TOWARDS A NATIONAL COLLECTION

UKRI Arts and Humanities Research Council

FINAL REPORT

Discovery Projects

UNPATH'D WATERS: Marine and Maritime Collections in the UK

Edited by Barney Sloane

Archaeology Data Service | Bangor University | Glasgow School of Art
Historic England | Historic Environment Scotland
Maritime Archaeology Trust | Mary Rose Trust | MOLA
National Maritime Museum | Nautical Archaeology Society
Royal Commission on the Ancient and Historical Monuments of Wales
University of Bradford | University of Portsmouth
University of Southampton | University of Ulster
University of St Andrews | Wessex Archaeology

February 2025

Table of Contents

List of Figures

List of Tables

Report Contributors

Anna Aldous,
Historic England

Dan Atkinson,
Wessex Archaeology

Dr Claire Bailey-Ross,
Faculty of Cultural and Creative Industries,
University of Portsmouth

Lara Band,
Bangor University

Caroline Barrie-Smith,
Museum of London Archaeology

Mark Beattie-Edwards,
Nautical Archaeology Society

Andrew Bicket,
Wessex Archaeology

Cathy Blakey,
Bangor University

Jamie Bradley,
Archaeology Data Service

Dr Andy Brown,
Historic England

Iro' Camici,
Maritime Archaeology Trust

Dr Scott Carballo,
Glasgow School of Art

Prof Adrienne Chapman,
Department of Computer Science,
University of Southampton

Dr Andrew Choong Han Li,
National Maritime Museum

Dr Ann Coats,
Faculty of Technology,
University of Portsmouth

Dr Jonathan Combey,
National Maritime Museum

Dr Maria Cotuna,
Glasgow School of Art

Prof Tom Dawson,
Department of Archaeology,
University of St Andrews

Jude Dicken,
Collections Information Manager,
Manx National Heritage

Raghdaa Eissa,
Historic England

Dr Tim Evans,
Archaeology Data Service

Dr Wes Forsythe,
Ulster University

Kitty Foster,
Wessex Archaeology

Dr Katrina Foxton,
Museum of London Archaeology

Prof Vincent Gaffney,
University of Bradford

Soizic Garnier,
Bangor University

Jan Gillespie,
Maritime Archaeology Trust

Deanna Groom,
Bangor University

Andrea Hamel,
Wessex Archaeology

Dr Rachel Harding,
University of Bradford

Andrew Henderson-Schwartz,
Museum of London Archaeology

Dr Alexzandra Hildred,
Mary Rose Trust

Dr Robert Inkpen,
Faculty of Science and Health,
University of Portsmouth

Prof Stuart Jeffrey,
Glasgow School of Art

Paul Jeffries,
Historic England

Frankie Lau,
Historic England

Brandon Mason,
Maritime Archaeology Trust

Hannah Matthews,
Mary Rose Trust

Prof Karen McBride,
Faculty of Business and Law,
University of Portsmouth

Dr Innes McCartney,
Bangor University

Peter McKeague,
Historic Environment Scotland

Rory McNeary,
Department of Communities
Northern Ireland

Hefin Meara,
Historic England

Alastair Miles,
Mary Rose Trust

Abigail Morris,
Historic England

Dr Phil Murgatroyd,
University of Bradford

Jasmine Noble-Shelley,
Maritime Archaeology Trust

Lawrence Northall,
National Maritime Museum

Marion Page,
Historic England

Dr Émilie Pagé-Perron,
Archaeology Data Service

Shaheera Pesnani,
Historic England

Dr Sara Perry,
Museum of London Archaeology
then University College London

Dr Jack Pink,
University of Southampton

Dr Clare Postlethwaite,
Marine Environmental Data
and Information Network

Dr Rory Quinn,
Ulster University

Prof Julian Richards,
Archaeology Data Service

Dr Michael Roberts,
Bangor University

Bruce Robertson,
Glasgow School of Art

Dr Peter Robins,
Bangor University

Julie Satchell,
Maritime Archaeology Trust

Sarah Saunderson,
Bangor University

Dr Garry Scarlett,
Faculty of Science and Health,
University of Portsmouth

Professor Eleanor Schofield,
Mary Rose Trust

Graham Scott,
Wessex Archaeology

Andy Sherman,
Museum of London Archaeology

Prof Fraser Sturt,
University of Southampton

Dr Tarek Teba,
Faculty of Cultural and Creative Industries,
University of Portsmouth

Carla Velterop-Martin,
Historic England

Dr Julian Whitewright,
Royal Commission on Ancient
and Historic Monuments Wales

Phoebe Wild,
Bangor University

Dr Holly Wright,
Archaeology Data Service

Executive Summary

The UK has a rich maritime heritage. It is impossible to tell the story of our islands without talking about our relationship with the sea. This maritime past is becoming increasingly important. People are more aware of our exploitation of the sea and topics such as colonialism, slavery and immigration.

Unpath'd Waters therefore sought to increase interaction with the UK's maritime heritage by making it easier to research and easier for the public to discover and share stories in new ways. Despite its importance, it is not always easy to study our maritime heritage. Records, maps and objects are scattered across hundreds of different archives, museums, libraries and galleries. A large part of our work has been to develop new ways of making information across these different collections easy to search and find.

This will help everyone – from researchers asking new questions to members of the public having direct access to records. We hope this will encourage more experts from all disciplines to use maritime collections in their own work. To make sure this project has a lasting impact, we have published all our methods, outputs, code and research so anyone can use it in their work and help the future of UK maritime heritage.

Unpath'd Waters tackled the challenge through eight key activities (Work Packages). The first was aggregating and assessing the character of more than 90 different maritime collections, matching their core attributes and creating a metadata framework which will allow them to be connected. The second was testing artificial intelligence and machine learning opportunities to help search these connected collections in new ways. Three connected research activities then tested this framework and these new tools to try to resolve three real-world challenges. We used innovative values-led evaluation to capture evidence of how people value wrecks in museums compared to some wrecks still on the seabed of the English Channel which have been surveyed and even excavated in part. We sought the identity of known but un-named wrecks in the Irish Sea and established their stories and their management needs. And we used collections to build a simulation of 15,000 years of now-lost landscapes under the North Sea where prehistoric peoples once dwelled before sea level rise.

Using the outcomes of this research and the collections framework and exploration tools, we co-opted key sample audiences: cross-disciplinary researchers, visually impaired people, and those who have little engagement with the sea. These audiences helped us co-design new ways of accessing this connected information so that we could create new portals for the public which are designed around what people themselves want rather than what we think they want. On top of this, we have been able to link and enhance the national marine heritage inventories of all four home nations – England, Scotland, Wales and Northern Ireland and inspired the Isle of Man to create their own inventory.

Unpath'd Waters was a large project, directly involving over 80 people with contributions and support from many more. A Management Group of experts in digital humanities, marine archaeology and history, ocean science and audience engagement and evaluation led a consortium of eight universities, five Independent Research Organisations and five collaborating organisations including archaeological trusts, museums and charities. These were supported by Partners whose number grew as the project gained momentum. We brought this diverse group together through the same values we used for the audience evaluation and in this report we make recommendations on the use of values for any future consortia research projects.

Key Products and Impacts of the Project

Unpath'd Waters has delivered a fundamental step-change in understanding how marine and maritime heritage collections can be integrated, shared, accessed, and it generated many valuable lessons which can be applied far beyond the marine heritage sphere.

Ontologies and Controlled Vocabularies

Unpath'd Waters led directly to the creation of an agreed UK wide controlled vocabulary for vessel types for the first time. Definitions for Scottish periods were published as URIs via the Perio.Do service, and for the first time an archaeological periodisation was agreed and published for the whole island of Ireland. Overall, the project increased the FAIRness of UK maritime data.

Unpath'd Waters successfully adapted the ARIADNE ontology, the AO-Cat, itself a subset of the CIDOC-CRM, to create a maritime-specific instance, the UO-Cat.

Use of Artificial Intelligence (AI)

For the first time, using AI, we brought together the four home nation marine inventories allowing us to understand aspects of the unified record that were previously impossible to explore. Our work on messages in bottles (written, mainly 19th-century, texts relating to the loss of vessels as they happened) has shown the potential of hitherto unaccessed collections to contribute narratives that speak to a distinctly human existence at sea while also demonstrating the complexities and challenges inherent in use of machine learning (ML) and the fundamental need for a human in the loop.

Critically our use of AI has demonstrated its strengths, in resolving inconsistencies in data creation and storage practices, and enhancing records where their 'thinness' prevented linking, and its weaknesses which are less to do with AI (as it is a tool) and more to do with the materials (what we were asking the tool to work with) and heightened expectation due to increased AI capabilities and media coverage.

Interdisciplinary Research

We have demonstrated how connecting collections can identify wrecks. As a result of our work, it is increasingly possible, without very expensive diving missions (human or Remotely Operated Vehicles), to propose or correct vessel identifications. We have also combined heritage and non-heritage data to develop the basis for a preservation model for wrecks, something of value when considering environmental issues related to hazardous cargoes.

In our simulation of the ancient landscapes now under the North Sea, we have been able to combine and visualise collections of *processes*, rather than places or sites. The medium to long term impact of both the simulation and the data package are of course uncertain, but the short-term impact has been noticeable within the research community.

Our target interdisciplinary researcher audience reacted favourably to the Unpath'd Waters Navigator VR environment as a research platform, enjoying departure from the 2D research mindset and encouraged by VRs potential to bring research (or heritage experiences) to life without having to travel.

An unexpected benefit of the project was our novel interdisciplinary work on values-led approaches to audience evaluation and consortium integration. Our values have demonstrably positively affected some aspects of the project's research and most aspects of its community-based partnerships and are materially influencing new projects.

Opening Marine and Maritime Collections to New Audiences

Our work with Solent and museum wrecks was able to identify a number of key benefits arising from connected collections. These included the experiencing of something previously unknown, the enjoyment of richer exploratory capabilities in a wider range of media, a commonly felt desire to connect with human stories, and the non-heritage benefits of heritage collections.

A particularly important outcome has been the opening of heritage collections to visually impaired people. A deliberate co-design approach with representatives of the visually impaired community has fundamentally shaped the design of our Unpath'd Waters VR Navigator, providing essential experience for opening access to those otherwise disadvantaged.

Collections Improvement

Evident benefit has been provided to the four home nations (and Isle of Man) marine heritage inventory managers. The work on integration, enrichment and aggregation made possible through our use of machine learning and named entity recognition, and presented via the Unpath'd Waters Portal, has driven rich conversations between the home nations about the future of their separate inventories. The project has also helped to shape future approaches to digital collection development and to enhance FAIR principles for digitisation.

Recommendations for the Future

A wide range of recommendations has emerged from the project.

In terms of developing a UK digital collection, we offer the following:

Supplementary recommendations for developing the national collection to support the TaNC call to action[1] which include:

- Being clear about the degree to which focus is placed on metadata or rich datasets. Both are needed to unleash the potential of a true national collection.
- Careful consideration of the use of authority files and controlled vocabularies, with a strategic approach to ensure a balance for different kinds of collections.
- Tracking of how outputs and labels have been created by AI will be essential, especially for collections used for legislative or strategic management purposes.
- Workflows for dynamic (ie growing/changing) collections that allow enhanced data to feed back into original repositories and be recognised there.
- Ensuring that the full range of abilities of users (for example the visually impaired) is built-in from the outset.
- Human and more-than-human centred design to be made a core component of any future national collection, at an infrastructure as well as a collection level.

Developing a strategic approach to the selection of and investment in digitisation of new collections, taking into account: provenance, rarity, condition and completeness, historical, cultural or scientific meaning, sensory and emotional impact, and marketing and exploitability, and using the balancing criteria: retention of faithfulness, removal of barriers to access, and preservation.

Taking account of key issues in developing programme infrastructure: funding approaches, support towards FAIRness, the use of a values-led approach for consortia and projects, suitable training in audience engagement, and appropriate management of carbon footprints.

For managing our UK national heritage inventories, we offer recommendations on improving these collections, developing better data flows and workflows, the equitable handling of citizen science, and active awareness raising of their value and potential to the public.

And finally, we offer recommendations on building values-led approaches into the research programmes of similar projects of this scale, and on managing large and complex consortia.

1 https://zenodo.org/records/13838916

Acknowledgements

The Unpath'd Waters Consortium is enormously grateful to the following organisations and people for their help, support and constructive contributions to the project's objectives. Without you, we would not have been able to achieve anywhere near as much as we did.

TaNC Programme Directorate: we are very grateful for the hard work and constant support of those on the TaNC programme directorate: Rebecca Bailey, Programme Director, and her team including Javier Pereda, Sophie Dietrich , Tertia Barnett and Michelle Forster-Davies.

Mary Rose Trust: Lina Fitzjames, Collections and Conservation Assistant; Tana Randle (Intern 2022), Hannnah McCann (Intern 2023), and Holly Pratt (Intern 2023) for their help with the Audience Evaluation Report.

University of Portsmouth Extended Reality Enterprise (eXRe) project facilitators/contributors: Professor Trevor Keeble, Executive Dean of Creative and Cultural Industries; Dr Brett Stevens Principal Lecturer, School of Creative Technologies; Pippa Bostock, Business Director, Centre for Creative and Immersive Extended Reality; Hattie Ball and Marc Cook, Technicians, Centre for Creative and Immersive Extended Reality.

Analogue Digital Connector Collections participants: Gosport Diving Museum, Kevin Casey; Navylist – Naval Biographical Database, Chris Donnithorne; Portsmouth Royal Dockyard Historical Trust Archive, Michael Huitson; University of Newcastle Marine Technology Special Collection, Ian Buxton; University of Portsmouth Map Collection, David Sherren.

Digital and Physical Maritime Collections Research Symposium 1 November 2023 participants (excluding Consortium members): Padmini Broomfield, Heritage Consultant; Serena Cant, Marine Information Officer, Historic England; Kevin Casey, Director Gosport Diving Museum; Dr Sean Cunningham, Head of Collections (Medieval, Early Modern, Legal and Map Records) at The National Archive; Kaja Marczewska, TNA Head of Collections Research, Research and Academic Engagement; Anna Delaney, University of Portsmouth Archivist; Dr Paola Palma, University of Portsmouth Research Development; Dr Panagiotis Papageorgiou, Senior Lecturer International College Portsmouth; David Sherren, University of Portsmouth Map Collection; Chris Donnithorne, Librarian, Naval Biographical Database; Daisy Turnbull, University of Portsmouth PhD student; Agniya Dremach, Lloyd's Register Foundation Research Librarian; Ben Ferrari, Senior Advisor Heritage and Education Centre, Lloyd's Register Foundation; Dr Stefan Ramsden, University of Manchester, Research Associate, Our Heritage Our Stories, AHRC TaNC Discovery Project; Dr Gethin Rees, Lead Curator, Digital Mapping, British Library

Archaeology and the Sea – diversifying our engagement with historic shipwrecks co-creators: Marie Costa, Padmini Broomfield, Lucky Haque, Lyn Brayshaw, Anon.

Science and the Sea assistance: Gwyn Roberts, Computer Manager, and Ahmed Ali, Software Analyst/ Developer, University of Bangor; Adrian Corkill, independent maritime historian (Isle of Man); Michael Lowrey, independent naval historian (North Carolina, USA); David Wilson, independent historian (Isle of Anglesey).

Unpath'd Waters Navigator Co-Design Collaborators: Visually Impaired Persons Group: Sally Booth, Caroline Mawer, Jean Davis, Norin Khanna, Velma Creft, Mahalia Creft, Vicky Blencowe – Co-Designer Curated Voyage, Ramona Williams; Non-Coastal Communities Group: Cliff Robertson, Vicky Johnson, McNabb Laurie – Co-Designer Curated Voyage, Andrew Murdoch, Debbie Marshall, Paul Goodwin; Cross-Disciplinary Maritime Researchers Group: Steph Piper, Scarlett Crow, Ben Urmston, Andrew Fraser, Martin Wilcox.

Sound Artists (Glasgow School of Art MDes Sound for the Moving Image): Ellie Ford – Shipwrecked sites; David Dore – Smuggling on the Solway Firth; Jamie Graham – Scuba-diving adventure to a sixteenth century sailing ship; Samuel Alexander – The decline of coastal communities; Dennie Landsman – German U-boat attacks; Marie Wahrn – Submarine sonar sounds

The Unpath'd Waters Exhibition: The compilers of this report would like to express their deepest gratitude to the institutions that participated in the project by generously hosting the Maritime Bus and/or versions of the static displays:

- Amgueddfa Ceredigion Museum, Aberystwyth
- Chatham Historic Dockyard
- The Cutty Sark, Greenwich
- Dundee Heritage Trust
- The Fleet Air Arm Museum, Yeovilton
- Manx National Heritage
- National Museum of the Royal Navy, Hartlepool
- Scapa Flow Museum, Orkney
- Scottish Maritime Museum, Irvine
- SeaCity Museum, Southampton
- Southend Museums
- Time & Tide, Great Yarmouth
- Tower Museum, Derry
- Tyne & Wear Archives and Museums

1. Introduction

Unpath'd Waters is one of five Discovery Projects supporting the UK Research and Innovation/Arts and Humanities Research Council *Towards a National Collection* (TaNC) programme. Its aim was to look at the UK's marine and maritime collections, to explore what potential existed for connecting those collections and opening them up to new audiences, and to set out what lessons could be learned in the drive towards developing a national collection.

Uniquely among the five TaNC Discovery Projects, Unpath'd Waters focused on collections of, and relating to, archaeological monuments and landscapes. Thus, we have considered our national collections of shipwrecks and the objects, charts, documents and images relating to them, as well as the submerged archaeology of prehistoric landscapes which were once dry land. Our project was thus highly oriented on matters of space and time. We used as our stage the UK Marine Area **(FIG 01_01).** This vast space covers a total of 867,400 km^2, 3.5 times the terrestrial extent of the UK, and holds remnants of human activity over the last 900,000 years. Our marine heritage is extraordinary. Shipwrecks from the Bronze Age to the World Wars bear testimony to Britain as an island nation, a destination for industry, trade, migration and conquest, and at times, the heart of a global empire. Coastal communities have been shaped by their maritime heritage with stories of loss and heroism. Deeper in time, what is now the North Sea was dry land, peopled by prehistoric communities: our current land would have been distant uplands above hills and plains and rivers.

Unpath'd Waters has engaged with numerous collections representing aspects of this remarkable heritage, covering 23,000 years, including the wrecks themselves, the historic coastal and intertidal structures, charts, documents, images, film, oral histories, sonar surveys, seismic data, bathymetry, archaeological investigations, artefacts, artworks and palaeoenvironmental cores. At present, these are unconnected and relatively inaccessible. This lack of connectivity and accessibility matters. Firstly, the story of our seas is of huge interest to the UK public, with millions visiting maritime museums and archives annually. Secondly, marine exploitation is increasing dramatically for energy, minerals, trade, food and leisure, and the potential impacts of this exploitation on our heritage need to be managed effectively. Thirdly, some wrecks and structures present environmental challenges, because of their cargoes or as navigational hazards. And finally, because some of our historic wrecks are also the last resting places for those lost at sea at war or in peacetime.

Unpath'd Waters set out to discover how we might best unlock new stories and effect sustainable management of our marine past. Our consortium brought together universities, government agencies, museums, heritage trusts and research experts to confront this challenge. We worked with known and new audiences to understand how they – the users – would wish to interact with this heritage. We focused on digital collections and computing techniques to innovate searching across collections, create simulations to help visualise landscapes, and we integrated scientific datasets and methods not normally applied to heritage collections to identify wrecks, understand their past, and explore their potential futures. We do not claim to have created new software or extended the boundary of approaches to artificial intelligence, but we have incontrovertibly shown how such techniques could be applied in the pursuit of a genuine national collection as well as uncovering some very significant challenges which will need to be overcome. Unpath'd Waters has delivered demonstrators of new management tools to protect our most significant heritage and to invite the public to co-design new ways of interacting with the collections. The methods, code and resources created have been published openly so they can used to shape the future of UK marine heritage.

1.1 Structure of this Report

This report has been deliberately shaped by our Unpath'd Waters living values (see **Chapter 6)** to be both accessible to a wide range of readers and playful in its formation. We hope that we have been successful in both endeavours. We have envisaged the whole project as a voyage and named the various chapters to reflect this. Thus, in 'Exploration' **(Chapter 2)** we set out our specific aims and objectives, and in 'The Riches' (Chapter 3) we set out the character of our marine heritage collections and consider their potential to meet these goals.

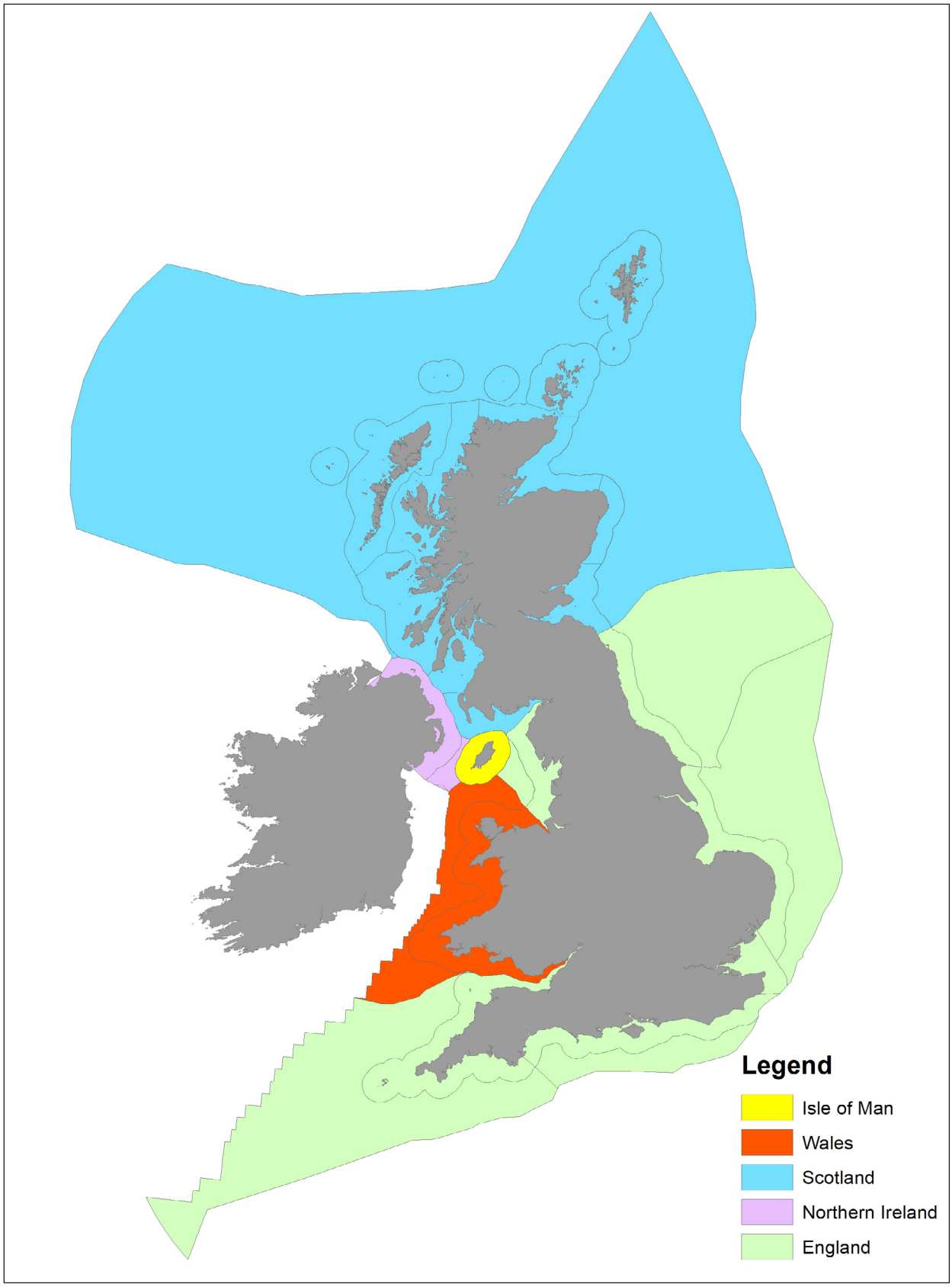


FIGURE 1_01
The UK Marine Area showing state administrative coverage.

