the wrecks and to consider how these sites can be best managed in the future.'* [E2]

They go on to highlight the importance of the work in raising awareness and understanding of the wreck sites by the general public, noting that:

*'Without it, these wrecks, and the artefacts within them, would only be accessible to the very small numbers of the public who can dive, and therefore visit these sites in person.'* [E2]

##### **Supporting the recovery of remains of airmen lost in the Mediterranean Sea**

In collaboration with the University of Malta, the 3D visualisation methods were used to locate and record the excavation of human remains from a B24 Liberator bomber shot down in 1943. The DPAA was set up in 2017 by the U.S. Government to locate and recover military personnel lost in action. At a depth of 65m, the Liberator is the deepest underwater project DPAA have commissioned. Our earlier work on HMS Olympus (110m) and L72 (100m) proved that the project was feasible. The B24 project was only the second successful recovery of military remains from a submerged aircraft by the DPAA. [E3]

3D visualisation of the Liberator was disseminated to the public as a short, animated film and exhibited at the "Confluence: Tradition in Contemporary Art exhibition" at the George Segal gallery in New Jersey, USA (Oct – Dec 2019). The exhibition was attended by over 2000 people, including 60+ *Leaders of The World Conference* delegates (from Ivory Coast, Venezuela, Argentina, Galapagos, Japan, China, UK, Sweden and other countries) [E6].

**Providing virtual access for the public to maritime heritage**

Maritime war graves are protected sites, to which access is rarely given. The award of a special licence to the research team has enabled images to be gathered that give virtual access to previously inaccessible maritime heritage sites for the general public. The interactive visualisations in our WreckSight and 3D animations and images of the shipwrecks have been distributed online and placed in museums for wide public access (Stromness and Lyness, Orkney) [E4, E5].

The German WWI High Seas Fleet was scuttled in Scapa Flow, Orkney in 1919. The centenary events commemorating this final military act of WWI took place in June 2019 under the banner of **Scapa100**. The project was co-ordinated by the Orkney community and included 3D visualisation of the eight remaining German wrecks at Scapa Flow. We produced a series of virtual reality enhanced presentations [E7] for public visitors to the events, including school outreach, public talks about the 3D visualisation work and VR demonstrations. The events recorded over 2,000 visitors over a two-week period and provided virtual access to the shipwrecks to the general public who would otherwise be unable to experience them. The 3D Visualisations were also represented in VR to the general public during the centenary events and later at the Scapa 100 conference (October 2019). A new diving guidebook to the Scapa 100 wrecks was published to coincide with the centenary containing 32 digital images of the shipwrecks [R5]. The work was also presented to the Scottish Parliament in 2019 and at the **Scapa100** conference in October 2019.

**5. Sources to corroborate the impact**

---

[E1] Kieran Duncan (2020) Fallen Oak: Revealing the wreck of HMS Royal Oak. Available at: <https://vimeo.com/460447596/559fe3e0cc> (Accessed 22 March 2021) 10,000+ views as at 31/12/2020

[E2] Letter of support from Historic Environment Scotland (pdf)

[E3] Letter of support from University of Malta (pdf)

[E4] BBC (2019) 'New images reveal sunken Royal Oak battleship' *BBC News*, 1 February 2019 Available at: <https://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-47072973> (Accessed 22 March 2021)

[E5] BBC (2019) 'Images reveal extent of HMS Royal Oak torpedo attack' *BBC News*, 14 October 2019 Available at: <https://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-50033917> (Accessed 22 March 2021)

[E6] Confluence: Tradition in Contemporary Art (2019) [Exhibition] 10 October-7 December 2019 Available at: <https://www.montclair.edu/galleries/exhibitions/confluence-tradition-in-contemporary-art/> (Accessed 22 March 2021)

[E7] CAA Tübingen (2018), *Immersion and the Submerged: The Scapa 100 Project* 18 October 2019 Available at: <https://www.youtube.com/watch?v=KwqJ0sO3XI4> (Accessed 22 March 2021)