The 'Vessel' **(Chapter 4)**, the 'Crew Manifest' **(Chapter 5)**, 'The Compass' **(Chapter 6)** and 'The Pilot' (Chapter 7) describe how we approached the project, who was involved, how we attempted to unite our consortium under common values, and how we managed the project. We believe these afford crucial insights which will support development of a national collection just as significantly as any technical or research lessons we learned.

The 'Cargo Inventory' **(Chapter 8)** sets out the collections sample – a sub-sample of those 'Riches' addressed in Chapter 3 – which we used in Unpath'd Waters and how we aggregated and managed them as datasets, while 'Stowage and Supply' **(Chapter 9)** documents how we developed ways of using artificial intelligence, and machine learning to access, link and enrich the collections.

Then follow four 'Voyages of Discovery' which describe the approach and results of four thematic ways of testing the value of linked and connected collections.

'People and the Sea' **(Chapter 10)** explores how it might be possible to use collections to enhance the understanding of wrecks – both those in museums (using the Mary Rose, a world-famous 16th-century wreck, and the Holland 1, the Royal Navy's first ever submarine), and those still on the seabed (using a range of known wrecks around the Needles, Isle of Wight, and the Holland 5, sister submarine to the Holland 1).

'Science and the Sea' **(Chapter 11)** explores how it is possible to combine (non-heritage) environmental science datasets and historical tidal and weather datasets with high-precision scans of wrecks on the seabed, and documentary evidence for construction, voyages and loss, to identify and give names and stories to unnamed or misnamed wrecks in the Irish Sea. This same combination of ocean science and heritage collections has also helped us to explore the preservation potential for these wrecks – of great interest in terms of heritage and environmental management.

'Lands beneath the Sea' **(Chapter 12)** explores how gathering marine archaeological collections together with evidence derived from ocean surveys and modelling of seabed and sub-seabed structures can provide the basis for a simulation of the way in which the North Sea encroached on prehistoric landscapes between c20,000 years ago when the icesheets began to retreat for good and 5,000 years ago, gradually overwhelming plains, valleys, ranges of hills, lakes and rivers. The resulting accessible simulation is as important for research into our shared past as for developing effective management tools for offshore renewable infrastructure.

'New Opportunities' **(Chapter 13)** explores how new forms of visualisation could open up accessibility to the national marine records, currently consisting of rather dry text-based databases, by using Storymaps and Virtual Museum approaches. In doing so it begins to reveal the combined power of these datasets for new narratives.

'Setting Sail' **(Chapter 14)** sets out how we co-designed the Unpath'd Waters Navigator for our three key target audiences (non-coastal communities, interdisciplinary researchers and visually impaired people). This is a virtual-reality immersive which draws on the range of collections selected for Unpath'd Waters and whose design was shaped by the three audiences, with particular emphasis on the needs of the visually impaired user-group. We include a range of evaluations of this process to help future design.

In 'Circumnavigation' **(Chapter 15)** we explain how we took the tools and research insights we had developed out to the public. It explains how we undertook our audience mapping to recruit three key test groups – interdisciplinary researchers, members of non-coastal communities, and visually impaired people – and how we engaged them to help us co-design the best ways possible to access and search among the collections. It also explains how we took the results to a wider public in a targeted touring exhibition and the lessons we learned from that.

In 'A Profitable Venture' **(Chapter 16)** we review the key highlights and impacts of the project in relation to the overall mission set by the *Towards a National Collection* brief, before looking 'Beyond the Horizon' **(Chapter 17)** to set out our conclusions and recommendations and finally providing some last words during our 'Disembarkation' **(Chapter 18)**.

A number of appendices provide a list of tangible project outputs, evidence of events and interactions with the project, a statement on the sustainability and infrastructure of the project and its products, and a list of project contacts.

2. Exploration – Aims and Objectives

All five Discovery Projects of the *Towards a National Collection* programme aimed to address the following six common objectives[2]:

1. Carry out world-class interdisciplinary research in key thematic areas, relying on original ways of discovering and using collections.
2. Grow and diversify audiences by introducing the public to new ways of engaging with the collections, including major research-driven public-facing outputs, addressing virtual and in-person audiences.
3. Devise technological and organisational solutions to the barriers between online collections and catalogues, including beginning to establish, as far as is possible, harmonised standards for data, cataloguing and metadata to facilitate interoperability across collections.
4. Deliver benefit not only to the collections of Independent Research Organisations, but also to collections and other heritage organisations of varied scale and geographic location, including organisations beyond metropolitan centres.
5. Create a sound evidence base for the future development of a virtual 'national collection', for example through informing UKRI infrastructure investment planning and digital investment decisions within culture and heritage organisations.
6. Produce evidence-based policy recommendations to inform the delivery of the relevant DCMS strategic objectives and those of the devolved nations.

Across these objectives, the programme sought to create impact within four areas:

- Dissolution of barriers between collections by addressing technological, organisational, and other issues that stand in the way of an integrated virtual 'national collection'.
- The increase of the UK's research capability to help maintain its leadership in cross-disciplinary and cross-collection research.
- Enhancement of and innovation in access for all stakeholders in the form of major research-driven public-facing outputs, to facilitate wider, better-informed and more inclusive public access.
- Provision of evidence for the development of future policy and strategy.

The Unpath'd Waters project framed its response to this brief through a series of research questions relating to marine and maritime collections.

> A. How can we integrate the UK's marine and maritime heritage collections? How can we establish meaningful links between such diverse objects and datasets as wreck sites, artefacts, photographs and videos, documents and records, surveys, cores and samples, charts, works of art, and more?
>
> B. How can we transform our ability to search those collections? How can we use AI and machine learning to create brand new ways of searching these collections across time and space to generate entirely new ways of understanding this heritage?

2 Towards a National Collection, Discovery Project Call Document V2 (2nd July 2020)

C. How can we demonstrate real progress against these two questions using the following tests:

i. How can we enhance the significance of submerged and displayed wrecks and thus increase audience engagement and prioritise management decisions? How can we establish what engages different people with historic wrecks either onshore in museums or offshore still submerged, and what does that mean for the way we as nations protect and provide access to them?

ii. How can we use these connected collections to identify unnamed wrecks and to improve their long-term management? How can we make substantial progress in identifying unknown wrecks through connecting their physical characteristics (structure, materials, location, condition) with other forms of evidence (historical, constructional, loss records), and use this same evidence to provide an understanding of how best to manage them?

iii. How can we open access to submerged prehistoric landscapes by combining complex collections? How can we connect current and future collections (core samples, seismic and bathymetric surveys, artefacts) to create dynamic and accessible representations of the drowned landscapes of the North Sea?

D. How can we co-design and co-create research and engagement access by and for new audiences (disadvantaged groups, disengaged communities, researcher communities)? What new forms of visualisation and immersion can be co-designed by and for people to engage with this new connectivity in a widely accessible manner?

E. How can we dependably measure the impact and public value that our innovations have had in the way people can now access and interact with these UK marine and maritime heritage collections?

F. What conclusions can we draw and what advice can we offer for strategic and systemic improvements for key decision-makers and collection managers in the future? How can marine and maritime heritage lessons be transferred to other kinds of collection?

What follows sets out how we approached and attempted to answer these questions.

3. The Riches – Character of the collections

The nature of the UK's marine and maritime collections is very diverse. This chapter provides a general, and necessarily high-level, summary of these collections. The Unpath'd Waters project could only look at a sub-sample of these collections, the nature of that sub-sample is set out in **Chapter 8**.

3.1 The Archaeological Resource – The Physical Collection

Our marine and maritime archaeological resource is an unusual kind of collection. It is not a collection in the sense of a museum or archive collection, but a collection of physical entities which represent the remains of human activities in the past. By its nature, it cannot be quantified as more discoveries are made with each passing year. But it is enormous. The category within it with which most people are familiar is that of wrecks, but there is a wide range of other archaeological sites and monuments spanning the last 950,000 years. This includes chance discoveries of palaeolithic stone tools, the remarkable fossilised human footprints discovered at Happisburgh, Norfolk[3], the Seahenge timber circles near Holme-Next-The-Sea, Norfolk[4], submerged medieval towns such as Dunwich, Suffolk[5], and a great variety of coastal settlements, sea defences, industrial and commercial structures, military installations, leisure facilities and other physical components of our more recent past. Unpath'd Waters has given us a chance to consider this collection in an entirely new light.

This collection does have its catalogues – collections in their own right. These are the national inventories (see **Section 3.2**). It also benefits from a further, growing collection of data in the form of reports and archives of investigations into the archaeological sites. These are increasingly housed on the Archaeology Data Service (ADS) platform[6]. Research which explores this collection is increasingly responding to national and transnational research frameworks[7]. Additional related collections include the physical archives of these investigations. These generally comprise some or all of: surveys and scans, dive logs and note books, plans and drawings, photographs and videos, samples and, of course, artefacts recovered from the site. Further digital collections and datasets arise from the scientific analyses of these assemblages and from work required to conserve artefacts. As of 1 October 2024, plans are in motion to develop a Heritage Science Data Service as part of the UK's Research Infrastructure for Conservation and Heritage Science[8]. As of December 2024, a national repository able to take these physical archives does not exist. Some are held by licensees of wrecks (if they are protected by law, under the Protection of Wrecks Act 1973), many are transferred to local museums in the vicinity of the wreck, and some are accessioned by regional or national museums. A good number of physical maritime archives are held in private ownership with uncertain access and future.

3.2 The National Monuments Records

England, Northern Ireland, Scotland and Wales and the Isle of Man each have state heritage inventories covering their seas. They are known as National Monuments Records. Each of these contain significant numbers of records that are maritime in nature and help to explain, interpret and enhance the understanding and enjoyment of maritime heritage. Although they record similar types of maritime data, often from similar sources, each is an individual National Record in its own right, with different origins and differences in approach.

---

3 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0088329
4 https://www.cambridge.org/core/journals/proceedings-of-the-prehistoric-society/article/abs/survey-and-excavation-of-a-bronze-age-timber-circle-at-holmenextthesea-norfolk-19989/968BB819897D0051C837A0F99BD99F60
5 http://www.dunwich.org.uk/resources/documents/dunwich_12_report.pdf
6 https://archaeologydataservice.ac.uk/library/search/searchResults.xhtml
7 For example, Flemming (ed) 2004; Ransley and Sturt (eds) 2013.
8 https://heritagesciencedataservice.ac.uk/

The following sections outline the background to each National Record, a summary of the content of that record, the sources of information that have contributed to it, and the structure of the data contained within it. We consider lessons learned and potential avenues for development in the future in **Chapter 17**.

3.2.1 Historic England's National Marine Heritage Record

Hefin Meara, Historic England

Background

The origin of Historic England's marine record dates to the early 1990s following the publication of the white paper 'This Common Inheritance', which tasked the Royal Commission on the Historical Monuments of England (RCHME) with the compilation of a database of historic wrecks and sites within territorial waters adjacent to England. The marine record, comprised of textual information stored in an Arches[9] database and a corresponding GIS spatial depiction, has been maintained by a dedicated team of Marine Information Officers.

A key driver for the redevelopment of Historic England's marine records has been the Heritage Information Access Simplified (HIAS) programme[10], which identifies Historic England as the first point of call for and primary trusted source of national datasets, including the national marine heritage dataset. While local authority Historic Environment Records (HER) are the primary point of contact for terrestrial data, the remit for the marine zone sits firmly with Historic England. Historic England's marine records are publicly accessible online on the Heritage Gateway[11].

Content of the Record

The marine component of Historic England's National Record of the Historic Environment (NRHE) comprises information on over 37,000 shipwrecks which have occurred within territorial waters adjacent to England. This figure can be broken down into approximately 6,000 wreck sites whose position on the seabed is known, and a further 31,000 wreck events which are known only from documentary sources[12].

These 'Casualty' records form a vital part of the record – they reveal the maritime archaeology potential of an area and provide avenues of research to suggest the identity of newly discovered wrecks on the seabed. Given that the precise locations of these losses are unknown, they're assigned to an arbitrary set of coordinates, based around the named locations described within the sources.

In addition to records for shipwrecks, the database also contains records of approximately 7,500 fishermen's fasteners, instances of fishing gear being snagged on a seabed obstruction. These are an indication of the potential for archaeological remains to be present on the seabed. There have been many examples of reports of the snagging of fishing gear, which on investigation were revealed to be nationally important shipwreck sites which were subsequently designated under the Protection of Wrecks Act 1973[3].

The database also contains approximately 1,000 records for isolated findspots. These are reported via a variety of flowlines, including material reported as Droits to the Receiver of Wreck under the terms of the Merchant Shipping Act 1995, material discovered during offshore development work such as the construction of offshore wind farms, or discovered during aggregate dredging operations.

Information on buildings in the marine zone such lighthouses, sites which have become submerged due to sea level rise, as well as historic aircraft crash sites comprise the remainder of the record.
The system also holds records for archaeological events such as geophysical surveys, diver investigations and underwater excavations. Additionally, the system holds a wealth of supporting information including bibliographic sources, as well as records for key people and organisations.

---

9 https://www.archesproject.org/what-is-arches/
10 https://historicengland.org.uk/research/support-and-collaboration/heritage-information-access-simplified/
11 https://www.heritagegateway.org.uk/Gateway/Resource_Desc.aspx?resourceID=19191
12 Figures in this report were correct as of July 2024

Sources of Information

The identified wrecks on the seabed are largely derived from a snapshot of the UK Hydrographic Office (UKHO) wreck index back in 1992, which has been further supplemented by other sources such as diver guides, information supplied by divers, and sites discovered through the course of seabed development. This has been enhanced by the results of research and fieldwork funded by Historic England, including underwater archaeological survey, rapid coastal zone assessments, and aerial photograph interpretation.

Recorded losses were initially sourced from Richard and Bridget Larn's *Shipwreck Index of the British Isles* (see bibliography), which was then expanded upon from other sources, including primary sources such as state papers, Lloyd's Register, Board of Trade wreck enquiries, U-boat logs etc, as well as historic newspaper accounts. Previously this required visiting archives and searching through the original papers. It is now considerably easier thanks to the advent of online sources such as the British Newspaper Archive – a hint of what would be possible with a fully integrated national collection. Information on fishermen's fasteners is derived from the various *Kingfisher Books of Obstructions* published by the Sea Fish Industry Authority. Findspots and isolated material are reported via the Receiver of Wreck, or through the various flowlines related to offshore development, such as the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest[13].

FIGURE 3_01
Diver exploring the designated wreck of HMS Colossus.

13 https://www.wessexarch.co.uk/our-work/marine-aggregate-industry-protocol-reporting-finds-archaeological-interest

Data Structure

One of the strengths of Historic England's shipwreck records is the quantity of information, which is contained within structured fields and recorded using controlled vocabularies. In addition to craft type, the current record is structured to record details of the final voyage, including port of departure, port of destination, cargo, manner of loss, nationality and more.

Historic England has been developing new data models for incorporation within its new Mariner[14] system during the Unpath'd Waters project. The new models build on the previous structure but allow for even more information to be captured in a controlled manner. One of the key principles is the move to recording the shipwreck site and the original floating vessel as different resources within the system. This allows for the full lifecycle of the vessel to be captured, including previous notable voyages and details of crew members. New fields added to the record during this redevelopment include Builder, Place of Build, numbers of crew/passengers as well as numbers of crew/passengers lost. Fields in the recording structure use the FISH controlled vocabularies[15] where appropriate.

3.2.2 Maritime Records in the Historic Environment Record of Northern Ireland

Rory McNeary, Northern Ireland Department for Communities

Background

In 1992 the Department of Environment Northern Ireland (DOENI) accepted responsibility for historic wrecks in Northern Ireland's territorial waters under an Agency Agreement with the Department of National Heritage[16]. It was recognised that fundamental to the successful management of the resource an understanding of the nature and extent of that resource would be required; several initiatives from 1993 included:

1. the recording of maritime-related sites on the coast and in the inter-tidal zone;
2. the compilation of documentary information pertaining to shipwrecks; and,
3. geophysical survey of inshore coastal waters.

These early initiatives formed the genesis of the wreck, and wider maritime records, that are held within the Historic Environment Record of Northern Ireland (HERoNI)[17]. In subsequent years NI Government archaeological curators have worked with the Centre for Maritime Archaeology (CMA) at Ulster University, and other relevant partners, to further augment these records.[18]

Content of the Record

The record of maritime-related coastal and inter-tidal sites has been generated through desk-top and field surveys initially undertaken from 1997 by a DOENI-funded Coastal Research Unit (CRU) and later by the CMA. These have been undertaken by region and sites assigned a unique number based on the relevant County and Irish Grid map sheet. To-date two major surveys have been completed: Strangford Lough, Co. Down[19] and Rathlin Island, Co. Antrim[20].

---

14 https://historicengland.org.uk/research/support-and-collaboration/heritage-information-access-simplified/reimagining-the-national-marine-heritage-record-for-england/

15 https://heritage-standards.org.uk/fish-vocabularies/

16 This initiative was in response to the Government white paper, *This Common Inheritance*; RCHME's pilot, *Testing the Water* and the transfer of administrative function with regard to the Protection of Wrecks Act (PWA) 1973 (Breen 1996)

17 See Historic Environment Record of Northern Ireland (HERoNI) | Department for Communities (communities-ni.gov.uk).

18 McNeary, R. and Westley, K. 2013. The Work of the Centre for Maritime Archaeology, University of Ulster: Past and Present. In: *Irish Maritime Heritage: Proceedings of the 3rd Galway International Heritage Conference 2013*: 11-24.

19 McErlean, T.R., McConley, R. and Forsythe, W. 2002. *Strangford Lough. An Archaeological survey of a maritime cultural landscape.* Belfast.

20 Forsythe, W. and McConkey, R. 2012. *Rathlin Island. An Archaeological survey of a maritime cultural landscape.* Belfast.

These surveys have been published and the results integrated into the NI Sites and Monuments Record (SMR)[21]. Further desktop surveys and fieldwork has been undertaken (principally the north coast) over the years. There are 938 Maritime Records recorded in the NI SMR as of July 2024.

The shipwreck record originated from an initiative entitled MAP (Maritime Archaeology Project) which was adopted by DOENI in 1993. MAP was initially based at the Institute of Irish Studies in Queen's University, Belfast. The project's primary brief was to create a computerised database and paper archive of all maritime sites in NI's coastal waters. Initial guidance was given by the Royal Commission on the Historical Monuments of England (RCHME) and the Joint Nautical Archaeology Policy Committee (JNAPC) data standard[22] adopted to record sites up to the 12 nautical mile limit, with a cut-off date of 1945, although more recent wrecks have been included. The sources of information used in compiling the register were largely documentary[23], supplemented by the Wilson archive[24], cartographic material, oral evidence and diver reports. In 1993 a Memorandum of Understanding between The Hydrographic Office and DOENI facilitated the transfer of information pertaining to known wrecks with good location evidence. The initial creation of this shipwreck record was completed in 1997. The shipwreck archive was subsequently maintained and updated as a stand-alone database by the CMA as part of the Maritime Archaeology Services contract (1999-2015). The database contains 2,748 entries as of July 2024. The earliest wreck in the database dates to 1588 but most entries are from the 19th and 20th centuries.

FIGURE 3_02
FPV Salar at Lacada Point, County Antrim, the site of designated shipwreck, La Girona, during a licensed dive inspection by the DAERA Marine Scientific Dive Team in September 2021.

21 See Sites and Monuments Record | Department for Communities (communities-ni.gov.uk).

22 Joint Nautical Archaeology Policy Committee (JNAPC), 1993. *Still at Sea, A Review of progress since the launch of the JNAPC's Heritage at Sea*. 8pp.

23 The most frequently used sources were the nineteenth-century House of Commons Sessional Papers, the Parliamentary Papers containing the Board of Trade wreck returns and Admiralty wreck returns listing shipping casualties; Lloyd's List Index to Casualties 1741-1783 and Lloyd's List (containing information after 1783).

24 A pre-existing catalogue of c. 1000 wrecks compiled by Ian Wilson for his book *Shipwrecks of the Ulster Coast* (1989) and acquired by DOENI in 1993.

The positional accuracy of these records is highly variable. In many cases the documentary sources provide limited information concerning the location of wrecks and only the broad general area is recorded. However, approximate positions have been assigned to all wrecks enabling the production of a general distribution map of wreck sites in Northern Ireland inshore waters. It was updated in 2009–10 primarily to improve positional information where possible. The database currently exists in three digital formats:

1. A Microsoft Word document with short descriptive records of each wrecking event;
2. As above but migrated to a Microsoft Access database; and,
3. ArcGIS shapefile with summary information.

In 2009-10 a 'known wrecks' database was compiled. This database contains records of known wreck remains on the seabed. It is based on information from multiple sources, but principally the UKHO shipwreck and obstruction database. Locations of wrecks have been checked against high resolution marine geophysical data (collected post-2008) where possible. Positional accuracy is variable but generally reasonable; the precise location of many of the entries is accurately recorded. The database contains fields reporting on the positional accuracy of each entry and the method used to obtain the position. The database initially contained 310 records, mainly 19th and 20th century wrecks, but now holds records of 382 shipwreck and downed aircraft locations. The database currently exists in one digital format: an ArcGIS shapefile with summary information.

As part of the drive in the 1990s to quantify the maritime archaeological resource, underwater geophysical prospection surveys (primarily side-scan sonar) funded (or part-funded) by DOENI were initiated. This initial geophysical research programme imaged c.80 19th-20th century wrecks and c.100 targets of further 'archaeological potential'[25]. These data were integrated into the Maritime Records as contact sheets. A digital database was not created. Since 2008, geophysical analysis has centred on multibeam echosounder data. To date most research has been conducted on a dataset generated by the Joint Irish Bathymetric Survey (JIBs) which covered the seabed off the north coast between Fanad Head (Co. Donegal) and Fair Head (Co. Antrim) out to three nautical miles[26]. These data have proved invaluable for updating positions of known wrecks and identifying anomalies. Similar work has been extended to the east coast where new multibeam datasets have become available such as Torr Head to Belfast Lough (collected by the Royal Navy and supplied courtesy of the UKHO and Agri-Food & Biosciences Institute (AFBI)) and the INIS-Hydro program (a partnership between the UKHO, AFBI and Marine Institute) which covers southeast Down and Carlingford Lough. These data have also been utilised in the investigation of submerged landscapes which has produced gazetteers of intertidal, submerged and buried sites in Northern Ireland with palaeolandscape evidence, as well as sites with archaeological evidence[27].

3.2.3 Scotland's National Record of the Marine Historic Environment

Peter McKeague, Historic Environment Scotland

Background

The Joint Nautical Archaeology Policy Committee's Code of Practice for Seabed Developers (1995), which aimed to encourage commercial operators to seek advice on the possible archaeological potential of proposed developments at the earliest opportunity, provided the catalyst for developing the maritime component of the National Record of the Historic Environment (NRHE). The UK Marine and Coastal Access Act 2009, Marine (Scotland) Act 2010 and reviews by Historic Scotland and BEFS (2009)[28]

---

25 Quinn, R. 2007. The Assimilation of Marine Geophysical Data into the Maritime Sites and Monuments Record, Northern Ireland. In: *Historical Archaeology*, 41(3): 9–24.

26 Westley, K., Quinn, R., Forsythe, W., Plets, R., Bell, T., Benetti, S., McGrath, F., and Robinson, R., 2011, Mapping submerged landscapes using multibeam bathymetric data: a case study from the north coast of Ireland. In: *International Journal of Nautical Archaeology,* 40(1): 99–112.

27 Westley, K., and Henry, S. 2015. *Archaeological Assessment of the Seabed in Northern Ireland: Submerged Archaeological Landscape Potential*. Unpublished Report, 44pp.

28 Historic Environment Scotland and Built Environment Forum Scotland 2009 *Towards a Strategy for the Marine Historic Environment*

and Wessex Archaeology (2011)[21] provided fresh impetus to develop the maritime record, through Project Adair[22] [23], to support Scottish Ministers' policies for encouraging sustainable economic growth in the coasts and seas around Scotland, in particular the introduction of marine planning. Emphasis on providing locational data for decision making was the priority.

Historic Environment Scotland forms part of the Marine Environmental Data and Information Network (MEDIN) Historic Environment Data Archive Centre, along with the Archaeology Data Service and the Royal Commission on the Ancient and Historical Monuments of Wales. MEDIN promotes best practice in managing and improving access to a broad range of marine datasets.

Content of the Record

The remit of the National Inventory is informed by, though not restricted to, the Scottish inshore waters (out to 12 nautical miles) and offshore waters (12 to 200 nautical miles). With approximately 18,743 km of coastline along the high-water line, 462,315 km^2 of sea and over 900 islands, Scotland has a rich and diverse marine heritage if not the concentrations of wreck sites seen elsewhere across the UK.
The record comprises 4,639 wreck and aircraft locations where the position has been identified, and 23,233 documented, or reported, losses where the location has not been confirmed. There are 1,386 obstructions (unidentified material, fisher fasteners etc) as recorded by the UKHO – some of which may relate to wreck sites, and five reported findspots.

Information about maritime losses is managed seamlessly alongside records relating to intertidal sites (including 496 fish traps, nine kelp grids, and four intertidal crannogs) and terrestrial buildings and sites (including 424 harbours and 145 lighthouses as well as many other maritime related monument types). To date there are no records for submerged landscapes or submerged peat deposits recorded in the national inventory.

The maritime record is searchable online through PastMap, Canmore and from early 2025 trove.scot. PastMap[29] is a map-based browser providing location-based searching across Designated Datasets (including Historic Marine Protected Areas (HMPAs), Scheduled Monuments and lost vessels protected under The Protection of Military Remains Act 1986), Canmore[30] records and many Historic Environment Records. Although the underlying data structure stores terrestrial, inter-tidal and maritime records in a single seamless database, for ease of use, terrestrial and maritime record are presented as separate layers. Users may either query individual records, linking through to more detailed information on related web pages, or undertake area-based searches across one or more datasets and download key information as either a.csv or.kml file under an Open Government Licence.

Canmore records may either be accessed through links in PastMap or through simple keyword or advanced, structured, searches or map searches on the Canmore website. Users may also search by thesaurus term or by archive collection. Canmore inventory records act as an online index to associated archival material with summary totals for the key archive types (Photographs, Prints and Drawings, Manuscripts and increasingly Digital Images and other digital files). From there the user may explore detailed indexes of catalogued material, view digital images and digitised video clips.
Under The INSPIRE (Scotland) Regulations 2009, Historic Environment Scotland also publishes View (Web Map Services) and Download (Web Feature Services) Services for its Designated Datasets and Canmore. Updated in real time, they can be accessed from the HES Download Portal, through spatialdata.gov.scot[31] and data.gov.uk[32], for marine related datasets, on the MEDIN portal. These services are published under an Open Government Licence with Ordnance Survey Presumption to Publish where relevant. The Historic Environment Scotland Download Portal[33] also provides user friendly access to these datasets.

Both Scottish Government's National Marine Planning Interactive[34] and SEWeb[35] consume these services within their own map portals where they can be viewed alongside datasets from other providers.

---

29 https://pastmap.org.uk/
30 https://canmore.org.uk/
31 https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/home
32 https://www.data.gov.uk/
33 https://portal.historicenvironment.scot/downloads
34 https://marinescotland.atkinsgeospatial.com/nmpi/
35 https://www.environment.gov.scot/

Users may also embed these services directly into their own GIS applications to use alongside their own project data.

Sources of Information

The maritime losses component of the NRHE was seeded by a download of the wrecks and obstructions dataset in 1995 and again in 201(2?), supplemented by information trawled from the Lloyd's Register Shipwreck Index and other sources by Larn and Larn (1998) and Ian G Whittaker (1998). In contrast to England and Wales, there is relatively little active research into maritime losses. Beyond ingesting these datasets, new data is added to the maritime record from projects commissioned or sponsored by Historic Environment Scotland from research and commercial archaeology projects, information reported via the Receiver of Wreck or from the offshore renewable industry.

Key Historic Environment Scotland projects include regular diving inspections of HMPAs and scheduled monuments, potentially nationally important wreck sites and thematic surveys. Large area remote sensing surveys help monitor the remains of the German High Seas Fleet and wider naval heritage of Scapa Flow over time. Key research projects include the work of Drs Colin and Paula Martin and Wessex Archaeology's Project Samphire which reached out to local maritime communities – from residents to recreational divers, fishermen, harbour masters and scallop divers – to record maritime cultural heritage sites along the length of west coast Scotland[36].

Summary accounts of fieldwork across Scotland are reported annually through Archaeology Scotland's *Discovery and Excavation in Scotland* journal. OASIS, an online system for reporting investigations into the historic environment and linking research outputs and archives, is the preferred mechanism for reporting fieldwork to the relevant local authority Historic Environment Record and Historic Environment Scotland. For marine records a workflow is in place to seed a metadata record in the MEDIN portal.
Research into the intertidal archaeology of Scotland's coasts has been well served by The SCAPE Trust established in 2001. Working with local communities, SCAPE has an active survey programme along Scotland's coast.

Data Structure

The structure of the maritime record was informed by that of the terrestrial record. Additional fields were added to manage coordinates in Latitude and Longitude alongside the OS National Grid System and a Maritime Craft thesaurus, modelled on FISH Maritime Craft Thesaurus, was introduced in the early 2000s. An additional table manages information about the vessel including nationality, port of registration, dimensions, method of propulsion as well as details of the last voyage including cargo.

Introduction of an Events module in the 2000s provided the opportunity to uniquely record and index separate activities within the database instead of adding information sequentially to a lengthy site description. Information from sources added as Events have been indexed as documentary sources. The Events module uses a local copy of the FISH Event Type Thesaurus for indexing recording events. This vocabulary is augmented by additional Event types to index activities relating to the documentary history of vessels.

One of the strengths of the NRHE is the relationship between the inventory and associated HES archives, including digital material (digital images and videos, spatial content and documents). For select records (The Duart Point Wreck / *The Swan*[37] and *HMS Dartmouth*[38]) users may also explore links through to the relevant catalogue entries for the physical objects in the National Museums Scotland. In a similar vein, Canmore can manage links across to specialist third party websites. For example, a user researching HMS Bullen can explore related information on UBoat.net[39] to make the records more understandable for the user.

---

36 https://www.wessexarch.co.uk/our-work/project-samphire
37 https://canmore.org.uk/site/80637/swan-duart-point-sound-of-mull
38 https://canmore.org.uk/site/102424/dartmouth-eilean-rubha-an-ridire-sound-of-mull
39 https://canmore.org.uk/site/255347; https://uboat.net/allies/merchants/ship/3385.html

3.2.4 The Maritime Component of the National Monuments Record of Wales

Julian Whitewright, Royal Commission on the Ancient and Historical Monuments of Wales

Background

The maritime component of the National Monuments Record of Wales (NMRW) began to be assembled in the 1990s alongside similar initiatives in England and Scotland. This work was undertaken by the Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW) as part of its Royal Warrant to create and maintain a National Monuments Record. These records were initially curated alongside terrestrial records by RCAHMW staff, but since 2007 have been part of the work of a dedicated 'maritime' member within the RCAHMW's survey and investigation team. In Wales, the remit of the RCAHMW extends to the limit of the Welsh sea area, as defined by the Welsh National Marine Plan (WNMP). This means that the maritime component of the NMRW extends beyond the 12-mile limit of territorial waters to the median line between Wales and its neighbouring countries; Ireland, England, Northern Ireland and the Isle of Man.

Content of the Record

The maritime component of the NMRW comprises all the archaeological sites and monuments located beyond or below the mean high-water mark, numbering c.8,300 records. This dataset is available for download from the Welsh Government's DataMapWales portal[40]. Notable groups of records include 50 prehistoric submerged forests, 218 fishtraps, and 360 crashed aircraft. Further records relate to harbour infrastructure, including 49 historic harbours, 162 charted anchorages and 186 individual quays/jetties/wharfs[41].

Records classed as WRECK are the largest single maritime site-type within the NMRW, numbering c.6,200. These can be broken down further based the form of evidence that we have for them. The biggest group are for c.4,700 'documented losses' of ships, where there is documentary evidence for the loss of a vessel but no archaeological remains. The locational accuracy of these varies enormously, from the very detailed to the extremely vague. More tangible are the 1,350 records termed a 'known wreck' where the main evidence is archaeological material on the seabed. A further 152 records relate to 'findspots' usually of isolated archaeological material such as an anchor, or in some cases a cannon.

The numbers just summarised for most of the different site types within the NMRW are relatively static; a previously unrecorded harbour infrastructure, or a newly identified fish trap might be added, but only in very small numbers. By contrast, the numbers of records for known wrecks within the NMRW has increased from 877 in 2021 to 1,350 in 2024. This is a combination of genuinely new wreck discoveries because of offshore and intertidal survey work (below), alongside revision and review of older records based on UKHO data but requiring an update due to new survey data.

Sources of Information

The shipwreck component of the NMRW has its origins in the UKHO wrecks and obstructions dataset for records of 'known wrecks'; information from the Receiver of Wreck for 'findspots'; and the Shipwreck Index of the British Isles compiled by Richard and Bridget Larn for 'documented loss' records. The latter have been further augmented in the past decade by a growing wealth of online resources, chiefly those provided by the Lloyds Register Heritage and Education Centre (LRHEC)[42]; Lloyds Register of Shipping, Casualty Returns, Survey reports and plans, etc.

---

40 https://datamap.gov.wales/

41 See Whitewright, J., 2024. The Historic Harbours of Wales. In Documenting Maritime Heritage at Risk. Digital Tools, Communities, and Institutions, E. Shotton & O. Prizeman (eds), pp. 42–52. Abingdon: Routledge. https://doi.org/10.4324/9781003385097

42 https://hec.lrfoundation.org.uk/

Other notable historical sources that are now consulted as standard include Welsh Newspapers[43] (freely available online for the period 1804–1919), and the journal of the RNLI[44] (available online from 1852 onwards), both of which can provide details on the location and circumstances of wrecking events.

Within the Welsh sea area, significant offshore wreck survey work has been undertaken by the School of Ocean Sciences at Bangor University, and the collection has been uploaded to the Unpath'd Waters Portal as part of this project[45]. Subsequent analysis has allowed many shipwreck identities to be revised and updated[46], with the results now incorporated into the NMRW (see also Voyages of Discovery 2, below). Work by the RCAHMW between 2022 and 2024 has allowed a major revision and expansion to the 'known wreck' component of the NMRW based on the latest wrecks and obstructions dataset published by the UKHO derived from their ongoing survey work. This element of the NMRW can now be updated on an annual basis as new survey data becomes available, and c.80% of the known wrecks within the NMRW are cross-referenced against a UKHO ID. It can be noted that a significant number, especially within the intertidal zone, exist as records within the NMRW, but are not listed by the UKHO. Further survey data, often including newly discovered wrecks, is ingested into the NMRW because of commercial marine development, for which the RCAHMW is a statutory consultee. Meanwhile, the c.150 known shipwrecks located within Wales' intertidal zone are subject to a targeted programme of survey work by the RCAHMW **(FIGURE 3_03)** to provide a 3D digital baseline of their remains and to create records of new discoveries[47][31].

FIGURE 3_03
A 29m-long wooden shipwreck (NPRN 240862) within the intertidal zone at Cefn Sidan Sands, Carmarthenshire, during a photogrammetry survey by the RCAHMW in October 2023.

Image 2024-03-18_2116, © Crown Copyright: RCAHMW.

43 https://newspapers.library.wales/
44 https://lifeboatmagazinearchive.rnli.org/
45 https://unpathd.ads.ac.uk/publisher/?publisher=iMarDIS%20-%20The%20Integrated%20Marine%20Data%20and%20Information%20System
46 McCartney, I., 2022. *Echoes from the Deep.* Leiden: Sidestone Press. https://www.sidestone.com/books/echoes-from-the-deep
47 https://skfb.ly/owCEK for RCAHMW intertidal and coastal survey work.

Data Structure

The NMRW uses the commonly adopted FISH Thesaurus[32] as its vocabulary to differentiate between site-types. More specific fields within each record are not currently available, but standard terms, for example from the FISH Maritime Craft thesaurus are used within the long-text description. All the fields, both maritime and terrestrial, within the NMRW are provided bilingually, in Welsh and English, and this requirement should be borne in mind when planning future work.

3.2.5 The Isle of Man Historic Environment Record

Jude Dicken, Collections Information Manager, Manx National Heritage

Background

Manx National Heritage, a Project Partner, has benefited directly from the work of Unpath'd Waters. The project catalysed the development of a new inventory of marine heritage for the Isle of Man and consequently Unpath'd Waters was able to include that national marine heritage data inventory within the Unpath'd Waters Portal (see **Chapter 8**). The partnership led to Manx National Heritage reaching out formally to independent shipwreck research specialist Adrian Corkill, devising a programme for him to work with them to create the inventory.

The territorial waters of the Isle of Man extend to 12 nautical miles or a point equidistant from neighbouring coastlines where the distance between jurisdictions is less than 24 miles. The total territorial sea area is about 4,000 square km, which is about 87% of the total area of the jurisdiction of the Isle of Man. The Isle of Man is therefore more sea than land.

Content of the Record

As of December 2024, a total of 1,967 underwater site and 1,089 vessel resources were discoverable on the public website[48]. Manx National Heritage has also drawn from its museum, library and archive collections to provide a rich context to the wreck site resources, including digitised artefacts, historic photographs, burial records, and crew lists. The inventory and public website attracted other content providers (such as the Isle of Man Sub Aqua Club) to upload recent images and 3D models for inclusion on more than several of the underwater site resources. In 2023, this data was shared and uploaded to the public portals of the Archaeology Data Service and ARIADNE[49], and work continues to upload further detail and more resources.

Data Structure

The inventory and public website (isleofmanher.im) are built using Arches, the CIIM, and MimsyXG. The resource models used (underwater site, vessel, archive and bibliography) consist of 'cards' of information which contain 'nodes' analogous to the units of information in MIDAS Heritage (UK Historic Environment Data Standard). The CIIM (Collections Information Integration Middleware) transforms the collections data and images managed in MimsyXG (the Manx National Heritage collections management system) and serves this as updateable content (daily) to the Arches endpoint, specifically 'Linked Resources' visible on the map pin to the underwater site.

48 https://isleofmanher.im/
49 https://unpathd.ads.ac.uk/ and https://portal.ariadne-infrastructure.eu/search?q=&publisher=Manx%20National%20Heritage

3.3 Maritime Museum Collections

Museums hold further maritime and marine collections. The National Maritime Museum (an Unpath'd Waters consortium member) was used as a case study. It contains over two million objects related to seafaring, navigation, astronomy and measuring time, divided into five subject areas: exploration, time and space; maritime commerce and conflict; the sea as resource; sea, ships, time and stars as inspiration; and maritime Greenwich. Objects fall into categories such as navigational instruments, historical charts and maps (eg **FIGURE 3_04**), fine art, decorative art, historic photographs, ship plans and models, textiles, ship equipment, weapons and more. In addition, using the search term 'England', the NMM holds well over 10,000 books in its library and 1,960 archived manuscripts and primary document sources. In addition to the NMM, other national museums dedicated to marine and maritime history are the Maritime Museum in Liverpool, the National Museum of the Royal Navy, and the Scottish Maritime Museum.

FIGURE 3_04
French chart of English Channel Ports, 1780
"Tableau hidrographique qui contient le detail maritime des principaux ports qui se trouvent representes dans la carte de la Manche".

Courtesy National Maritime Museum, Greenwich, London, Caird Collection.

In addition to the nationals, there are also numerous regional and local maritime museums such as the Portsmouth Historic Dockyard, the National Maritime Museum Cornwall, The Gosport Diving Museum, the Shipwreck Centre and Maritime Museum on the Isle of Wight, Lancaster Maritime Museum, Hull Maritime Museum, the Scapa Flow Museum, The Porthcawl Maritime Museum, and many more, each with significant collections. A particular form of maritime museum focuses on (and is sometimes physically located aboard) a single vessel, with examples such as Newport Medieval Ship Museum, SS Great Britain, HMS Unicorn and (Unpath'd Waters consortium member) the Mary Rose Museum[50]. The collections associated with these very specific museums relate to their commissioning, construction, voyages, crew, cargoes, engagement with historical events, and final loss or decommissioning. The scientific conservation and study of these items and artefacts creates further significant collections.

There is no complete list of museums which focus on or have major collections related to marine and maritime heritage and culture. However, the launch of the Museums Data Service[51] on 13 September 2024 will improve access to the collections of these specialist museums as they join. Already, a collections level search on 'Maritime' provides results for 49 museums which have significant maritime collections.

3.4 Maritime Archives

The extent of the unrealised maritime archaeological research resource extends across a range of archives represented by examples which vary from publicly held national documentary collections through to privately held seabed investigation collections.

The National Archive and the British Library provide access to a huge collection of documents related to maritime and marine history and heritage, but there are also key archives which hold collections of a specifically maritime character. For example, the UK Hydrographic Office Archive (an Unpath'd Waters Partner) was established in 1795 and holds over 400 years of maritime history[52]. It is one of the most comprehensive maritime collections of its type worldwide. It is a Place of Deposit under the Public Records Act 1958.

Commercial interests generate nationally important collections too, exemplified by those belonging to Lloyd's Register. The Lloyd's Register Foundation, Heritage & Education Centre[53] (HEC, another Unpath'd Waters Partner) collections are centred on maritime technology and safety, and include Lloyd's Register of Shipping, also known as Register Books, providing information about ships from 1764 onwards. HEC hosts an extensive collection of ship plans and survey reports (c.1.1 million documents), currently digitised and freely available online. With the endorsement of Unpath'd Waters it was possible to coordinate the digitisation of the Missing Vessels Books, a resource physically housed at London's Guildhall Library, part of Lloyd's (insurance) Maritime Collection. As a result, a total of 16 volumes covering the years 1873-1954 are now available through the HEC website. These volumes can support researchers in identifying wrecks not covered by vessel loss lists.

The advent of SCUBA diving in the 1960s opened up the underwater world, including the vast resource of cultural heritage lying on the seabed. The archaeological investigations that have been undertaken in subsequent decades by a range of organisations, groups and individuals have resulted in archives that have received highly varied treatment. The fate of the objects, paper records, photographs and digital files forming archaeological archives has been uncertain: only a small number reside in public repositories, while others are in private exhibitions and personal collections.

There are significant holdings across the sectors involved in maritime archaeology and generating archive including archaeological contractors, universities, independent research organisations, designated wreck site licensees and archaeologists and other individuals. A lack of frameworks for monitoring production and museums and archives for deposition mean there is still a 'back-log' within the sector.

---

50 https://maryrose.org/
51 https://museumdata.uk/
52 https://archive.ukho.gov.uk/
53 https://hec.lrfoundation.org.uk/archive-library

Independent and volunteer interests also create important archives. For example, consortium members hold important research collections: the Nautical Archaeology Society[54] who maintain the 'In Search of Missing Vessels' collection which was used in Unpath'd Waters, and the Maritime Archaeological Trust[55] who developed from their collections the Needles Voyager as part of Unpath'd Waters, while other independent organisations[56] provide useful links to yet more collections. Avocational divers and maritime historians themselves hold important collections, and Unpath'd Waters has benefited from a number of these 'citizen science' collections, including the work of Adrian Corkhill on wrecks around the Isle of Man, now the basis of their marine heritage record; and the exemplary collection of research reports created by the Malvern Archaeological Diving Unit (MADU) during the COVID lockdowns[57], and now available through the Archaeology Data Service.

54 https://www.nauticalarchaeologysociety.org/
55 https://maritimearchaeologytrust.org/
56 For example https://www.maritimearchives.co.uk/
57 http://www.madu.org.uk/

4. The Vessel – Structure of the Project

The Unpath'd Waters project was conceived as a three-phase project, each phase corresponding broadly to one year of its duration. The Incubator Lab involved the discovery, aggregation and characterisation of the collections we would use; the development of search and access tools; and the establishment of the research basis for the three major marine themes **(see Chapters 10–12)**. The Innovation Lab involved the application of the research tools in real-world scenarios to see how well they worked and what challenges they raised in terms of research; and the employment of these outputs to explore and evaluate genuine innovation in co-design and co-creation capability. Delivery, the final phase, saw development of the formal documentation and final reporting outputs and project evaluation.

Given the scale of the project and the scope of its ambition, we divided the work into Work Packages (WPs). These were designed to run concurrently and reflexively, informing and being informed by each other. This ensured that the whole project consortium was effectively active for the whole project, rather than being sequenced in 'blind' to previous activity.

WP1 and 2 addressed the more technical challenges of connection, access and searching, WP3.1 – 3.3 represented 'test lenses' to work through real-world research demonstrators, and WP4 and 5 were focused on visualisation, audience engagement and evaluation. WP6 was the underpinning programme management work.

WP1 (lead: Archaeology Data Service) addressed the issues of aggregation and characterisation. Its objectives were to assess, enhance and aggregate a range of digital components of the UK's marine heritage collections; review the demands and capabilities of existing digital infrastructures; and enhance these to deliver the UK marine heritage collections to researchers and the public via human and machine-readable interfaces. It also developed appropriate data standards and cataloguing practices to help achieve interoperability and deliver sustainable access routes and a primary data archive for the Unpath'd Waters' own data outputs.

WP2 (lead: University of Southampton) harnessed recent developments in artificial Intelligence and machine learning and built on work done in the *Towards a National Collection* Heritage Connector Foundation Project[58], to enrich sparse data, increase interoperability and enable a diversity of search options. WP2 deployed a low-shot/zero-shot approach to machine learning, leveraging the assets created in WP1 via named entity recognition. In addition, computer vision (object detection) and increased spatial/temporal awareness/visualisation was explored within the cases studies detailed in WP3. This enabled distinct modes of discovery and recovery (text, image, 3D shape, sound, spatial, temporal).

WP3 formed the three research lenses which focused on real-world research application. It was split into three sub-packages:

WP3.1 'People and the Sea' (lead: University of Portsmouth) used a sample of submerged Protected Wrecks (and nearby unprotected wrecks) in the English Channel (The Needles wrecks, *Mary Rose* and *Holland 5* sites) and displayed wrecks (*Mary Rose* and *Holland 1*), testing new stakeholder processes for elevating the significance of underwater wrecks in relation to displayed wrecks. The work tested the capacity of connected collections, including wreck site surveys, recovered artefacts, documentary records and scientific samples, to engage audiences in co-creating new narratives and innovative ways of engaging with the wrecks. Analysis of public feedback was undertaken to establish which approaches appeared to work best.

WP3.2 'Science and the Sea' (lead: Bangor University) tested connectivity between disparate marine scientific collections to identify wrecks and model a much better understanding of their preservation potential. It linked a collection of high-resolution multibeam sonar surveys from incorrectly identified or unidentified wreck sites in the Irish Sea to other collections (shipping and naval archives, vessel plans, insurance records, personal correspondence and photographs etc), to demonstrate how connected collections could help to provide or correct their identities as well as unlocking their maritime stories.

58 https://www.nationalcollection.org.uk/sites/default/files/2022-03/Heritage%20Connector%20Final%20Report_compressed.pdf

WP3.2 also tested integration of site-related geophysical and hydrodynamical/sediment transport datasets and marine ecological data to enable site-specific assessments on localised site conditions, integrity and sustainability of the national collection of shipwrecks.

WP3.3 'Lands beneath the Sea' (lead: University of Bradford) pioneered a method of accessing complex digital scientific collections relating to the underlying processes that created the archives representing the inundated prehistoric North Sea landscape. These processes linked users, data and unifying concepts between different datasets, including evidence for climate change and rising sea levels. This was a trial of a process-led access model, previously largely untried. The work involved the creation of a bespoke computer simulation based on a range of collections and datasets to allow users to experience the dramatically changing world and provide a more comprehensible and interactive method of engaging with it.

WP4 (lead: Glasgow School of Art) was focused on 'Designing, Connecting, and Immersing'. It covered the technical and human challenges of co-design of novel interfaces with integrated maritime datasets using immersive systems, with and for three user-group case studies (non-coastal (inland) communities who do not identify with the sea; visually impaired publics; and cross-disciplinary natural science and cultural researchers).

WP5 (lead: Museum of London Archaeology/National Maritime Museum), linked closely to WP4, covered our work on engaging and evaluating audiences. It explored mechanisms for ensuring that our Unpath'd Waters sample audiences were truly representational and empowered, both through the process of co-design (WP4) and in terms of user experience. It also sought to develop mechanisms so that their inputs could be formally evaluated. As part of this, WP5 explored shared values for the project (and to guide audience-focused work) in line with the Digital Culture Charter, and developed metrics to assess project accountability to the values; conducted audience mapping, to specifically identify and articulate a programme to ensure representation of our three key target user-groups (see WP4); facilitated testing and evaluating of the pilot designs that emerged and coordinated and evaluated an exhibition programme of the project outputs, including enrolment of other museums partners and industrial and third sector collaborating organisations into the programme to connect with their existing initiatives.

WP6 (lead: Historic England) formed the programme, financial and communication management component of the project.

5. Crew Manifest – Structure of the Consortium

The Unpath'd Waters consortium was a large and complex structure. We deliberately designed it in this way because as a team we are convinced that the future of a national collection will rely not on a small number of powerful bodies setting the agenda and progressing action, but instead on 'swarms' of different kinds of organisations combining and recombining into partnerships to achieve what will be needed. Therefore, we reasoned, there was a need to explore how a consortium of different research bodies could interact. This section summarises the organisations which joined the Unpath'd Waters voyage and the strengths they brought to bear.

5.1 Participating Organisations

The project brought together three kinds of participant organisations: 12 Investigator Organisations (those normally eligible for funding from UK Research and Innovation); five Collaborating Organisations (highly research active organisations not, at the time of the project, eligible to apply directly to UKRI, but allowed to be funded as part of *Towards a National Collection*); and eight Partner Organisations (not funded but recipients of benefits from the project outcomes and donors of in-kind support such as data or advice). This categorisation simplifies a deeper complexity in the nature of the various organisations involved, and the strengths they brought to the project.

5.1.1 Independent Research Organisations

The conditions of the project required that Independent Research Organisations (IROs) played a lead role in delivery of the *Towards a National Collection* Discovery Projects. IROs are a varied group of organisations, ranging from major museums, through research-active non-governmental public bodies to charitable trusts. For Unpath'd Waters we brought together five such IROs: Historic England (HE), with its responsibility for marine heritage data, and remit for advising government on the protection and management of heritage in English waters; Historic Environment Scotland (HES), with a similar remit in Scotland; the National Maritime Museum (NMM) with its extensive internationally important maritime collections and deep expertise in collections management and exhibition; Museum of London Archaeology (MOLA) with their involvement in audience-centred research and investigations of the intertidal zone; and the Marine Environmental Data and Information Network (MEDIN), with its remit to improve access to and management of UK marine data. The research that IROs undertake is essentially entirely applied toward specific issues relating to the mission of each organisation. This created an added anticipated benefit that the research work undertaken as part of Unpath'd Waters had a direct input to activities of these organisations.

5.1.2 Universities

Unpath'd Waters combined the capabilities and expertise of eight universities. Addressing the digital humanities aspects of the project were: the Archaeology Data Service at the University of York, with substantial expertise on ingesting, preserving and providing access to digital heritage collections, archives and datasets; the University of Southampton whose Departments of Archaeology and Computer Science provided the core of our machine learning and AI capability and our link to marine data aggregator MEDIN; the University of Bradford whose Department of Archaeological Sciences provided the simulation expertise for our North Sea work; and the Glasgow School of Art's School of Simulation and Visualisation which led on the immersive virtual reality co-design. Bangor University's Department of Ocean Sciences and the University of Ulster' Department of Geography and Environmental Sciences provided our capability in linking heritage collections with wider scientific datasets and techniques. The University of Portsmouth's Heritage Hub Centre of Excellence provided significant expertise in historical maritime archival research and public engagement, while the University of St Andrews School of History supported video documentation and content preparation.

5.1.3 Collaborating Organisations

In a welcome move, the Arts and Humanities Research Council promoted the inclusion of Collaborating Organisations in the *Towards a National Collection* Discovery programme. This allowed Unpath'd Waters to draw on a range of unique and vital research and engagement skillsets held by smaller organisations working in the maritime heritage sphere. We welcomed on board five such organisations, all quite different in style and character. These were: the Mary Rose Trust and its remarkable museum and collection relating to Henry VIII's flagship which was lost in the Solent and raised before an international audience of millions in 1982; the Royal Commission on the Ancient and Historical Monuments of Wales who maintain Coflein, the Welsh national record of monuments (including marine heritage); the Maritime Archaeology Trust, a charitable trust founded to promote and protect maritime archaeology in the UK and beyond, and which runs the Shipwreck Centre and Maritime Museum on the Isle of Wight; the Nautical Archaeology Society, a membership charity which aims to support education, research and publication in marine archaeology in the UK, and which publishes the important International Journal of Nautical Archaeology; and Wessex Archaeology, one of the UK's largest archaeological contractors with a long pedigree in working on marine archaeology.

5.1.4 Partners

Key principles of the TaNC Discovery projects were that they should be UK-wide, and that they should be able to demonstrate their benefit to relevant organisations outside the specific consortium membership. To this end Unpath'd Waters sought and gained the support and interest of eight key project Partners. Providing governmental support was Cadw, the Welsh historic environment service and the Historic Environment Division of the Northern Ireland Department for Communities. Representing marine planning and management interests was the Marine Management Organisation, while the British Geological Survey and UK Hydrographic Office Archive represented large collections and datasets. The Lloyd's Register and Lloyd's Register Foundation both provided crucial access to archives and records built up over centuries of support for commercial shipping. Finally, the Protected Wrecks Association represented the volunteer and avocational diving community entrusted with helping to look after England's Protected Wrecks.

5.1.5 The Advisory Board

The Advisory Board included the following individuals:

- Karl Brady (Underwater Archaeologist, National Monuments Service, Ireland)
- Maria Economou (Professor of Digital Cultural Heritage, University of Glasgow)
- Connie Kelleher (State Archaeologist with the Underwater Archaeology Unit (UAU), National Monuments Service (NMS), Department of Housing, Local Government and Heritage, Ireland)
- Martijn Manders (Head of Maritime Programme, Cultural Heritage Agency, Netherlands)
- Ian Murphy (Head of Maritime Museum, National Museums Liverpool)
- Ian Oxley (Freelance Maritime Archaeologist, formerly Head of Marine Archaeology, English Heritage)
- Kate Roberts (Acting Head, Historic Environment Branch, Cadw)
- Miranda Willis (Senior Evidence Specialist, Marine Management Organisation)
- and, observing, Rebecca Bailey (TaNC Programme Director, AHRC)

5.2 Consortium Organisation and Governance

Governance of the consortium was necessarily multi-layered. A shared contractual agreement was signed by all of the organisations in receipt of AHRC funding. This made provisions for regular payments in relation to delivery, handling of disputes (of which there were none) and agreements over intellectual property and data sharing. A programme manager was recruited to work 50% of their time across the three years of the project (see **Chapter 7)**. A management team was established which comprised the Principal Investigator, the lead investigator of each of the Work Packages, the programme manager, the communications lead and the project administrator. This supported the consortium as a whole and acted as the conduit for management information for the individual Work Packages. The consortium was invited to convene quarterly, while the management group met monthly.

The different organisations were allocated to one or more Work Packages. This allowed the Work Package leads to establish tasks and identify participants for their completion. This allocation was not a precise science since at the outset, we were unsure of how each of the Work Packages would develop and what would be needed. But it provided a basis for resource management which was deemed by the management group to be of considerable value.

Members of the management group also attended individual project meetings and joint Discovery Project meetings with the TaNC programme directorate, to provide assurance on progress and address matters which cut across all five Discovery Projects.

Altogether, the Unpath'd Waters project involved over 80 individuals not including those recruited for co-design and audience engagement.

5.3 Research Culture in Large Consortia

A feature of the Unpath'd Waters consortium which had not been fully anticipated was that it brought together different research cultures. IROs tend towards directly applied and strategic research objectives which match the focus of their core missions. These are often articulated within Strategic Plans or Research Agendas. Universities are encouraged to consider research excellence more than strategic fit and by and large do not have overarching research frameworks. Commercial organisations provide research activities in fulfilment of contracts, while museums and charitable trusts tend to place their public interaction at the heart of any research activities. These differences drive significant cultural diversity which needs to be taken carefully into account in the establishment of a consortium of this kind. Challenges associated with this diversity manifested within Unpath'd Waters primarily through: assumptions made (sometimes by the Principal Investigator) about capability to, and comfort levels with, change to ingrained methods and approaches; readiness or confidence of organisational representatives to constructively challenge proposed approaches to, or resourcing for, a research area; and the varying approaches to programme and project management within work packages.

Tools for identifying and mitigating any potential major issues within Unpath'd Waters were rapidly established once the issue had been identified. Open and honest communication across the consortium was essential and did much to reduce or eliminate risk. Careful, diplomatic, and responsive programme management was also an essential. But the foremost mechanism for creating a shared landscape of behaviour and action was the development of our Project Values, the subject of the next Chapter.

6. The Compass – The Project Values

Katrina Foxton (MOLA), Sara Perry (UCL), Caroline Barrie-Smith (MOLA), Andy Sherman (MOLA), Andrew Choong Han Lin (National Maritime Museum) and Jon Combey (NMM).

At an early stage in the project, we agreed to experiment with a values framework which would hold us accountable to certain ethical positions within our research and practice. At the design stage of Unpath'd Waters, it was clear that the maritime subject matter itself, the format of maritime heritage data collections, and the sheer number of collaborating partners participating within the project presented serious ethical and practical challenges. A values-led approach informed by design theory was identified as a vital support system for navigating this complex work. Drawing from research by Shilton (2013, 2018), Gray et al. (2022) and Fish and Stark (2020) and informed by a social justice-led approach to heritage, we aimed to build a 'living values framework' to guide Unpath'd Waters across its three years of operation, and to reflect critically and transparently on its effectiveness throughout (Perry 2022).

6.1 Uniqueness of the Unpath'd Waters Approach

Our approach draws from recent research into 'values-led design' which posits that the creation of any digital outputs should be informed by human and non-human centred practices and ethically oriented principles (Dolcetti et al. 2021, Pillai et al. 2022, Richardson et al. 2022). Following Gray et al's (2022) missive, alongside applying a values-led approach, we also aimed to create a reflective account of our successes and fallbacks – a "meta-design" for values-led practice – to support others in navigating similar efforts in the future. Ultimately, we have produced a framework of 'Living Values' which could be applied not only by Unpath'd Waters, but by other practitioners in other areas. By 'living' we mean that values lead to actions and can evolve through a dynamic process of reviewing and reworking them through various interventions. However, as will be discussed below, the framework we created was not sufficiently nimble to 'live' and evolve and hence has functioned mainly to highlight for us many important barriers to values-led work.

Whilst our approach is unique, the context in which we are experimenting is also atypical. Unpath'd Waters is a very specific and temporally bounded context for practice, connected to the ambitions of the TaNC programme. We brought together over 80 active personnel working towards different aims for the project, employed within different organisational contexts and bringing with them many forms of expertise. These individuals had different conceptions (or no conceptions) of what values consist of and how they can be used. In short, Unpath'd Waters was a non-cohesive research entity, which posed a challenge when striving towards a shared values framework (see **Section 5.3** above).

The project also sought to address multiple wider publics who were not necessarily represented within the existing consortium. Appreciating that if you design something it won't be for everyone, our key audiences (around whom we designed our outputs) were identified at project conception as non-coastal communities, visually impaired communities and cross disciplinary researchers. We attempted to work with these groups whilst adhering to our Living Values Framework, with varying degrees of success.

The digital collections we sought to integrate, and share are managed according to varied archival frameworks and repositories, some of which are very difficult to render accessible. Where they can be accessed practically, in some cases, the content of the maritime heritage data or the presentation of them conflicted with the values we sought to uphold, as discussed below.

6.2 Values-Setting Method

Our work on Unpath'd Waters values began with research into how values have been iterated elsewhere as part of innovation and design activities in cross-disciplinary settings (Gispen 2017; Dolcetti et al. 2021; Transfeminist Technologies (nd); for a description of the process see Perry 2022). This research was conducted to inform an interactive workshop to support 'surfacing values' (Richardson et al. 2022) within Unpath'd Waters management team (comprising up to 13 people) and, subsequently, the wider consortium. Recognising the importance of buy-in from leadership to drive successful application of values, we began the values-setting process with the management team **(FIGURE 6_01)**.

The workshop was separated into five sections:

- Surfacing values that individuals brought to the event based on completion of pre-workshop tasks.
- 'Pitching' emergent value statements from which an initial 'Living Values List' was created.
- Reflecting on the values in relation to specific challenges or 'worst case scenarios' (e.g. could the value stand up to negative headlines or comments on social media?).
- Reporting back on challenges and 'worst case scenarios' (how could Unpath'd Waters mitigate against such challenges?).
- A final review of the values where we aimed to collectively decide on a draft 'Living Values List' for circulation to the wider consortium.

Following the workshop, further edits to the draft values were made via email with the project management team. This led to agreement on six Living Values:

- **Equitable** | We advocate for equity – between people, stories, sites, collections (local, regional, national).
- **Connecting with people on their own terms** | We prioritise connecting with people on their own terms, always communicating with clarity and foregrounding our audiences' needs.
- **Empowering through collaboration** | We aspire to empower through collaboration – actively enabling individuals to link to wider communities and global narratives and vice versa.
- **Reliable and sustainable** | We strive for reliability underpinned by sustainability, following FAIR principles and honouring relevant measures of the CITiZAN (2022) climate pledge in our activities.
- **Constructive** | We champion constructiveness – as we debate, create, explore, invent and test, we take all points of view on board constructively and sensitively.
- **Adventurous** | We embrace the adventure – we are driven by curiosity, optimism and challenging the status quo with open minds and a concern for creativity. We value failure as much as success.

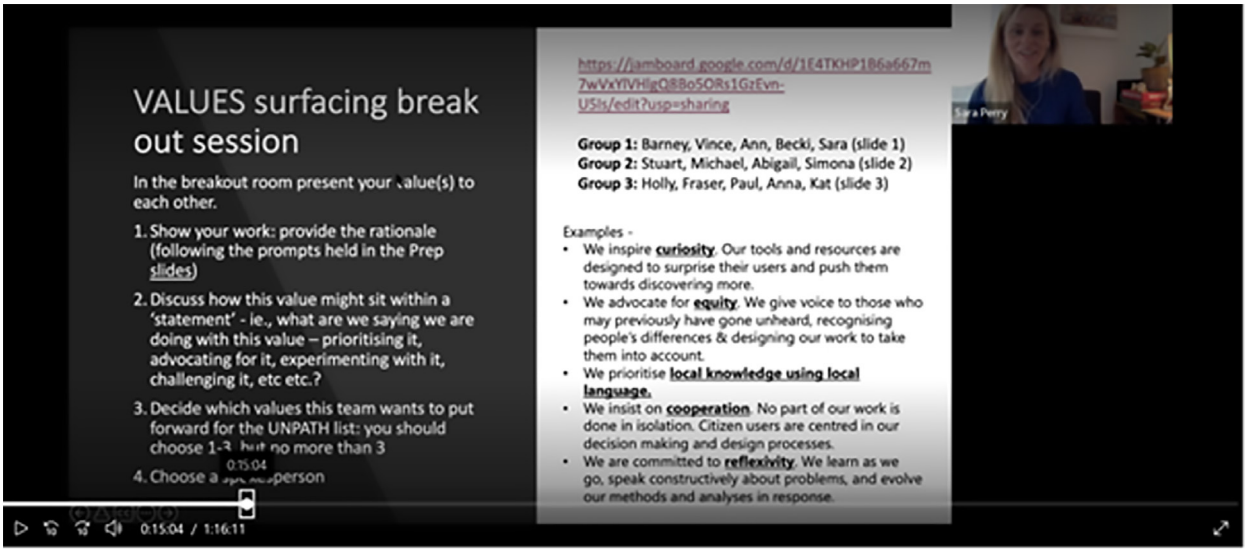


FIGURE 6_01
Screen shot from values surfacing activity, part of a workshop to set values for the project with Unpath'd Waters work package leads.

Unpath'd Waters consortium members were asked to review and comment upon them and consider how we could hold ourselves accountable to them via specific measures. The replies were adapted into a values accountability 'matrix'. **(FIGURE 6_02)**.

6.2.1 Reflections on Initial Value-setting Exercise

Overall, the initial values and accountabilities process was relatively seamless. However, it is worth noting that we received a low level of input into the process overall: contributions were received from only 30% of the consortium. The reasons for this were capacity envisioned for the reporting requirements, and lack of certainty over exactly what activities would be undertaken as part of their work on Unpath'd Waters (particularly with target audiences). This meant that establishing accountabilities and means to monitor them effectively was very difficult – the project itself was still being shaped and we were asking for decisions to be made without a sense of the full picture of audiences and data requirements.

6.2.2 Attempts to Define and Align Value Measures with Everyday Unpath'd Waters Practices

The Unpath'd Waters management team then considered how to establish measures to accompany each value. These conversations eventually led to 14 measures underpinning what we began to refer to as a Living Values Framework **(TABLE 6_01)**. The Framework was presented to the consortium, the importance of the values flagged repeatedly, and they were published and promoted on the project website to further amplify their presence.

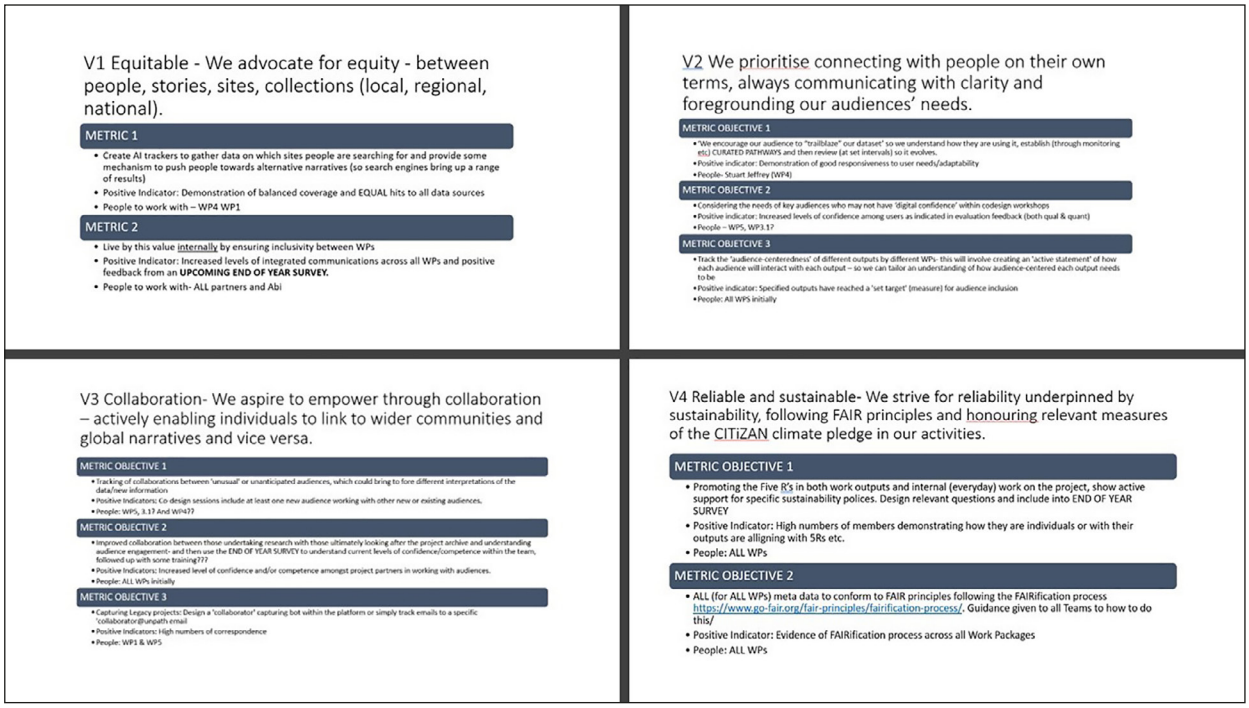


FIGURE 6_02
Extract of early attempts to create value measures, presented to Unpath'd Waters Work Package Leads during the project's Incubator phase.

Value	Value Measure
Equity	1.1 Create tags that track people's accessing of particular sites, locations, words, etc., as well as how they are navigating through the platform, and then provide some mechanism to encourage people towards alternative narratives
	1.2 Live by this value internally by ensuring inclusivity between WPs.
Connection	2.1 Encourage our audience to 'trail-blaze' our dataset so we understand how they are using it, establish (through monitoring) curated pathways and then review and revise
	2.2 Foregrounding the needs of key audiences who may not have 'digital confidence' within codesign workshops
	2.3 Track the 'audience-centredness' of different outputs by different WPs
Collaboration	3.1 Targeted tracking of collaborations between 'unusual' or unanticipated audiences in an effort to bring to the fore different interpretations of the data
	3.2 Wider capture of legacy projects: track new projects/ideas that arise from Unpath'd Waters – use at the end of phase review to ask people to identify where new opportunities have emerged
	3.3 Share collaborative skillsets within the consortium, particularly in relation to collaboration with new public audiences
Reliability and Sustainability	4.1 Adhere to a select number of the CITiZAN climate pledge activities, as agreed by management team
	4.2 Ensure all metadata conform to FAIR principles following the FAIRification process (https://www.go-fair.org/fair-principles/fairification-process/)
Constructiveness	5.1 Track criticisms and declare when any change or no change has been made based on these criticisms and why. Design and share a simple template and guidance on how to respond to criticisms via the Commsteam
	5.2 Respondence rate: type will depend on context so possibly a review of this once feedback starts coming in? But emails at very least could have auto response
Adventure	6.1 Participants experience wonder, curiosity and new perspective taking; their unique input is actively integrated into Unpath'd Waters outputs
	6.2 Openness about failure – will give guidance through Comms but also WP5 will begin to produce some examples to inspire others to reflect on their candid 'adventures' in this project

TABLE 6_01
The Value Measures supporting the Unpath'd Waters Values.

Consortium members were generally supportive of the values themselves and our overarching framework, although some sought guidance and leadership from the values researchers about how they could feed the values into their work. One-to-one or one-to-many support was offered where possible, but given the scale of the consortium, proactive strategic support was not feasible.

An overview perspective was required to enable us to understand which measures might be more relevant to the different work packages. A pre-emptive 'values heat map' was created (cf Dixon et al. 2023) **(FIGURE 6_03)**, visualising where work package teams may be fully or partially contributing – providing data – to the value measures and where they may not. A 'fully' contributing team was both gathering and reviewing data about their values practices; a 'partially' contributing team would pass gathered data to the values team, or to another team that was fully contributing, for analysis. A 'not yet contributing' reference meant that the team was not yet able to identify how to provide data.

Unfortunately, the heat map was ultimately not effective in its current form. Its appearance and 'performance management' style approach perhaps led to a perception that the values framework imposed a burdensome bureaucracy and heightened a sense of being 'judged' by colleagues. It might work where a recognised leader took ownership of the heat map but enabled and encouraged others across teams to contribute to it, successful use of this tool being deemed to be dependent upon the 'positionality' (Rees 2024) and dynamics of teams.

Whilst the values heat map was an experiment (which may be adopted by future projects), we shifted towards other means to monitor the values and delegate associated data collection across the consortium: this involved designing a methodological and analytical approach.

Value Measure	WP 1	WP2	WP3.1	WP3.2	WP3.3	WP4	WP5	WP6
1.1 Create tags that track people's accessing of particular sites, locations, words, etc., as well as how they are navigating through the platform, and then providing some mechanism to encourage people towards alternative narratives.	Fully Contribute	Fully Contribute	Partially Contribute	Not Yet Contributing	Not Yet Contributing	Fully Contribute	Partially Contribute	Does not Contribute
1.2 Live by this value internally by ensuring inclusivity between WPs.	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Fully Contribute
2.1 We encourage our audience to "trailblaze" our dataset' so we understand how they are using it, establish (through monitoring) CURATED PATHWAYS and then review and revise.	Fully Contribute	Fully Contribute	Partially Contribute	Not Yet Contributing	Not Yet Contributing	Fully Contribute	Fully Contribute	Does not Contribute
2.2 Foregrounding the needs of key audiences who may not have 'digital confidence' within codesign workshops	Fully Contribute	Fully Contribute	Fully Contribute	Not Yet Contributing	Not Yet Contributing	Fully Contribute	Fully Contribute	Does not Contribute
2.3 Track the 'audience-centeredness' of different outputs by different WPs	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Fully Contribute
3.1 Targeted tracking of collaborations between 'unusual' or unanticipated audiences, in an effort to bring to the fore different interpretations of the data.	Partially Contribute	Partially Contribute	Partially Contribute	Not Yet Contributing	Not Yet Contributing	Partially Contribute	Fully Contribute	Fully Contribute
3.2 Wider capturing of legacy projects: track new projects/ideas that arise from UNPATH – use the end of phase review to ask people to identify where new opportunities have emerged	Partially Contribute	Partially Contribute	Partially Contribute	Not Yet Contributing	Not Yet Contributing	Partially Contribute	Fully Contribute	Fully Contribute
3.3 Sharing collaborative skillsets within the consortium, particularly in relation to collaboration with new public audiences;	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Fully Contribute
4.1 Adherence to a select number of the CITiZAN climate pledge activities, as agreed by management team.	Fully Contribute	Fully Contribute	Fully Contribute	Fully Contribute	Fully Contribute	Fully Contribute	Fully Contribute	Fully Contribute
4.2 ALL Meta data to conform to FAIR principles following the FAIRification process https://www.go-fair.org/fair-principles/fairification-process/.	Fully Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute
5.1 Track criticisms and declare when any changes or no change has been made based on these criticisms and why. WP5 to design and share a simple template and guidance on how to respond to criticisms via the Comms team (Katherine Newton)	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Partially Contribute
5.2 Response rate: type will depend on context so possibly a review of this once feedback starts coming in? But emails at very least could have auto response	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Partially Contribute
6.1 Participants experience wonder, curiosity and new perspective taking; their unique input is actively integrated into UNPATH outputs.	Fully Contribute	Fully Contribute	Fully Contribute	Not Yet Contributing	Not Yet Contributing	Fully Contribute	Fully Contribute	Does not Contribute
6.2 Openness about failure – will give guidance through Comms but also WP5 will begin to produce some examples to inspire others to reflect on their candid 'adventures' in this project.	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Partially Contribute	Fully Contribute	Partially Contribute

FIGURE 6_03
Values heat map: measures are listed on the left and Work Packages across the top row.

6.3 Values Evaluation Data Collection Methodology

Considering the challenges outlined above, a methodological framework was developed to gather data from different contexts. We strove to ensure that any data gathering would fit into pre-existing tasks, meetings, and delivery timetables to avoid additional work for the consortium. The methods by which to monitor adherence to the values required iterative learning, as a form of "governance-in-making" (Finn & Shilton 2023): but, as we discovered, such governance was a slippery fish. We identified nine methods for 'catching' this fish in different contexts – pertaining to the collection of data related to the 14 values measures. Below we list them and how they were applied.

- **Audience Evaluation – WP 3.1** (abbreviated as **Aud-A**): evaluation methods designed for the outputs of our 'People and the Sea' research (WP 3.1, see **Chapter 10** below) for external audiences were reviewed and a series of questions, incorporating relevant Unpath'd Waters values, were devised for the team to use in surveys, interviews, focus groups and other evaluation contexts. These questions were informed by existing literature and learnings from past values-led projects (Freeman et al. 2018; Lessiter et al. 2018; Dawson et al. 2020; Katifori et al. 2020; see https://doi.org/10.5281/zenodo.14837533 for final evaluation questions).
- **Audience Evaluation – All** (abbreviated as **Aud-B**): Drawing from the questions designed in Aud A (above), surveys and focus group questions were designed to test the user experience of various outputs beyond WP3.1, including the Unpath'd Waters Navigator, the visitor experience of the Unpath'd Waters Touring Exhibition programme and the Discovery Bus. The data collected as part of Aud-B is discussed below in **Section 15.2**.
- **Project Evaluation – General** (abbreviated as **P-General**): we aimed to support the Unpath'd Waters Project Manager in general programme evaluation, including inputting into Mentimeter and other data gathering activities, typically as part of annual evaluation activities. We supplied questions and offered suggestions on how to collect data in comparable ways that speak to how the project was and was not living by its values. This data gathering technique proffered somewhat limited results, as many did not complete the surveys, but those who did gave interesting insights discussed further in **Chapter 17**.
- **Project Evaluation – Values Ethnography** (abbreviated as **P-Reflex**): This adopted a reflexive approach, recorded through notetaking during design meetings with specific Work Packages, wherein those present reflected upon their practices and logistics. Due to the nature of working relationships and agreed commitments, this method came to be applied with Work Packages where WP5 had more 'cross-over', resources committed, or inputs to share. As a result, the associated data were focused mainly on the activities of WP4 (the Unpath'd Waters Navigator codesign team) and WP3.1. These data are included in Chapter 14.
- **Co-design Evaluation – Ethnography** (abbreviated as **Co-ETHNO**): Here we asked our codesigners taking part in workshops to undertake critical reflection at the end of the workshops. This process was structured around Aud-A evaluation questions which were revised through reflective debriefs between WP4 and WP5, and through discussions with visually impaired codesigners specifically. On the whole, the method was successful: results are presented in Chapter 14.
- **Communications Data** (abbreviated as **Comms**): Here WP5 proposed to work with the MOLA Communications team, primarily to gather data related to web and social media coverage of Unpath'd Waters, use of Unpath'd Waters outputs in online environments (e.g., embedded viewers), and the project team's engagement with the Unpath'd Waters Comms Plan. However, we ultimately abandoned this method as the communications data was overwhelmingly quantitative, with few qualitative comments on Unpath'd Waters social media platforms.

- **ADS FAIR Audit** (abbreviated as **FAIR**): Here WP1 created a FAIR audit as part of value measure 4.2. The Audit outlines the FAIR status of each WP, but it is difficult to use to comment on conformance to our 'reliable and sustainable' value. WP1 thus provided their own reflections, which are included below in **Section 7**.
- **WP Technical Reports** (abbreviated as **WP-Tech**): Here WP5 proposed that reports be produced by individual work packages (in relation to their activities and outputs) in order to testify to specific measures, including 1.1 (Create tags that track people's searching and navigation; Provide a mechanism to encourage people towards alternative narratives) and 2.1 (Encourage our audience to "trailblaze" our datasets so we understand how they are using them). However, this was not possible as it depended heavily on other work packages, who understandably needed to prioritise their own deliverables.
- **WP Management Reports** (abbreviated **WP-Mgm**): Unpath'd Waters team members' contributions to the quarterly management reports were gathered and analysed to consider value measures 3.2 (Track new projects/ideas that arise from Unpath'd Waters, monitoring the project's potential legacy) and 6.2 (Recognise and reflect on failure). Whilst 'tracking' was in reality a difficult task (and we had not devised a method for reporting back), these data instead allowed for reflection on the ways in which teams hold conversations together, and how such conversations might accommodate specific discussions around values (see **Chapter 17** for recommendations).

6.3.1 Reflections on Data Collection Methods

Our data collection methods sought to align the value measures with Unpath'd Waters practices and forced us to consider in more depth the logistics of holding teams accountable. Despite our efforts, however, they did not always hit the mark and were arguably far too extensive in scope and onerous both for the values team and for other teams. Some work package teams struggled to apply certain methods (e.g. technical reports were never provided, which means we could not reflect on key measures 1.1 and 2.1, like the use of data by codesigners) and ultimately some of the methodologies were applied. Nevertheless, a large amount of data was collected which, as discussed in **Chapter 17**, gives us insight into how a multi-partner project can hold itself to account around its values framework.

6.3.2 Values Evaluation Data Analysis via Thematic Coding

Qualitative data from five of the nine methodologies – Aud-B, P-General, P-REFLEX, Co-ETHNO and WP-Mgm – were analysed using thematic coding techniques (performed in Atlas.Ti) then quantified. The thematic coding structure drew from Shilton's 'stages' and value levers (2013) and Foxton's 'moments' (2018), with three simple 'stages' for the values and associated measures identified. Reading through data, Foxton coded where certain values were being:

- **targeted** (e.g., colleagues were aiming towards certain goals which could be relevant to the values – such as coordinating cross-team meetings to respond to value measure 1.2, etc.)
- if **challenges** specific to achieving those values were broached (e.g., delays, lack of availability, specific data consolidation issues, etc.)
- or whether there was evidence that any values were being **achieved** (e.g., positive feedback from participants, etc.).

The coding process was a highly interpretative exercise "rather than an exact science" (Richardson et al. 2022), and reflections were captured by way of a 'coding diary'. Once all data were coded, the results were extrapolated into graphics for the full analysis, where the coded results for each value measure are evidenced and reflections are provided on their applicability.

6.3.3 Reflections on Data Analysis via Thematic Coding

Coding required significant time but the benefits were numerous. Some measures duplicated each other (e.g., value measure 1.1 concerning the exposure to new stories vs 6.1, new perspective taking) and some were difficult to capture (e.g., measure 4.1 concerning 'reliability' following the FAIR principles) because the language was too technical to code. Nonetheless, coding provided a useful way to review relationships between the values. It also allowed us to discern which measures were emerging as more prevalent than others, and which may be more significant in a project than first expected. For example, the 'Adventure' value measure 6.1 was the most coded out of all measures, demonstrating that Unpath'd Waters was targeting, challenging and achieving curiosity, wonder, new perspective taking and new ideas, more than it is 'Collaborating' or 'Connecting'.

Coding also showed where multiple values manifested simultaneously within discussions, leading to the term 'Values Rich Conversations', the impact of which is discussed in **Section 14.2**. In addition, new codes emerged through the process, which could themselves be the basis for new values:

- **Boundary setting** - setting perimeters in terms of capacity and declaring intentions with the aim to build trust and working relationships.
- **Honesty** – being open about one's opinions.
- **Care** – safeguarding and mitigating against harm or negative impact, either physical or mental.
- **Enabling independence** – where audiences are able to 'find their own way' through the Unpath'd Waters data, using our outputs.
- **Enabling a positive environment** – entwined with 'Audience-centeredness' (Connection) and 'Adventure', we can see how our outputs have successfully allowed audiences to contribute to Unpath'd Waters activities in positive, constructive ways.
- **Fostering an environment for creativity** – entwined with 'Audience-centeredness' (Connection) and 'Collaboration', we can see how contexts for Unpath'd Waters have successfully allowed audiences to 'spark' new creative ideas.

The results of our values-based evaluations are presented alongside the results of the various activities that we evaluated. Thus, evaluation of the co-design process is set out in **Section 14.2**, while the evaluation of the public exhibition is described in **Section 15.2**. Our overall conclusions and recommendations on how a values-led approach can benefit future initiatives are set out in **Chapter 17**.

7. The Pilot – Programme Management

Carla Velterop-Martin and Barney Sloane

The programme management experience of Unpath'd Waters provided some useful insights into the handling of a large consortium operating at several structural levels. These may be helpful in considering next steps for the national collection, so are summarised here.

7.1 Programme Management People

The Programme Manager was a crucial role in the consortium. Resourced at 50% across the three years, this was just about sufficient considering the scale of the consortium. The manager[59] needed to be expert at programme management, the use of relevant software, but also at foresight (in terms of analysing potential problems before they eventuated), and diplomacy (required for communicating with and coordinating a wide variety of people who were geographically and organisationally diverse).

The Programme Administrator[60] was an equally crucial role, one which in the event had been under-resourced in the bid. This role was crucial in maintaining meeting minutes, organising events and sorting logistics.

7.2 Systems and Tools

The programme was established on a Microsoft Project platform which created ideal critical pathways for each work package across the three-year duration and then linked these to identify key dependencies across the project. This enabled reflexive responses to changes within the work packages and an early warning system to ensure that dependencies across the programme could be managed and met. The tool worked very well for this purpose, allowing the team to focus programme support where it was most needed and providing the basis for more summary highlight reporting to AHRC, the management team and the consortium.

Project documentation was placed primarily on a cross-organisational Microsoft Teams site. This permitted upload and sharing of project documents and outputs across the consortium.

Financial management was provided at two levels: first, by individual consortium members (where in receipt of project funding) and then an integrated financial management system overseen by Historic England, which kept account of payments from AHRC, payments to consortium members, and expenditure by Historic England itself.

7.3 Meetings

A variety of meetings were set up to coordinate the consortium and programme.

Monthly:

- Programme Management meetings which involved just the Principal Investigator (PI), the Programme Manager (PM) and the Programme Administrator (PA).
- Management Group meetings, which included the PI, the seven Work Package Lead Co-Investigators (WP LCo-Is), the PM, the PA, the Communications Lead (CL), and invited guests.
- Work Package meetings, mainly 1:1s between PM and WP LCo-Is. Sometimes, due to capacity pressures on the WP LCo-Is, 1:1 wasn't always possible, so the PM attended WP Team meetings in lieu.

---

59 The consortium actually had two, Abigail Morris followed by Carla Velterop-Martin.

60 The Principal Investigator and the consortium are indebted to Anna Aldous for her amazing work as Administrator.

Bi-monthly:

- WP6 Liaison meetings were held with Historic England staff not on the Unpath'd Waters project, due to direct synergies between Unpath'd Waters and relevant activities in Historic England, especially relating to the development of the Mariner system supporting the National Marine Heritage Record (see **Section 3.2.1** above).

Quarterly:

- Consortium meetings (to which the whole consortium was invited) – these were occasionally held in-person, which was both popular and useful as it allowed for free discussions, enabling greater linkages between work packages and enhancing the outputs overall. Locations were varied to try to give the greatest number of people a chance to attend. We held consortium meetings in Portsmouth, Liverpool, Glasgow and Manchester.
- Advisory Board meetings (PI, PM, admin support and members of the advisory board).
- Individual catchups between the PI, PM, and Co-Investigators/Collaborating Organisations (this only began about a year from the end of the project, but it was noted by most that in future projects this would be useful to have from the beginning).

7.4 Documents

The core documents for managing the consortium were the project bid document (uploaded to UKRI's J-eS system and (the non-confidential) parts shared with the consortium members) and, for the 16 funded consortium member organisations, a legally binding collaboration agreement.

The following management documents were maintained:

- Assumptions, Issues, Dependencies, Opportunities log (issues updated when identified, revised approximately every 6-months)
- Risk register
- Integrated Programme Plan
- Timesheet tracker
- Finance/budget trackers
- Quarterly Highlight Reports which were adapted into a presentation for both the management team and advisory board, and a short one-page consortium update shared with the wider consortium.

7.5 Communication

Cross-consortium and externally facing communication was another vitally important function under the programme management umbrella. Unpath'd Waters benefited from the early input of Andrew Henderson-Schwartz (Head of Public Impact at MOLA) who helped develop our cross-consortium brand and communication guidance, but also from Marion Page, Communication and Engagement Manager for Historic England's Heritage Information Access Simplified programme, who took on the key role of managing and overseeing Unpath'd Waters website (www.unpathdwaters.org.uk[61], now archived on the Historic England website).

61 Developed and maintained by Midwinter Web Design/JP IT Solutions LTD

Communication Tools:

- Unpath'd Waters Communication Guide
- Communications and events diary
- Website template
- Logotypes, branding and presentation templates
- Image library from HE Archive and co-investigators, partners and collaborators
- Google Analytics data on digital presence
- Communication Strategy:

During development of the Unpath'd Waters project, we chose not to prioritise a full social media presence (and the necessary administration and support that would require across the three-year period). Instead, we relied heavily on our independent website, along with frequent use of the HE_Maritime and sometimes Historic England and HE_Archaeology Twitter/X accounts. We also encouraged posting on LinkedIn accounts, while individual co-investigators, collaborators and partners posted on their own accounts, with re-posts amongst each other, where news and updates were particularly focused on Work Package or specific organisational activities (see for example, news articles being published in Marine Data News[62]).

We managed consistency through the creation of a communications guide for all consortium members. This was backed up by the development of a distinct Unpath'd Waters logo, templates for presentations and web design.

The website linked to the following social media channels: Facebook, Twitter/X, LinkedIn, Tumblr and straight to emails. It was signposted on the Historic England website, while individual consortium organisations also created their own web presence. We also provided a project email address and monitored inbox.

Internally to Historic England, we offered internal news stories about the project and two 'Lunch and Learn' webinars on progress (both very well attended).

Upon closure of the project in November 2024, we transferred the archived webpages to the Historic England website for a duration of 10 years.

7.6 The Values Framework

As set out in **Chapter 6**, we applied our values approach to the Unpath'd Waters consortium. While by no means perfect, this produced significant benefits in terms of coordination and consistency of approach across the project and led to some specific case studies of good practice showing the potential of this approach.

The team developing the Navigator **(Chapter 14)** used the values for "rethinking research objectives" and adapted each value to the unique context in which they were working.

62 https://mailchi.mp/3a953204b189/marine-data-news-july-2024#unpathdwaters

Similarly, the Data Discovery team **(Chapter 9)** – linking the digital infrastructure, the data themselves, and the multiple teams supplying, using and presenting the data for different audiences – used the values to shape the ethos of their work in three ways:

1. Clear recognition that data are derived from existing repositories whose collection practices may have little relevance to, or may sit in conflict with, values such as equity and connecting with people on their own terms.
2. Understanding the role of failure in some tasks as both a contribution to the Adventure value and, in encouraging forms of reuse, a contribution towards the Sustainability value.
3. Recognising intractable problems related to environmental sustainability. Applying AI tools and building bigger and more linked datasets has severe implications for climate values.

The People and the Sea team **(Chapter 10)** made concerted efforts to embed the values into multiple aspects their work, including their evaluation protocols for events and outputs with collaborators and external audiences, and their ethics application.

While the values-led process was endorsed by a significant number of the Unpath'd Waters consortium, others did not engage, and a very small few demonstrated aversion to – or disinterest in – the values or expressed concern about the practicalities of 'doing values'. The supporting **Research Report** sets out recommendations in how future projects might benefit from lessons learned.

8. Cargo Inventory – The collections sample

Julian Richards, Holly Wright, Tim Evans & Émilie Pagé-Perron

Establishing a robust, secure and coherent base for the sample of all the digital collections that Unpath'd Waters was to explore was the responsibility of our Work Package 1 (Aggregation and Characterisation).

8.1 Aims and Objectives

Led by the Archaeology Data Service but drawing on support from a wide range of the project Co-Is and Collaborating Organisations, the aim of WP1 was to investigate how to integrate the UK's marine collections, providing an exemplar for TaNC of the challenges of the aggregation of heterogeneous heritage data. The five subsidiary objectives were to:

i. assess, aggregate and catalogue the digital components of the UK's marine national collections.

ii. assess the demands and capabilities of existing digital infrastructures.

iii. enhance this collection and deliver it to researchers and the public via existing and new human and machine-readable interfaces.

iv. develop appropriate data standards to achieve interoperability.

v. provide means of sustainable access routes and a primary data archive for Unpath'd Waters data outputs.

The first stage for WP1 was therefore to create an informal catalogue of the potential data sources that describe the UK's maritime heritage. Given the huge variety of sources, as well as their heterogeneous, disparate and fragmented nature, it was accepted from the outset that this was never going to be a comprehensive catalogue. As the resource is also dynamic as new discoveries are made all the time, it was also clear that it would be a snapshot in time, providing a demonstrator for TaNC, but that we could provide recommendations for how such catalogues might be maintained as live resources in the future.

During the proposal stage it was also agreed that the optimal approach would be to combine many "thin" metadata records, providing national coverage, with a smaller number of much richer "thick" collections reflecting individual digital collections, thereby demonstrating both the breadth and depth of the national collection. It was also considered important to reflect the fact that many research resources are not in digital form, but to show how digital records could provide an analogue-digital connector, pointing users to offline resources.

8.2 The Resources

After the assessment of available data, for the "thin" records it was decided to prioritise the aggregation of maritime data from the five national inventories maintained by the heritage agencies for England, Scotland, Wales, Northern Ireland, and the Isle of Man, all partners in the project, and giving full UK coverage (see **Chapter 3** above). These are essentially sites and monuments inventories, sharing similar data structures, but with differences in data schema and vocabularies. In each case the agencies have responsibility for maintaining a national record; all make it available online via their own digital infrastructures and most use stable identifiers. In each case, therefore, the slim metadata record harvested by Unpath'd Waters links to the primary record, and changes and updates to the core record do not affect the metadata link, so long as the link address is maintained. In some cases, we linked direct to the live record; in other cases, to a brokered record hosted by the ADS.

Although it was relatively easy to extract the shipwreck and aircraft loss records from the national records, one of the goals of Unpath'd Waters was to include maritime records found on land, including lighthouses, dock and shipyard structures, canal locks and maritime monuments. This could only be achieved by a relatively arbitrary choice of keywords which were used to extract additional records, resulting in a patchier coverage of land-based records.

In contrast to the authoritative national records provided by the state heritage agencies, we were also able to aggregate the very different national dataset, which was the outcome of the CITiZAN project, undertaken by MOLA. CITiZAN, the Coastal and InterTidal Zone Archaeological Network, was a community archaeology and citizen science project set up to create a written and photographic record of the coastal and intertidal zone. Messages in Bottles, created by the late Ed Cummings and maintained by the Nautical Archaeological Society, was a similar type of community-generated resource, in this case providing evocative details of messages recovered from bottles found on the seashore in the 19th Century, written by persons aboard distressed vessels, and recorded by Lloyd's of London and in the British Press. This collection presents significant difficulties (such as lack of locational data for the loss, authenticity – see **Section 13.2**), but has been added to the Unpath'd Waters Portal[63].

For the thicker "event" records referring to underwater archaeological fieldwork and research we used two categories of data managed by ADS. Firstly, we identified fieldwork reports referring to maritime interventions which had been logged in the national OASIS fieldwork recording system. Metadata for these was uploaded from the ADS Library, including DOI links to the full PDF reports curated by ADS. As a result of a contact made at the first TaNC conference, we were able to include within the library an additional 240 desk-based reports of wrecks created by members of MADU (Malvern Archaeological Diving Unit) during Covid lockdown. These provided another example of the integration of a 'Citizen Science' dataset.

In addition, we included metadata links, again with DOIs, to complete ADS digital archives, each containing a rich range of marine survey and excavation data files. A second source of fieldwork data came from iMarDIS (The Integrated Marine Data and Information System), maintained at the time of the project by Bangor University. This contains marine survey data, including multibeam bathymetric surveys undertaken by Bangor (see **Chapter 11**), below). For the wreck of the Mary Rose we created an additional ADS archive, including some 100 images of artefacts found in the wreck. We wanted to use this case study to show how data could be aggregated at item level, in this case individual objects recovered from the wreck, and searched alongside data for complete wrecks.

For the work on the Analogue-Digital Connector (ADC) (see **Section 12.3**) we took records from Bangor and Portsmouth Universities, reflecting their desk-based research on the wrecks in the area of the Needles, Isle of Wight, and the Irish Sea and including identifiers for paper documents and charts held by the UKHO, The National Archives, and other analogue resources.

8.3 The Existing Digital Infrastructures

Before Unpath'd Waters there was no single means of interrogating the UK's maritime heritage. In common with the wider UK heritage record, the maritime record is split between the constituent nations, with independent infrastructures for England, Scotland, Wales, Northern Ireland, and the Isle of Man. This makes curatorial sense, but is an impediment to wider research, heritage management, and public interest, where the UK coastal waters need to be viewed as a whole. The Marine Environmental Data and Information Network (MEDIN) portal[64] provides UK coverage for marine resources of all disciplines, but not at the level of individual wrecks. The Archaeology Data Service provides a UK wide archaeology catalogue, ArchSearch, but it is difficult to isolate maritime data in this interface. Data catalogued for Unpath'd Waters was also provided to both these infrastructures but neither provided an ideal UK wide interface for the project.

At proposal stage it was therefore agreed that Unpath'd Waters would build upon the digital infrastructure developed by the ARIADNE RI, which provides an international aggregation portal for archaeology and heritage. The ARIADNE portal and its underlying architecture had been developed with European research infrastructure funding over the previous decade, with two four-year projects: ARIADNE, and ARIADNEplus (Richards 2023)[65]. The portal sits on top of a Linked Open Data triplestore, and the ontology is based upon CIDOC CRM, so it should be extensible for other projects. The ADS decided to use Unpath'd Waters to test if they could create a version of the ARIADNE portal hardwired for UK maritime data.

---

63 https://unpathd.ads.ac.uk/search?creator=Jack%20Pink
64 https://medin.org.uk/using-medin-portal
65 https://ariadne-infrastructure.eu/

The metadata harvested for Unpath'd Waters was therefore loaded into the existing ARIADNE triple store, but the Unpath'd Waters portal (see **Section 8.7** below) provides a hardwired view of a subset of the wider knowledge base. The approach demonstrates the principle that data (and metadata) can be stored once, but can be re-used many times, in interfaces which are tailored for different audiences. Since the data sits in a triple store it can also be directly queried and is available for human and machine interrogation via SPARQL queries.

8.4 Ontologies and Data Structure

The ARIADNE Ontology, AO for short, was developed at the start of the ARIADNEplus project for the purpose of integrating the archaeological data of the ARIADNE partners into a common information space. Building upon earlier projects, the CIDOC CRM, the standard ontology in the cultural heritage domain, was adopted as the conceptual backbone of the AO, providing a unified and coherent linguistic and axiomatic framework. Subsequently, the CRM has been specialised, under a specially devised namespace, to cater to the needs of the different subdomains covered by ARIADNE. The first of those specialisations was the AO-Cat, the part of AO dealing with the representation of the resources in the ARIADNE Catalogue. After testing the AO-Cat with Unpath'd Waters partners, it was agreed that this covered the core metadata that would be needed to describe the digital resources that would be aggregated. The ontology is based around the attributes of What, When and Where, which underpin a powerful and intuitive search interface. Therefore, for Unpath'd Waters it was agreed to implement a further specialisation of the AO, defined as the UO-Cat. The only suggested addition required for the UO-Cat was that for maritime resources, to adequately describe 'Where', the property of Depth needed to be added to Easting and Northing. This was done, although in practice none of the datasets aggregated described depth in a consistent manner, so this attribute was not implemented in the portal interface.

The Unpath'd Waters knowledge base provides a collection-level representation of the resources shared by the project partners. However, while the distinction between collection level and item level may seem obvious, it can be applied in many ways, according to how we define what we consider to be items. This in turn depends on the specific research context and research question. For example, at the level of maritime landscape research, each wreck may be considered to be an item of observation, and the collection-level record refers to the site level record, whereas for an artefact-based study, individual objects may be the items of interest, and the collection-level record now refers to the database of artefacts, for example from the Mary Rose. But at each level the same attributes of What, When and Where can be applied.

8.5 Data Mapping

Having designated the UO-Cat as a shared ontology, interoperability between the partner resources was dependent upon mapping the data models of heterogeneous partner datasets to the UO-Cat. For this the X3ML Toolkit developed by FORTH was used. The X3ML Toolkit is a set of small, open source, microservices that follow the SYNERGY Reference Model of data provision and aggregation. It allowed us to define equivalences between the various attributes in partner-provided data with properties in the UO-Cat. However, to facilitate a useful cross-search it was also essential to achieve interoperability of the metadata used to describe the three main facets of 'Where', 'When' and 'What'. To support effective cross-search of metadata originating from many different partners requires some shared common understanding of the meaning of the metadata. The 'Where' and 'When' facets may be communicated using common data types and comparable values (e.g. spatial coordinates relative to a known location on the earth, date ranges relative to a known epoch). The 'What' (subject) aspect can be more difficult to define in a commonly understood and comparable format.

Despite the relatively advanced state of controlled vocabularies in the UK heritage sector, it became apparent that each of the agencies described maritime heritage in different ways, and at different levels of granularity. Rather than attempt to map every subject vocabulary to every other subject vocabulary it was agreed to map each vocabulary to a common spine (Binding et al. 2015). The Getty Art & Architecture Thesaurus (AAT) provides concepts and terms to describe cultural heritage concepts. The AAT is available as Linked Open Data, so each concept in the thesaurus has a unique identifier in the form of a URI (for example, http://vocab.getty.edu/aat/300233041 is the identifier of the concept 'brigantine' – a specific type of vessel).

Unpath'd Waters followed the approach tried and tested in ARIADNE by adopting the AAT as a central hub for scalable interconnection of local subject vocabularies. Mappings for most maritime terms had already been created by ADS for ARIADNE, and partners also provided additional mappings for their own local subject vocabulary (all terms used to describe subjects in their own metadata) to the AAT. It was noted, however, that at the fine level of vessel classification, the Getty AAT was not sufficiently granular to cover all categories of ship. In the longer term this could be resolved by requesting a formal extension to the Getty AAT. In the interim, the Unpath'd Waters Portal filters include a filter by "native subject" which can be used for more granular searches.

To deal with the spatial dimension, all spatial coordinates in Unpath'd Waters were expressed using the World Geodetic System 1984 (WGS84)[66]. This is a standard geographic coordinate system, comprising a global horizontal and vertical datum and a coordinate system used (particularly by GPS systems) to express global positioning on the surface of the Earth. This is essential in the maritime context, where the location of some sites is beyond the range of the respective national grid systems. Coordinates in local datasets sometimes required normalisation/transformation prior to aggregation in order to improve opportunities for cross searching the integrated datasets.

For the 'When' dimension we again followed the practice adopted in ARIADNE by asking partners to use the online Perio.Do[67] period gazetteer service to define the 'From' and 'Until' absolute dates for cultural period terms. This gets around the problem that the date range of the Iron Age, for instance, is not the same in Scotland, Ireland, and England, allowing users to interrogate the knowledge base via the cultural period term, or via an absolute date range. An incidental impact of the project was that it led to a conversation between archaeologists of Northern Ireland and the Irish Republic, and an agreed set of Perio.Do definitions for the whole island of Ireland.

8.6 Metadata Enhancement

AI-based enhancement was used to enhance two of the datasets included within the Unpath'd Waters catalogue. The Welsh national record, Coflein, did not employ a detailed classification for vessel type, so most vessels were identified simply as "wreck". To provide interoperability with the records for England and Scotland it was therefore necessary to add more detailed subject terms for vessel types. The Southampton team employed an AI BERT[68] model to extract vessel types from the free text descriptions in Coflein. Similarly, the Messages in a Bottle dataset simply comprised text reports, held as PDF files, providing transcriptions of the messages and information about where they were found. In this case Southampton extracted vessel names, dates and locations from the PDFs and, after further manual cleaning we were able to create a structured database which could be mapped to the UO-Cat and loaded to the triple store. In each case, however, it was important to distinguish the enhanced metadata from the primary record. We therefore added a disclaimer to each record noting that: "Subject keywords for maritime craft type recorded at time of loss have been enhanced by the University of Southampton using an AI BERT model as part of the Unpath'd Waters project. These do not from part of the official Coflein record".

8.7 The Unpath'd Waters Portal

As noted above, the Unpath'd Waters Portal[69] provides one view into the data held in the RDF triple store which forms the Knowledge Base used by the project. The triple store is currently managed by CNR ISTI in Pisa, and is held in an open-source version of Graph DB. As of August 2024, the triple store comprises 491,695,356 statements, or triples.

66 https://epsg.io/4326
67 https://perio.do/en/
68 https://research.google/pubs/bert-pre-training-of-deep-bidirectional-transformers-for-language-understanding/
69 https://unpathd.ads.ac.uk/

Data can be loaded to the triple store by different methods, but most of the Unpath'd Waters data was loaded as pre-prepared XML files and then enriched with Getty AAT terms during aggregation. However, the architecture also supports the use of APIs to load data to the triple store and automated harvesting using OAI-PMH. This can be set to harvest at regular intervals (e.g. daily, weekly, monthly) and would allow the portal to maintain an up-to-date window into the UK's maritime record **(FIGURE 8_01)**.

Various user-friendly interfaces can be built on top of the triple store. The current version of the ARIADNE portal uses Open Search indices to facilitate searching, browsing, and filtering records, according to the What, When, and Where parameters, but also allowing filtering by Publisher and Contributor, as well as Resource Type, a high-level subject classification. For the Unpath'd Waters portal we used geographical location and Resource Type to restrict searching to UK data, and Maritime records **(FIGURE 8_02)**.

Spatial searching is enabled by a map-based interface. This displays the density of records in the selected view as a heat map. As the user zooms in further then individual records appear and can be selected **(FIGURE 8_03)**.

The results page displays all records which correspond to the selected filters and allows users to identify specific records of interest **(FIGURE 8_04)**.

A full user guide to all the features of the Portal is available[70].

At the conclusion of the Unpath'd Waters project, the Portal provided access to over 100,000 digital resources, with complete UK coverage, and reflecting the full range of digital data **(TABLE 8_01)**.

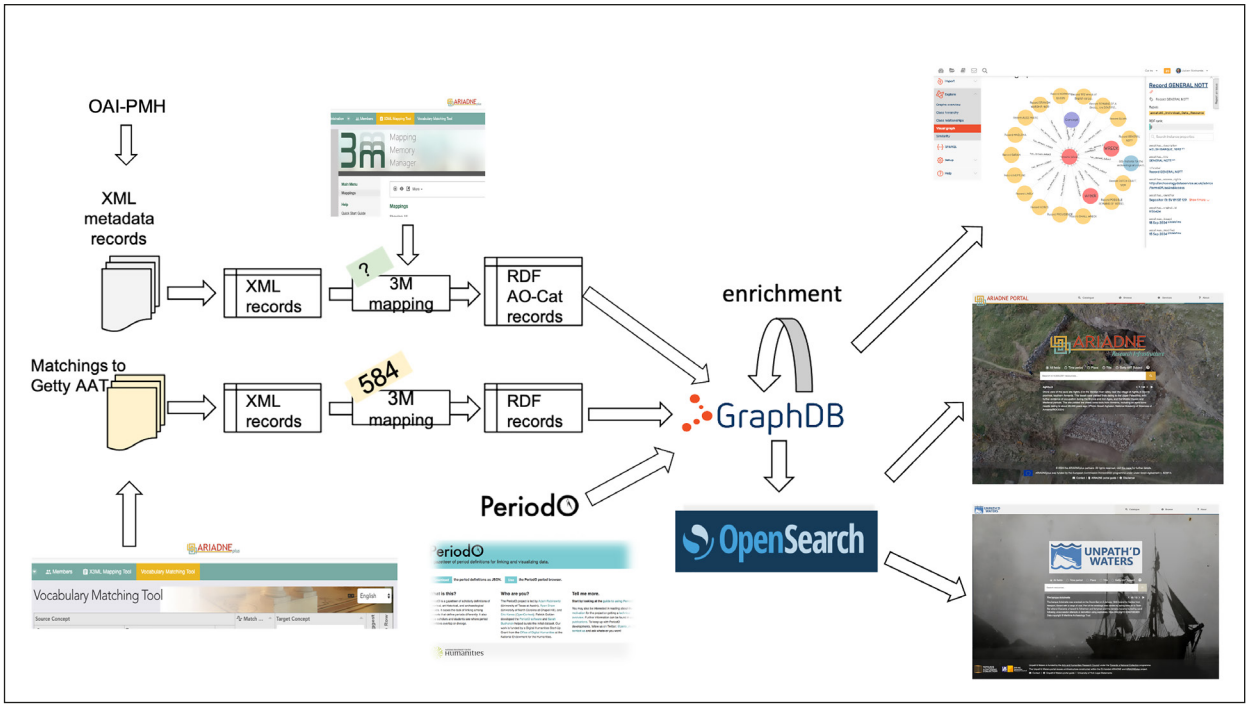


FIGURE 8_01
The workflow to upload data to the Graph DB triple store, including enrichment stages.

70 https://unpathd.ads.ac.uk/guide

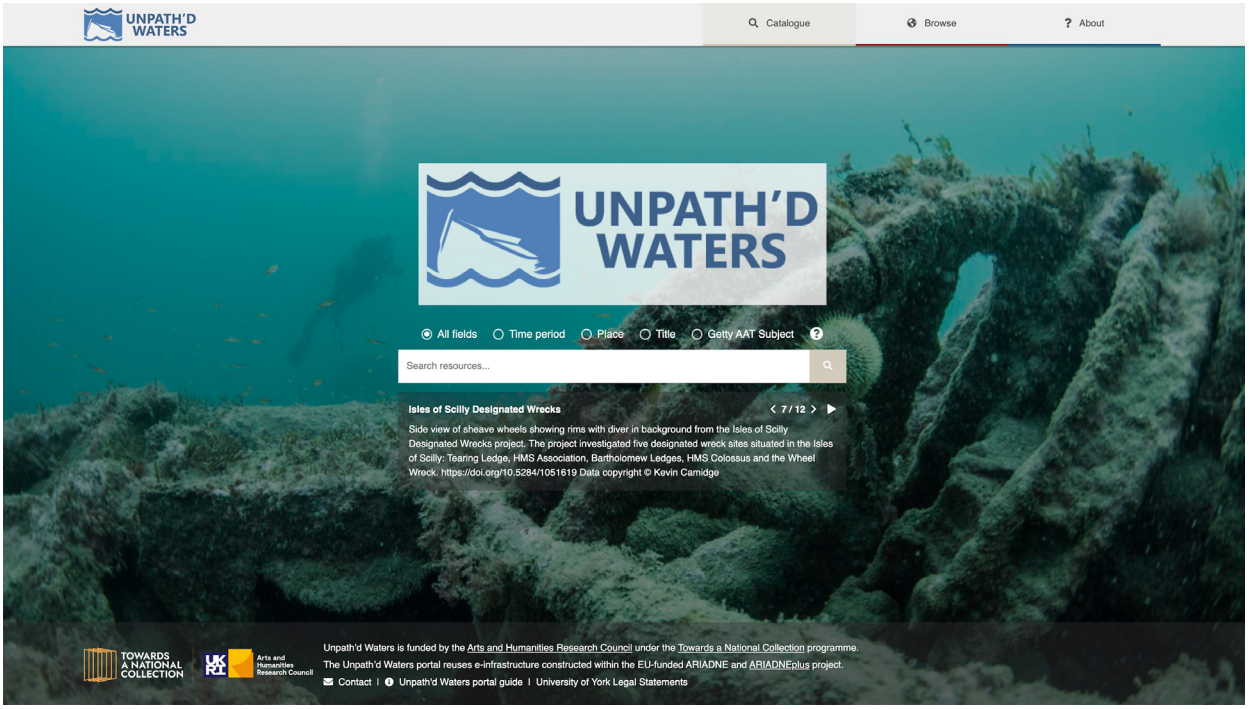


FIGURE 8_02
The Unpath'd Waters Portal landing page.

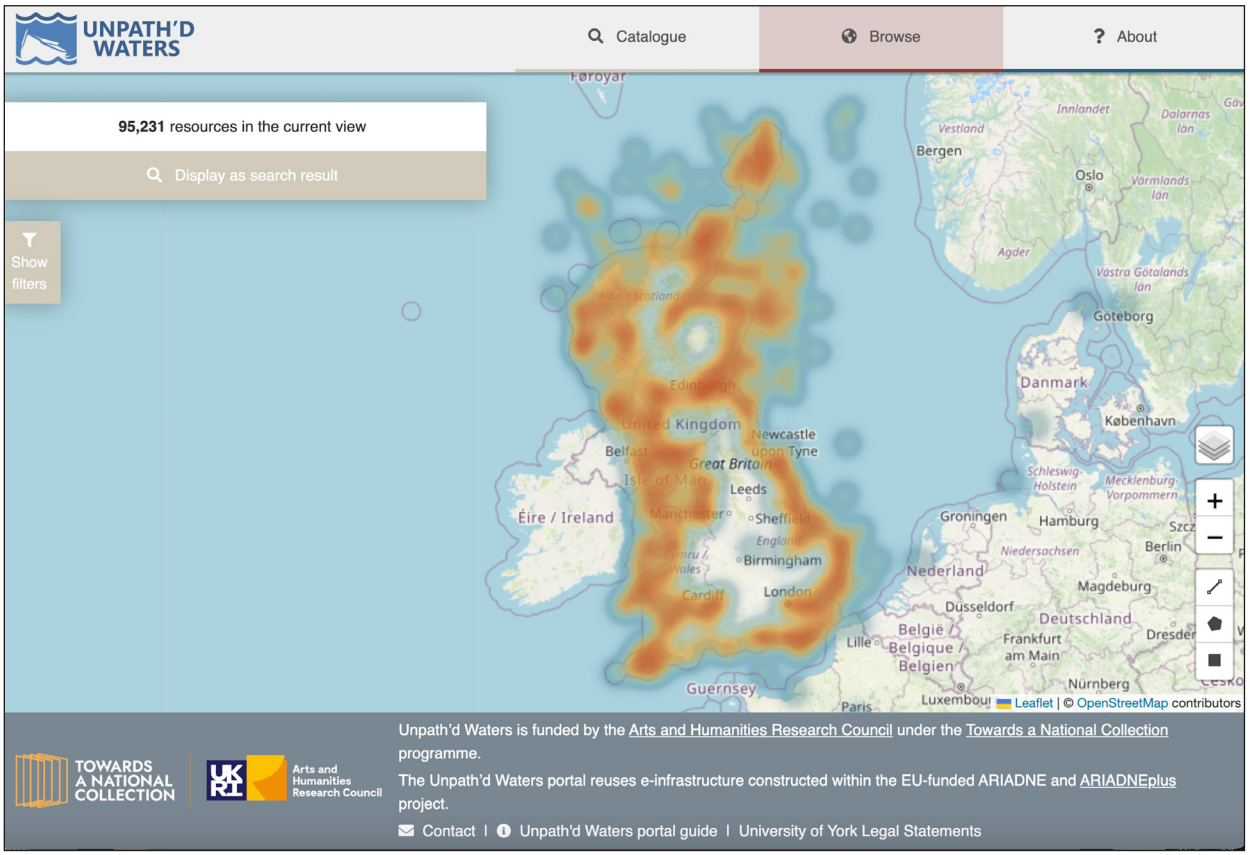


FIGURE 8_03
The advanced spatial search interface, showing the heat map for UK maritime records.

8.8 Data Provision to External Portals

Since the Unpath'd Waters Portal was built on top of the Graph DB triple store managed by the ARIADNE RI, this has the bonus that data provided by partners automatically appears in the ARIADNE portal at the same time as it appears in the Unpath'd Waters Portal. In this context it is cross-searchable with some four million heritage resources from some 40 countries and provides a showcase for the UK's marine heritage for an international audience.

Metadata was also supplied for the MEDIN portal for those datasets not already harvested from the MEDIN, including for CITiZAN and Messages in Bottles. For their audience, MEDIN chose to take single collection records for the national inventories, rather than individual site records, underlining that for a national collection different views into the data are needed for different audiences. This link to MEDIN exposed the Unpath'd Waters datasets to audiences beyond the heritage sector and enabled them to feed onto the digital infrastructure of the UN Ocean Decade.

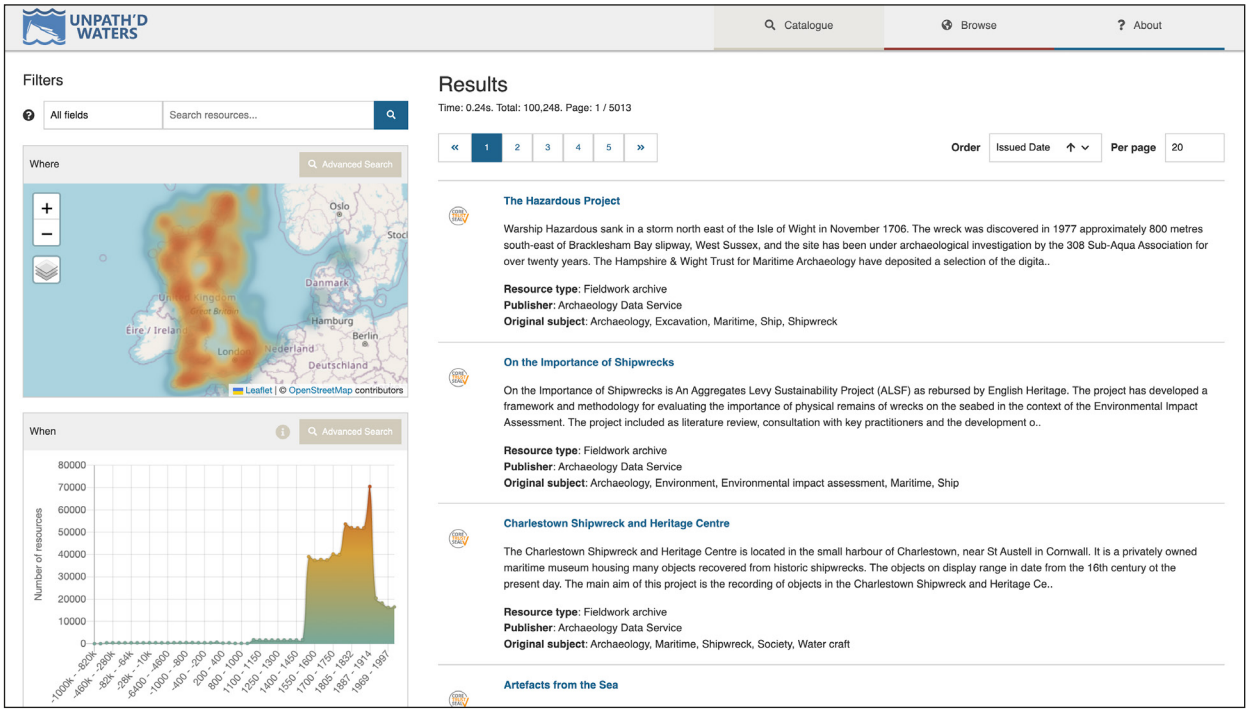


FIGURE 8_04
The Portal results page, showing the Where and When search boxes on the left hand side.

Number of records	Provider	Dataset
National Inventories		
50,680	Historic England	AMIE dataset which forms the basis of Mariner
33,379	Historic Environment Scotland	Canmore
8,285	Royal Commission on the Ancient and Historical Monuments of Wales	Coflein
627	Department for Communities, Northern Ireland	Northern Ireland Wrecks Database
1,916	Manx National Heritage	Isle of Man HER
Fieldwork		
540	Archaeology Data Service	Library of Fieldwork Reports, including 240 reports from MADU
94	Archaeology Data Service	ADS archives
359	Bangor University	iMarDIS
100	Mary Rose Trust	Artefact sample
Citizen Science		
3,874	Museum of London Archaeology	CITiZAN
385	Ed Cumming via Nautical Archaeology Society	Messages in Bottles
Analogue to Digital Connector		
c.40	Bangor University	Wreck stories – Analogue-Digital
4	Portsmouth University	Analogue-Digital connectors, wreck case studies

TABLE 8_01
Records accessible on the Unpath'd Waters Portal.

9. Stowage and Supply – Searching and linking

Jack Pink, Fraser Sturt, Adrienne Chapman (University of Southampton)

At the heart of this project was a desire to explore what a national collection for maritime heritage might look like and how it could be delivered. It was recognised from the start that this would require engagement with a variety of data types, sources, stakeholders, and perspectives. This was the work of Work Package 2, led by the University of Southampton, again with support from a wide range of consortium organisations.

9.1 Artificial Intelligence and Record Enhancement

Pink et al. (in press) set out in detail the rationale and approach adopted for record enhancement as well as giving an account of the broader literature on this topic. While still a relatively novel activity in archaeology, with a comparatively small number of publications (e.g Jeffrey et al. 2009, Richards et al 2015, Vlachidis and Tudhope 2016, Brandsen et al. 2022, Suissa et al 2022), techniques have been developed and deployed in other fields which are directly relevant and applicable to the challenges we face. At the start of the TaNC programme a meeting of technical work packages across the five Discovery Projects was held. In this meeting it was agreed that a 'reduce, reuse, recycle' approach should be adopted when developing solutions to ensure maximum sustainability. Thus, rather than develop bespoke solutions, wherever possible established routes should be tested and utilised. In addition, it was agreed that FAIR and CARE principles should be adhered to.

A variety of different established approaches were tested to determine the most appropriate method for record enhancement for the datasets Unpath'd Waters was engaging with. These included:

- supervised machine learning techniques,
- shot learning,
- rule-based approaches.

It was recognised that this enrichment step was critical, as without it cross-search and analysis would be impossible due to dataset variability. To ensure we lived up to our FAIR commitments, all scripts developed were archived at our gitlab site. In order to assess which techniques performed best, accuracy, precision and recall values were generated. To do this Pink prepared a labelled dataset. The dataset was then split into 'train' and 'test' sets on a 70:30 ratio. Accuracy values were generated by comparing a models prediction for tests sets against the actual labels on the train set.

Precision and recall help to determine what sort of errors a model might be making. For every prediction the following determination is made:

- True Positives (TP),
- False Positives (FP),
- True Negatives (TN),
- False Negatives (FN).

Precision considers false positives and is calculated via: TP/(TP + FP). Recall considers the impact of false negatives and is calculated via: TP/(TP + FN). From these data an F1 value can be calculated, it is a blend of precision and recall as: 2 * (Precision * Recall)/(Precision + Recall).

9.1.1 Supervised Machine Learning

Two forms of supervised machine learning were trialled, Support Vector Machines and Random Forest:

Support Vector Machines

Support Vector Machines (SVMs) (Cortes and Vapnik 1995) are a class of supervised learning algorithms for classification and regression tasks. Supervised learning is a type of machine learning where a model is trained to make predictions based on labelled data. The model is presented with input data and the corresponding correct output, in this case the training dataset produced by Pink. The goal is to make accurate predictions on new, unseen data.

Random Forest

Random Forest is a supervised learning model (Breiman 2001). It is an ensemble learning method that combines multiple decision trees to create a ”forest”. Each tree is trained on a random subset of the data and a random subset of the features. To make a prediction using a random forest, the input data is passed through each decision tree in the forest. The output from each tree is combined to form a final prediction. In classification problems, the most common class predicted by the trees is selected as the final prediction.

Random Forest was implemented with TF-IDF. Use of TF-IDF here helped to identify the important terms within the fields in each record and facilitate classification. A separate model was implemented with Global Vectors for Word Representation (GloVe) (Pennington et al., 2014). GloVe creates a matrix based on the words that appear within the context of a term. This matrix captures the meaning of the term and its relationships with other words in the vocabulary. GloVE was used with Random Forest for terms in the FISH thesaurus that did not have training data in the Coflein dataset.

9.1.2 Zero-Shot Learning

Zero Shot Learning (ZSL) utilises an AI to learn, recognise and categorise new, unseen classes based on their understanding of relationships between known classes. Instead of explicit training, models utilise semantic associations between tokens (word-parts) to make predictions for novel instances. This enables systems to bridge the gap between familiar and unfamiliar concepts, expanding their capabilities.

Within Unpath’d Waters, the ZSL approach was split into two kinds:

- records where the craft type is present in the rich text description
- records where type could be summarised from the description using domain expertise.

Where no ship type was present the record was passed to the ZSL algorithms (see **FIGURE 9_01**).

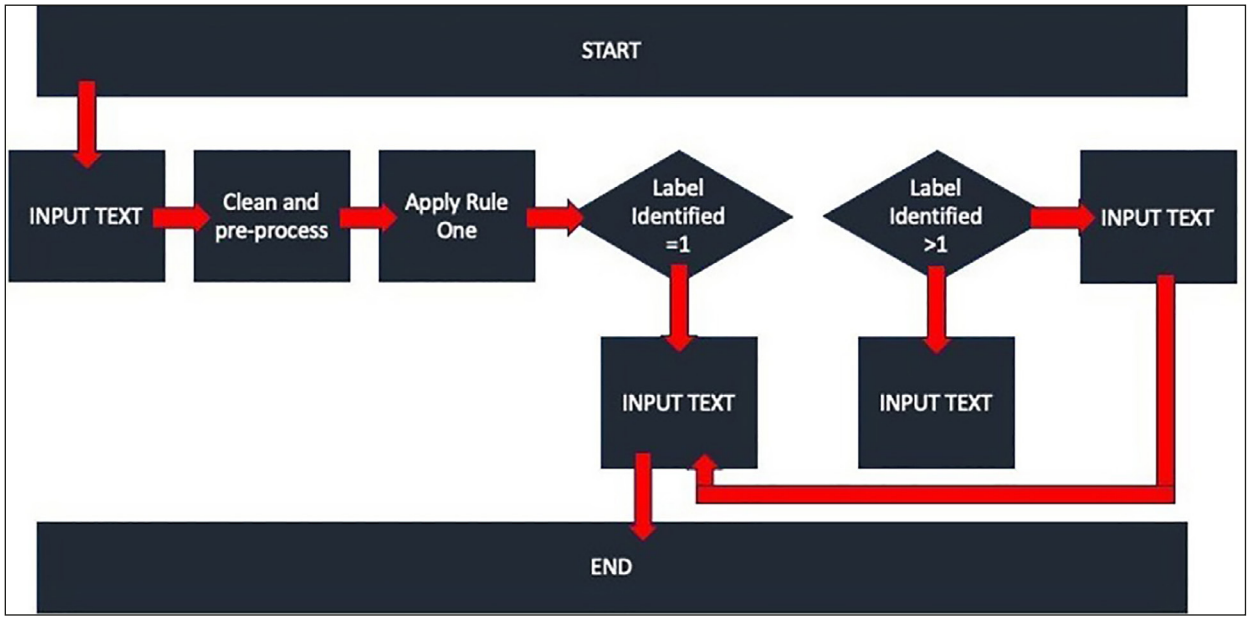


FIGURE 9_01
The complete ZSL Loop including a Cleaning Phase and the rule-based split to process individual records.

A series of rules were created to be used with the ZSL based on the process Pink would take as a domain specialist to identify a vessel from these records. These are summarised in **TABLE 9_01**.

Rule	Description	Output
Rule 1	Matches all ship-type labels present in the text and returns a list. If only one label is present this is marked as a strong match. If more than one label is present it is sent through to the ZSL algorithms.	Ordered list of ship type labels present in text.
Rule 2	If similarity scores identify more than one label in an entry and a single preference cannot be identified preference is given to the label that occurs first in the sentence.	Ordered list of labels based on similarity and word location
Rule 3	Builds upon rule one. This tags labels returned by Rule One as nouns, spacy's pre-implemented library is used for parts of speech tagging.	Ordered list of labels based on use of ship type name as noun (avoids erroneous tags from verbs that match ship types such as: sailing, fishing and so on)

TABLE 9_01
Rules applied as part of the
Zero-Shot Learning approach.

The similarity scores referenced by Rule 2 are included as **Table 9_02**. Two ZSL implementations were used. The first was trained on the Sentence Transformers repository (Reimers and Gurevych, 2019) and mapped the text to a 384 dimensional dense vector space. It found the cosine similarity between each label and the text independently. The final prediction was the label that had highest similarity score. The second was trained on the MultiNLI dataset (Williams et al., 2017). This method deploys softmax classifier and distributes probabilities over all the labels. The label with highest probability values was returned.

Label	Sentence BERT ZSL	Facebook BART MNLI
tanker	0.29562	0.00527
trawler	0.24494	0.0034
schooner	0.23405	0.00472
submarine	0.23026	0.00338
barque	0.20950	0.00446
dredger	0.20717	0.0037
naval	0.20137	0.03228
barge	0.20076	0.00321
tug	0.19190	0.00439
liner	0.17651	0.00649
sloop	0.14961	0.00644
brig	0.14320	0.00232
yacht	0.13979	0.39251
ketch	0.11566	0.00417

Label	Sentence BERT ZSL	Facebook BART MNLI
lighter	0.11265	0.02292
craft	0.10871	0.28454
wherry	0.10382	0.01546
yawl	0.10137	0.01307
lugger	0.09451	0.0063
drifter	0.08355	0.01842
cargo	0.05608	0.0112
fishing	0.05578	0.00352
launch	0.054143	0.01809
smack	-0.003999	0.02922
transport	-0.00848	0.03024
patrol	-0.018542	0.00987
customs	-0.03886	0.02121
indiaman	-0.056150	0.00285
escort	None	0.01245
passenger	None	0.00548

TABLE 9_02
Records the similarity scores from BERT and BART models.
These measure how closely two sentences are related in meaning.
Both models produce scores to show identification of terms in the set.
Higher scores from 0–1 indicate stronger similarity.

9.1.3 BERT, Simpletransformers and Few Shot Learning

BERT or Bidirectional Encoder Representations from Transformers (Devlin et al., 2018) was the main model adopted by the Unpath'd team. This was the same choice made for AGNES (Brandsen et al., 2022) when undertaking a similar task. We used BERT-base-cased with the simpletransformers (Rajapakse, 2020) library's ClassificationModel class to define and train the model. These are used for sentence/text-level classification (multiclass text classification).

Few Shot Learning (FSL) enables a model to learn and make predictions from a small number of examples. It is particularly useful in situations where data is limited or expensive to obtain, such as that often seen in heritage datasets. One popular approach to FSL is to use a pre-trained model, fine-tuned on a small number of labelled examples from the new task. This was the method adopted here.

9.1.4 Human-in-the-Loop

'Human-in-the-loop' (HiL) refers to the involvement of a specialist in an AI-system. As shown in **FIGURE 9_01** this sees a domain expert reviewing and guiding the output of AI algorithms, correcting errors and providing insights. This feedback loop helps to refine the algorithm and enhance their performance. In this case an FSL model was deployed and Pink worked to generate the labelled dataset and correct the predictions from the model.

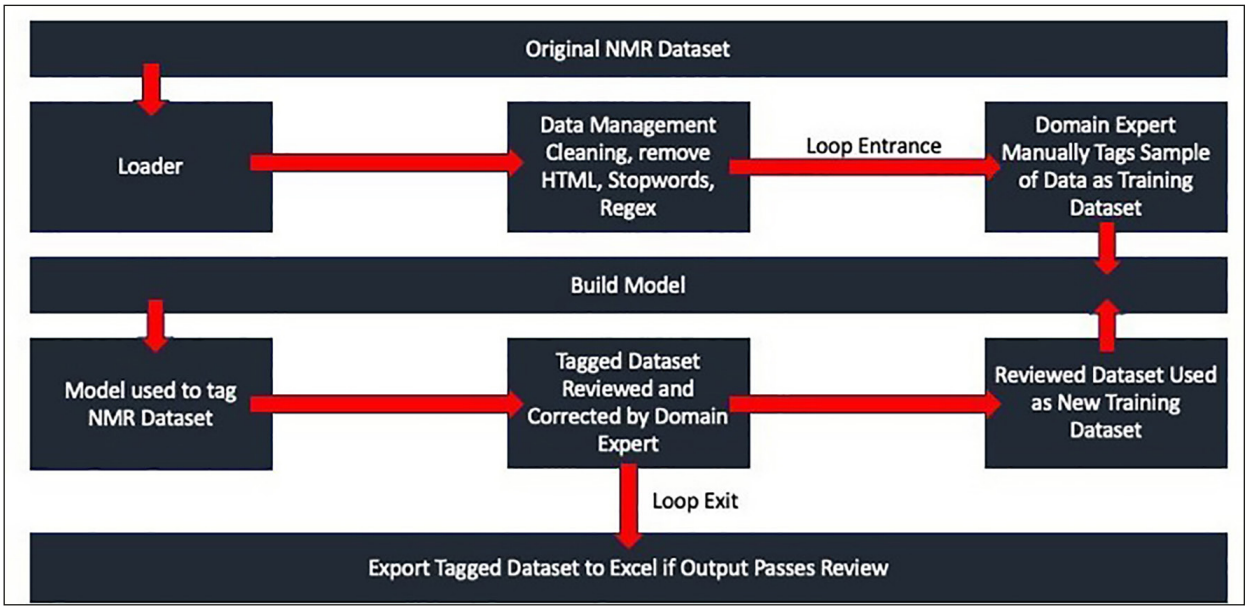


FIGURE 9_02
Schema showing the Human in the Loop procedure adopted for Unpath'd Waters.

9.2 Results

Of all the methods trialled, FSL with HiL was the most successful and thus the one chosen to complete enhancement tasks. **TABLES 9_03**, **9_04**, and **9_05** detail accuracy, precision, recall and F1 scores for the final model. The successful implementation based on this kind of training data demonstrates how powerful FSL can be when combined with human domain expertise in this context. The model's accuracy was not impacted by the number of labels it was tasked with, indicating the model is robust and promising. The model used for FSL classification was fine-tuned on 70% of the dataset before testing. Some ship types like 'wherry' had only one entry in the entire RCAHMW dataset. The algorithm took just over one minute to train and each prediction took about 0.5 seconds. Precision and recall are shown in **TABLE 9_05**, where ship types had too few entries it was not possible to report precision and recall.

Shot-Learners perform significantly better when they are fine-tuned, even though they are designed to generalise on unseen domains. The results also show only FSL could map synonymous words. In the craft list the word "barque" is the best example as it is synonymous for the word "bark". Both words refer to a sailing vessel with square-rigged fore- and mainmasts and a fore-and-aft rigged mizzenmast and both terms are present in Coflein. Even though Support Vector Machines used the same training data, that model was unable to predict it accurately.

Data Type	Model	Epoch	Batch Size	Accuracy
Data with at least 4 samples each	BERT	45	4	83.85
Data with at least 2 samples each	BERT	45	3	75.59

TABLE 9_03
FSL results from implementations of BERT using different numbers of data sample.

In this table 'epoch' refers to one complete pass of the entire training dataset through the model. 'Batch size' is the number of training examples processed in one forward and backward pass during each iteration. 'Accuracy' is a metric of the proportion of correctly predicted outputs over the total number of predictions.

Configuration	Facebook BART-MNLI Accuracy	Sentence-BERT Accuracy
Without Rules	0%	29.86
With Rules	81.42%	89.95

TABLE 9_04
ZSL Accuracy Results for Facebook
BART-MNLI and Sentence-BERT Models.

Ship Type	Precision	Recall	F1 Score
Barge	1	1	1.000
Barque	1	1	1.000
Brig	0.8	1	0.889
Cargo	1	1	1.000
Craft	1	0.667	0.800
Dredger	1	1	1.000
Drifter	1	1	1.000
Fishing Vessel	0.667	1	0.800
Indiaman	0	0	None
Ketch	1	1	1.000
Launch	None	None	None
Lighter	1	0.5	0.667
Liner	None	0	None
Lugger	1	1	1.000
Naval Vessel	1	0.4	0.571
Schooner	1	0.8	0.889
Sloop	1	1	1.000
Smack	1	1	1.000
Submarine	0.8	1	0.889
Tanker	1	1	1.000
Transport	0.125	1	0.222
Trawler	1	1	1.000

TABLE 9_05
Precision, recall and F1 scores for a selection of
Maritime Craft types from the FSL model.

9.3 Challenges with the Datasets

As noted above **(Chapter 8)**, for the mapping to the UO-CAT three facets were critical: Where, When and What. The different ways in which each of the NRHE had been created, and the way they had accumulated over time, meant that each dataset had very different qualities and affordances. This was true both within and between datasets. Thus, although controlled vocabularies, such as those given by the Forum on Information Standards in Heritage (FISH), had been utilised by national bodies, they may not have been used at the start of data collection (and thus not uniformly applied within datasets) or may not have been interpreted and used in the same ways. For much archaeological data specialist knowledge is required for interpretation, and this may lead to differing interpretations and encoding of that data.

For the mapping to UO-CAT a key challenge emerged around determination and mapping of 'What' in relation to the Welsh national record, Coflein. As noted above, whilst the challenge was most apparent in this dataset, the underlying causes and implications could be seen in other datasets. Essentially, the problem was one of historical practice, of data being encoded relatively simply following the structure shown in **TABLE 9_06**. This record contains a significant amount of important information, but much of it is concatenated within the 'description' field. Thus, while the resource type of 'wreck' was suitable for the needs of the record creator, it was not suitable for mapping to the UO-CAT in anything other than a very basic manner. More significant detail, however, is present within the description, the *Abbey* is a wooden sailing vessel, which sank in 1819, providing clearer data for both what and when. One of the key tasks was that of information extraction (IE), drawing critical data from dense text fields to enable integration of datasets.

NPRN	MMRW Name	Description	NMRW Heritage Resource type	NMRW Cultural Period	MMRW Evidence	OSGB Grid Ref.
272340	Abbey	"This record consists of a documentary reference to a shipping casualty which has been assigned to the maritime named location HOLYHEAD HARBOUR pending more information which may allow a more precise location for the loss to be assigned. Event and Historical Information: The ABBEY was a wooden sailing vessel. At time of loss on 30 August 1819, it was carrying a cargo of china clay from Charleston, Devon, to Liverpool under the command of master Cowling. The vessel is reported to have run onto the back slope of the pier at Holy- head and to have been bilged. Sources include: Larn and Larn Shipwreck Database 2002 Lloyds List, 21 September 1819, issue number 5423 Maritime Officer, RCAHMW, June 2008."	WRECK	Post Medieval	Documents	SH2568882760

TABLE 9_06
Excerpt of a shipwreck record from the Coflein database.

As discussed in Pink et al (in press), this challenge did not come as a surprise. Within the archaeological literature there is a clear thread for over thirty years marking out this problem. As Aberg and Leech (1992, 165) noted, the 1980s had been a period of rapid data capture, with the hope being that the 1990s could be one of data linkage and integration. The hope was clear that some of the challenges created by rapid data creation could be solved through technological advancement. Interestingly, Aberg and Leech (ibid, 167) argue that focus need not be on visualisation (through emerging technologies like GIS), but increased accessibility and usability – it is very much a vision of a national collection of records. Sadly, as Richards (2006, 199) noted, things did not transpire as people had hoped. Instead, there was a surge of increased digitisation, but this increasingly digital record became no more coherent. As such, some of the challenges noted in the 1980s and 1990s remained in the datasets engaged with for this project. Fundamentally a number of these challenges relate to choices taken in data storage and data entry practices, pointing to the critical importance of these skills to bodies undertaking this task and, perhaps at key points in the past, an under-investment or under-valuing of them.

9.4 People and Machines

The prior understanding of potential problems with datasets led to exploration of other ways of adding depth and meaning to thin records. The large language models (LLMs) leveraged to enable artificial intelligence applications are only viable due to the significant amounts of training data available, and in many cases considerable amounts of human time and money (hundreds of millions of dollars) spent in developing them (Perrault and Clark; 2024, 64). Heritage data is never likely to directly receive such high levels of funding to permit rapid development of training datasets by commercial parties, and as such, a community-based approach was considered.

Barber (2018) noted the potential of ZOONIVERSE to enable crowdsourcing of data from within 'hidden collections'. ZOONIVERSE is a platform that allows large numbers of people to interact with datasets under set conditions. Thus, it becomes possible to invite the world to take part in your data challenge, be that tagging of images or writing improved metadata. While the focus of Barber's (2018) article was on the ability to generate accurate metadata for library catalogues, the possibilities with regards to the broader GLAM sector were readily apparent. ZOONIVERSE has hosted a range of innovative heritage focused crowdsourcing activities since its launch, leading to a white paper being published on its broader potential for the sector (Ridge et al 2023).

A discussion was had with all project partners with regards to data disparities and user expectations and interests. Specifically, we wanted to consider known gaps between interests amongst the broader population and what can be easily found within the national datasets. The result was identification of slavery as a key topic of interest, but one that produces surprisingly few (67) records if searched for on the National Monument Records. This is due to classificatory terms relating to ships and infrastructure often not reflecting that type of economic practice being undertaken. Thus, while a search for 'schooner' will produce 7,347 results, 'slavery' only produces three. While heritage professionals will understand this, other users wanting to access the record to understand this facet of the past would struggle to find relevant records. Graham Scott of Wessex Archaeology produced a list of terms that would help to highlight vessels which could have been associated with the slave trade, based on date and ports of operation, as well as drawing on information from the Slave Voyages database. Xiaohe Lu, an MSc student in electronics and computer science at the University of Southampton then built a Zooniverse project to allow testing of how crowdsourcing could be used to review records and highlight terms or in-text references that may indicate a vessel could have been associated with the slave trade. Two modes of operation were developed, one a straightforward flagging process (i.e. this record includes material that suggests it could have an association) and two a narrative construction, where known records could be elaborated on to bring different sources together. This trial demonstrated the potential of such a route, but also possible challenges in that while records could be flagged, determining the voracity of the link remained time consuming and based on traditional archival research methods. Thus, the flagging of 'possibles' increased, but not well evidenced examples. With greater digitisation of records this could, however, be radically improved. Thus, while in this instance Zooniverse was not seen as the solution to a complex problem, it did highlight the greater potential of crowdsourcing to resolve thin records and to help create linkage. In an industry that is unlikely to immediately attract large scale metadata and digitisation efforts at the scale needed to drive change, community generated content is likely to be key.

10. Voyages of Discovery 1 – People and the Sea

Ann Coats, Karen McBride, Tarek Teba (University of Portsmouth), Caroline Barrie-Smith (MOLA), Mark Beattie-Edwards (Nautical Archaeology Society), Alex Hildred (Mary Rose Trust), Julie Satchell (Maritime Archaeology Trust), Graham Scott (Wessex Archaeology)

Our first Voyage of Discovery was aimed at addressing the research aim 'How can we enhance the significance of submerged and displayed wrecks?'. By using a very wide range of different marine and maritime collections, we wanted to establish the answers to two specific questions:

- How can we establish what engages different people with historic wrecks either onshore in museums or offshore still submerged, and what does that mean for the way we as nations protect and provide access to them?
- How can we enhance the significance of submerged and displayed wrecks and thus increase audience engagement and prioritise management decisions?

In this chapter, the Collections are introduced as exemplars of challenges and opportunities for enhanced digital access to maritime collections. Then the methods, results and analysis of their case studies designed to attract new audiences and promote interest in underwater cultural heritage are described. Finally, recommendations are made to TANC to improve public access to a future national collection.

Proof of concept is evidenced through four linked case studies:

1. Evaluation of new animations to improve visitor engagement and explain unanswered questions and misconceptions about the *Mary Rose*.
2. Interrogation of dispersed archives relating to the *Holland* class submarines and a hackathon to create a Hollands prototype immersive for new audiences.
3. Development of the Needles Voyager Immersive, displayed at public events in the Discovery Bus, within a museum setting and online, to attract new audiences to explore the complex datasets of the Needles wrecks.
4. Exploration of personal connections to physically inaccessible wrecks through diverse community perspectives.

People and the Sea demonstrates that immense opportunities exist for imaginative interpretation through the senses, scientific research, advanced educational practice and public engagement using a variety of IT tools to make maritime sources available digitally in the future.

10.1 The Collections Sample: a Summary

Shipwrecks might seem a morbid basis for a research project, as they involve disaster, loss and frequently death. But wrecks also signify human creation, productive processes, communication, transference and drama. Ships represent communities of shipbuilders, suppliers of matériel, crew, passengers and cargo, many of these international, and coastal and underwater environments. They can be recovered physically through maritime archaeology, and recreated through art, drama, technology, documents, the senses and emotions. While not everyone can physically visit a shipwreck, People and the Sea has sought to bring the wonder of these phenomena digitally to new audiences to demonstrate the potential wealth of a national collection.

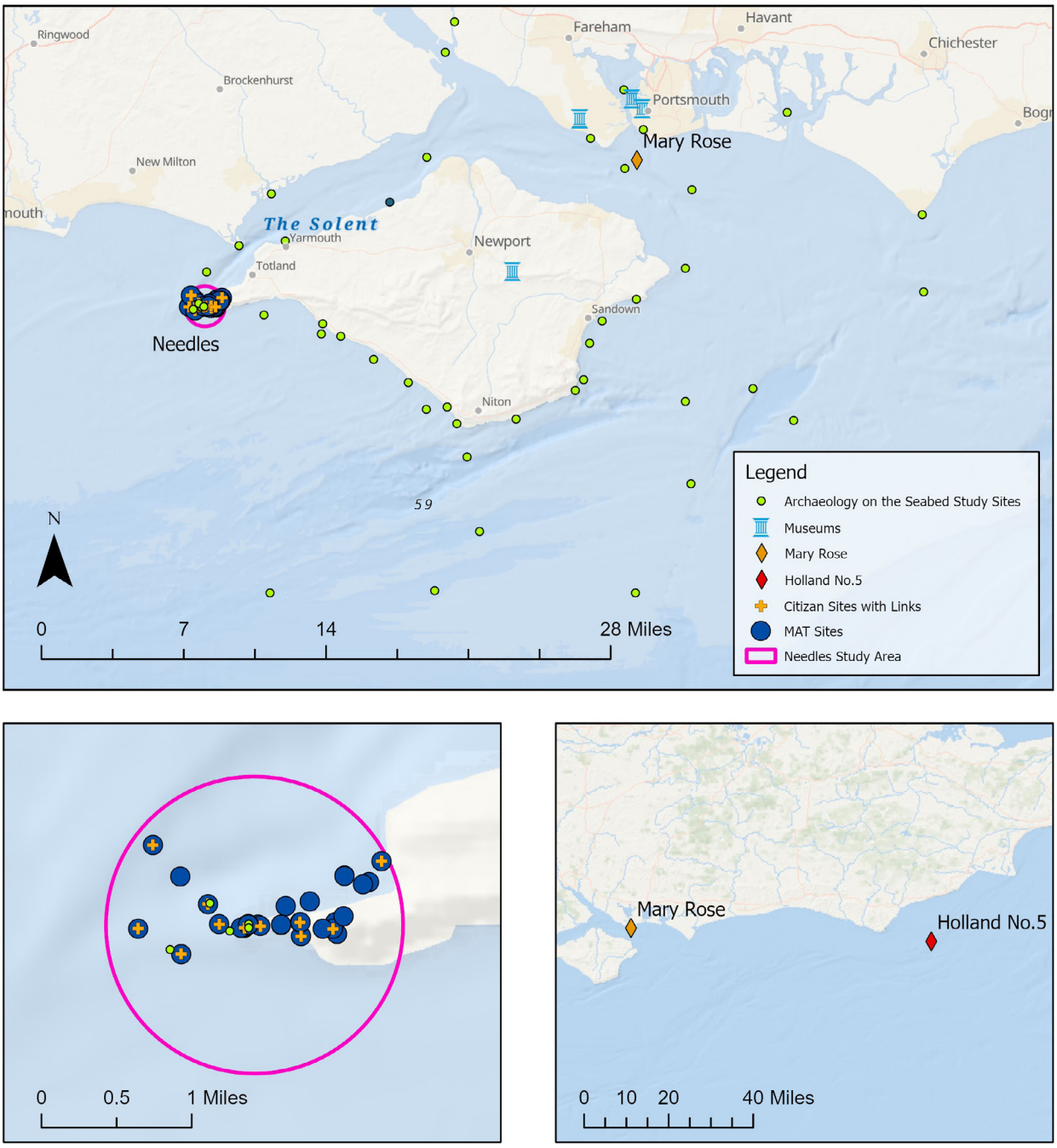


FIGURE 10_01
The position or area distribution of each of the collections used in People and the Sea. Jasmine Noble-Shelley, MAT.

People and the Sea case studies focused on shipwrecks and associated collections in the wider Solent area **(FIGURE 10_01)**:

- *Mary Rose* displayed wreck and submerged Protected Wreck site[71]
- *Holland 1* & *Holland 5*: displayed museum[72] and submerged Protected Wreck site[73]
- MAT Needles protected and unprotected wrecks: Voyager interactive[74]
- CITiZAN Solent area dataset and nationally linked sites[75]
- UoP Analogue Digital Connector: Collections[76], seven Needles wrecks
- UoP Immersive Co-creation Subgroup: MRT/NAS Hackathons, Observations, Holland Prototype

The physical vessel collections are the most visually accessible. The Mary Rose Museum in Portsmouth Historic Quarter displays the partial hull of *Mary Rose* (launched 1511, lost 1545) and recovered artefacts **(Figure 10_02)**, while the surviving seabed remains, protected under the Protection of Wrecks Act 1973, are invisible.

Government archives record the building, career and sinking of *Mary Rose*, but modern accounts document its excavation through 27,560 dives between 1979–82. Its archive includes diver's reports, dive management files, archaeologists' journals, underwater photographs and films, remote sensing data, specialist reports, artefact and conservation record cards, archaeological drawings, site plans, survey data, radiographs, and micrographs.

The Holland submarines were the Royal Navy's first submarine fleet, launched 1901–2. *Holland 1* is displayed in The National Museum of the Royal Navy (NMRN) Submarine Museum at Gosport **(FIGURE 10_03)**, and *Holland 5* is on the seabed **(FIGURE 10_04)**.

Admiralty and contractor archives and newspapers documented this controversially innovative form of warfare, their sinking under tow (*Holland 5*, 1912; *Holland 1*, 1913), and subsequent discovery. Crucially, they represent a unique era of British submarine development and were obsolete before deployment. *Holland 5*, sunk off Sussex, was protected in 2005 under the Protection of Wrecks Act (1973). It is the only Holland-class submarine on the seabed which can be studied by archaeologists and visited by qualified SCUBA divers.

All four sites offer a myriad of global connective opportunities and experiences through their innovative digital potential. Complementing these physical collections are the Solent shipwrecks underwater and associated archaeology in the intertidal zone. The Needles site, designated under the Protection of Wrecks Act (1973) lies off the Isle of Wight and includes HMS *Assurance* (1753), a 44-gun 5th rate frigate; *Pomone* (1811), a 38-gun 5th rate; along with wrecks representing 600 years of vessel, aircraft and cultural heritage with regional, national and international connections. The wrecks are linked to collections and archives relating to underwater archaeology (discovery and recovery), artefacts, ship types, ship losses, shipbuilding, shipyards, ship owners, naval documentation, crews, passengers, life on board, trade, conflict, UK and world ports, cargoes and origins. Alongside these wrecks we also integrated CITiZAN intertidal and coastal discoveries and archives in the vicinity[77].

---

71 https://historicengland.org.uk/listing/the-list/list-entry/1000075
72 https://www.nmrn.org.uk/visit-us/submarine-museum/hms-holland-1
73 https://www.nauticalarchaeologysociety.org/holland-no5-submarine
74 https://unpath.maritimearchaeologytrust.org/
75 https://archaeologydataservice.ac.uk/archives/collections/view/1003027/metadata.cfm
76 Gosport Diving Museum https://www.divingmuseum.co.uk/; Historical Diving Society https://www.thehds.com/; Naval Biographical Database https://www.navylist.org/; Newcastle University, Marine Technology Special Collection https://archiveshub.jisc.ac.uk/search/locations/81d1460a-645f-3c83-b547-0d8ff6a9b46e, https://archiveshub.jisc.ac.uk/search/archives/d13c89bd-cf95-39c3-8974-3ae0e481158f; Portsmouth Royal Dockyard Historical Trust https://portsmouthdockyard.org.uk/; University of Portsmouth Map Library https://library.port.ac.uk/maps.html
77 https://archaeologydataservice.ac.uk/news-events/citizan-archive/

FIGURE 10_02
The Mary Rose in its museum with adjacent display cases.

Photography © Stephen Foote by permission of Mary Rose Trust.

FIGURE 10_03
2022 Laser scan of the Holland No.1 submarine carried out by the Centre for Maritime Archaeology, University of Southampton.

FIGURE 10_04
Photogrammetry model of the *Holland No.5* submarine carried out in 2022 by InDepth Photography for the Nautical Archaeology Society.

We went beyond existing digital databases to develop new wreck narratives for the Needles Voyager interactive by surveying sample maritime collections which evidence the diversity of collections relevant to these Solent wrecks. These include records of Portsmouth Dockyard personnel who built and repaired naval ships; historic diving records and artefacts; detailed maps and charts of the Solent unavailable elsewhere; records of British shipbuilding, marine engineering, ship repairing and shipbreaking; and the Naval Biographical Database connecting 300,000 dates, 35,000 individuals and 7,000 ships.

We also used Historic England's National Marine Heritage Record, complemented by many internet sources, to explore how important and engaging physically inaccessible wrecks and regional losses can become through diverse community perspectives. This pilot explored disparate archives in different ways to reflect those audiences' interests.

10.2 Case Studies: Methodology, Results and Analysis

10.2.1 Mary Rose Museum

The Mary Rose Museum, supported in part by Unpath'd Waters researchers from the University of Portsmouth, evaluated new ways of interpreting its collection to re-engage and attract audiences and correct the misconception that all of *Mary Rose* has been excavated. Much of this work was either already in existence before Unpath'd Waters, or was being developed during the project. Unpath'd Waters research did however provide the focus for coordinated evaluation.

The Mary Rose Museum's breadth of research into human and animal DNA, tools, musical and navigation instruments, clothing and weapons was imaginatively refashioned by UoP's Centre for Creative and Immersive Extended Reality (CCIXR). The Enabling XR Enterprise Project (eXRe) explored how extended reality could engage visitors, educate, and entertain through innovative, creative, and immersive technologies. These assets were installed and tested at the Mary Rose Museum, Portsmouth Victorious Festival (65,000 visitors daily) and We Shine Portsmouth Festival of Light in 2022 (2,198 counted visitors). The following approaches were taken.

Holofan

A range of photogrammetry, lidar scanning, 3D modelling software, visual effects software and tools generated a 3D-rendered, looping animation of *Mary Rose* re-forming around the wreck. Strips of LED lights on four blades rotated at high speed generated holographic images and videos, creating the illusion of 3D objects floating in mid-air. Visitors experienced the wreck re-forming into the full ship, with visual effects showing its sails and flags billowing in the breeze. By recreating the hull's incomplete starboard side from contemporary and modern images, it interprets the incomplete structure.

456 visitor responses were captured, feedback was gathered on statements with a six-point scale of Strongly Agree (SA) to Strongly Disagree with a N/A option or as open-ended comment questions. The responses were typically positive.

- I learnt something new about the ship or the lives of the people on board from these devices. SA = 56%
- Using/viewing these devices offered a new insight into the story of the Mary Rose. SA = 55.9%
- Using/viewing these devices was a valuable addition to the museum. SA = 57.1%
- It was easy to use/view these devices. SA = 57.5%
- The content of these devices was clear and easily understandable. SA = 56.3%
- These devices were entertaining and enjoyable. SA = 55.9%
- Those strongly disagreeing never exceeded 2%.

VR Headset Tour 'Our Silent World' (OSW)

This was a narrated virtual reality tour of the *Mary Rose* which provided a direct connection between the skeleton hull, the displayed objects within the galleries, and the ship on the seabed during the excavation. Evaluation of 60 questionnaires about the experience gave some useful feedback about the use of VR. 14 respondents (23%) cited this as the experience they most enjoyed. They felt they were on a dive, and part of the original diver's experiences was their favourite part of OSW. 11 (18%) noted the VR experience, citing the ability to take in the whole environment as the aspect they enjoyed most. 10 (17%) said that the ability to see the ship from a new perspective was their favourite aspect, and 9 (15%) were impressed by the scale of the ship in OSW's final sequence. 6 (10%) people noted the graphics and "realism" of OSW as the aspect they enjoyed most. 21 (35%) had used VR technology before, 17 rated OSW as on par or above their previous VR experience, whilst one believed OSW to be of a lower quality than their previous experience(s).

Time Detectives: The Mystery of the *Mary Rose*

In a pioneering multi-sensory augmented reality game, players became time-travelling detectives tasked with solving the mystery of the *Mary Rose* sinking. Using a phone as a 'magical spyglass' to reveal past secrets, players followed a museum trail, based on their chosen 'character'. On their way they collected and interrogated clues to complete their mission for the king[78]. They received backpacks which triggered different scents at key moments, for example smelling gunpowder when a gun was fired. To gather information, trigger points activated talking photorealistic 3D characters created from forensic reconstructions of crew members.

FIGURE 10_05
Experiencing the Mary Rose Dive 4D immersive.

© and courtesy of Harvey Mills.

78 https://www.youtube.com/watch?v=L-YiGstQhKg

This was a challenge: the timetable for installation was too demanding; installation required trigger points for activating 'characters' and scents to be illuminated to work, which affected existing bespoke lighting for each display case; the ability of players to reach specific triggering positions during busy museum times was compromised; the scent technology was problematic and too bulky; and some earlier mobile phones did not support the game. Feedback reflected these difficulties.

Dive the Mary Rose 4D

Connecting the display galleries adjacent to the ship with the seabed excavation, this explained the techniques used to excavate, record and raise the ship. It also countered beliefs that nothing of importance remains on the seabed site. This is a permanent experience.

Designed for all audiences in a state-of-the-art 4D theatre, it combines archive assets, CGI and multi-sensory features, including sounds, smells, bubbles, wind and movement. It relates the ship's sinking in 1545, immediate attempts to lift the ship, and 20th century rediscovery. Visitors then journey to the wreck as one of the divers on the excavation. Donning 3D glasses, they are escorted to the seabed by an original diving archaeologist. They witness the gradual exposure of the ship and artefacts and see other archaeologists excavating, recording and recovering objects, before watching the lifting of the hull. The final sequence covers dives in September 2022 with a clear message: this is still a Protected Wreck Site, and more is to be found **(FIGURE 10_05)**.

Evaluation explored how immersive experiences are perceived and identified visitors' current reactions to museum collections/experiences. It sought to verify what audiences think of immersives, what they want from them, and to articulate the social value of the heritage assets. Different audiences (general visitors, academic/researchers and the Bangladeshi community) were tested at different times.

Observations enabled prolonged and immersed access to audience actions and interactions during the immersive experience, permitting capture of spontaneous and unexpected activities/experiences/interactions. The follow up survey captured participants' immediate overall impression of impact, cultural value and engagement and emotional responses. A focus group sought to dive deeper into audience reflections and capture more information to contextualise responses.

The team conducted four observation and survey sessions:

- General audience 1–7 April 2023: 68 participants (25 observations + 68 surveys)
- Academics/Researchers 8 June 2023: 12 participants (4 observations, 12 surveys + 1 focus group session)
- Bangladeshi Community Group (1): 8 Nov 2023: 14 participants (4 observations + 14 surveys + 1 focus group session)
- Bangladeshi Community Group (2): 2 Feb 2024: 13 participants (2 observations + 13 surveys + 1 focus group session)

Participants rated the Mary Rose 4D Experience using five global experiential quality dimensions on a scale of 1–5, with higher scores indicating a more positive perspective (e.g., Good vs. Not Good, Powerful vs. Not Powerful). The Mary Rose 4D Experience is generally well-received, with high ratings across all quality dimensions, particularly for its uniqueness and storytelling aspects.

Most participants rated the experience as 5, with an average rating of approximately 4.78, indicating very high overall satisfaction. The 4D experience was generally perceived as powerful, with a significant majority giving it the highest rating. Most participants gave high 'memorability' ratings, indicating that respondents mainly found the experience memorable. 50 participants (87%) agreed or strongly agreed that the experience was different from what they had encountered before, while 50 participants (87%) also agreed or strongly agreed that the experience allowed them to explore new stories. The survey results suggest that the Mary Rose 4D experience is perceived as highly unique and engaging by most of the general audience participants.

The survey also used questions related to the perceived cultural value of the content. Most respondents rated the Mary Rose 4D Experience very positively. 75 respondents rated the experience as a 5, indicating that they found it very interesting. On average, participants viewed the Mary Rose 4D Experience favourably in terms of whether they would want to experience it again, reflecting a strong inclination towards it being an enjoyable activity. A significant majority of participants rated it as a 5 (42 out of 63 responses), indicating a widespread desire to repeat the experience.

Participants clearly felt that the Mary Rose 4D experience was personally relevant, with 68% indicating agreement (Agree or Strongly Agree) with the statement "I felt like the Mary Rose 4D experience was made for me." In terms of comfort, responses were varied: 42% agreed or strongly agreed that the experience sometimes made them feel uncomfortable, while 31% were neutral, and 27% disagreed or strongly disagreed with this statement. In terms of intellectual challenge and provocation, a substantial majority (73%) agreed or strongly agreed that they felt challenged and provoked during the experience. Similarly, most participants (70%) agreed or strongly agreed that the Mary Rose 4D experience opened their eyes to new ideas.

Mary Rose Hackathon

Project partners and students from the University of Portsmouth formed a co-creation 'community of researchers' who addressed one problem in depth for a week. This Hackathon explored methods of engaging multi-disciplinary students in finding solutions to communicate and engage audiences in unfamiliar heritage data (historic DNA). The brief was to design and build an interactive innovative interface communicating data relating to mitochondrial DNA (mtDNA) extracted from the human remains collection excavated from *Mary Rose* and sequenced. The challenge was to take potentially intimidating mtDNA sequence data and present it invitingly to a non-specialist **(FIGURE 10_06)**.

One team targeted researchers and built a data navigation method using a coding system and motion capture controller for an immersive experience. A second team targeted children and built a gameified and interactive illustrated experience to engage the younger generation/children with the data through interactive narratives[79].

The effort to cross disciplinary boundaries was rewarding. It generated a wide range of valuable ideas and innovations not typically produced within traditional disciplinary silos. The diversity of group membership created a diversity of creative innovation which yielded many insights and explored directions not previously considered by the owners of the maritime heritage data. How the community of researchers established a routine and common language, evolved prototypes, and overcome obstacles was instructive. There are clues and markers here for how a wider public might engage with a national collection.

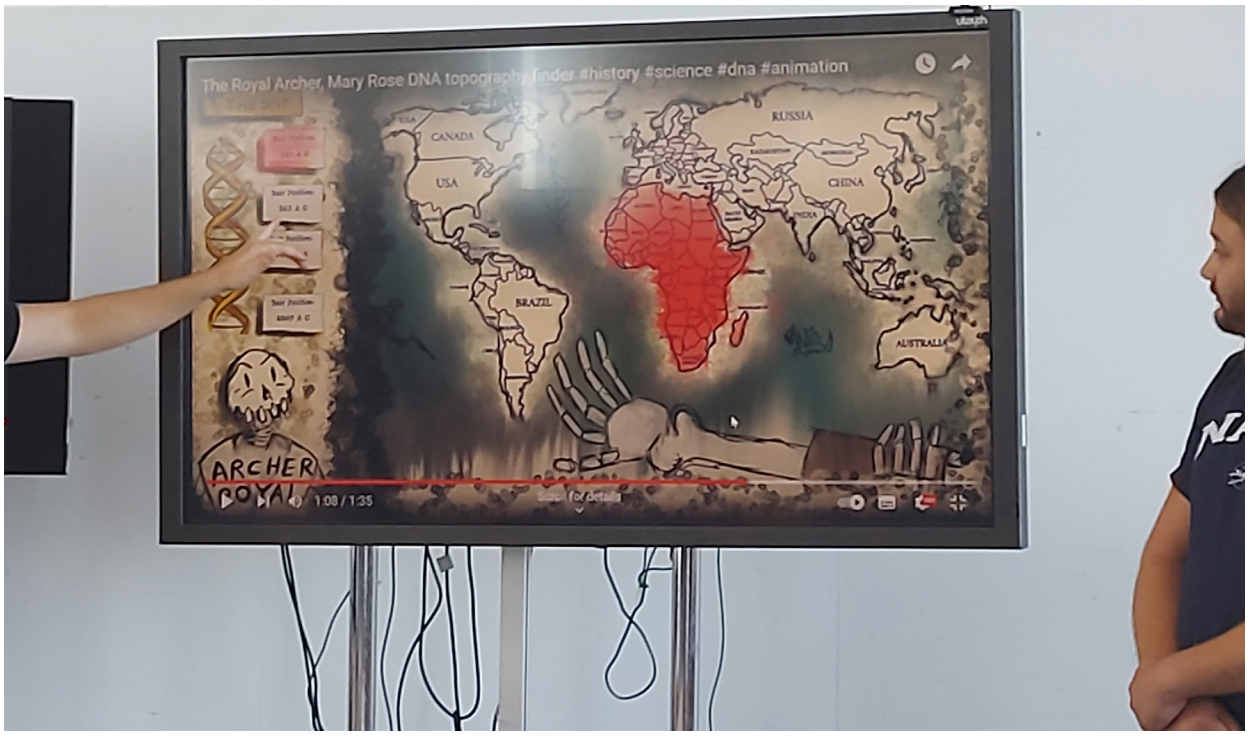


FIGURE 10_06
Developing the aDNA Mary Rose Hackathon.

79 YouTube https://www.youtube.com/watch?v=u-XB7R19LYQ The Royal Archer

10.2.2 *Holland 1* and *Holland 5*

The aim of this case study was threefold – to test what collections we *couldn't* see digitally which related to the history and archaeology of the two submarines, to create a digital model of the *Holland 1* which could be incorporated into an immersive, and to use a hackathon approach to create an interactive prototype to integrate the digital collections for both submarines.

Members of the Nautical Arch has visited and documented the *Holland 5* wreck since 2010, initially through its Education Programme where students studied an early submarine class on the seabed. A virtual diver trail already allows online exploration of the wreck[80] . This was one of the first developed for underwater historic assets and included a tour of the wreck and the Holland class history.

The subsequent enriched programme drew on the following sources:

- Existing surveys, investigations and condition assessments of Holland 5 (NAS 2014, ADU 2000 and 2001, and Wessex Archaeology 2006, 2007, 2008, 2008b, 2012). It included the archive of Gerry Dowd, finder of Holland 5, and information from the current protected wreck licensee, Sara Hasan.
- The National Archive (ADM 12 (Admiralty) and DEFE (Defence)) was consulted to reveal the geopolitical context for developing the submarine fleet, the loss and salvage of Holland 1 and the loss of Holland 5.
- The National Heritage List for England was consulted (Hob Uid: 1397999) for Holland 5's wreck site as a Protected Wreck.
- Cumbria County Council Archives hold four images of Holland submarines, built in Barrow-In-Furness, available digitally on request. Vickers-Maxim boatyard archives, now operated by BAE Systems, are held by the NMRN.
- National Museum of the Royal Navy curates and displays Holland 1 at the Submarine Museum in Gosport with the first submarine fleet items and documents. Online access is available to a catalogue of 121 documents, 47 technical drawings, 8 photographs, 5 fittings, and 1 silver snuff box[81] (Object Number RNSM G02/2/82).
- In 2023 NMRN created a tile on their archives webpage, making the Holland collection more accessible. As at 2024 digitisation of the Holland archive is incomplete but facilitates access to the Royal Navy's first submarine fleet.
- University of Cambridge Library online ArchiveSearch[82] revealed several images of the Holland submarines from the Vickers-Maxim archives and Admiralty contracts with Vickers-Maxim to build the five Holland boats.
- The UK Hydrographic Office Taunton (UKHO) holds a letter (HD667-1912) from *HMS Harrier* at Portsmouth, 10 August 1912, describing Holland 5's loss under tow from Portsmouth to Sheerness. *HMS Harrier* assists the tug Enterprise in searching for the 'derelict submarine'.
- Archaeology Data Service (ADS) ArchSearch reveals 'Ultrasonic thickness measurements of the *Holland No.5* and the HMS m/A1 submarine' (Wessex Archaeology 2012) and '2006 Designated Site Assessment' (Wessex Archaeology 2006). "Submarine" returns HMS/M A1 condition survey[83].
- The Wellcome Collection holds 'The Navy and Army Illustrated': 5 April 1902 issue covering the first Royal Navy submarine's launch and trials **(FIGURE 10_07)**.

80 https://www.nauticalarchaeologysociety.org/holland5-dive-trail
81 https://collections.nmrn.org.uk/results
82 https://archivesearch.lib.cam.ac.uk/ https://archivesearch.lib.cam.ac.uk/search?utf8=%E2%9C%93&op%5B%5D=&q%5B%5D=Holland+Submarine&-limit=&field%5B%5D=&from_year%5B%5D=&to_year%5B%5D=&commit=Search
83 https://archaeologydataservice.ac.uk/archives/view/hmsa1_medin_2012/

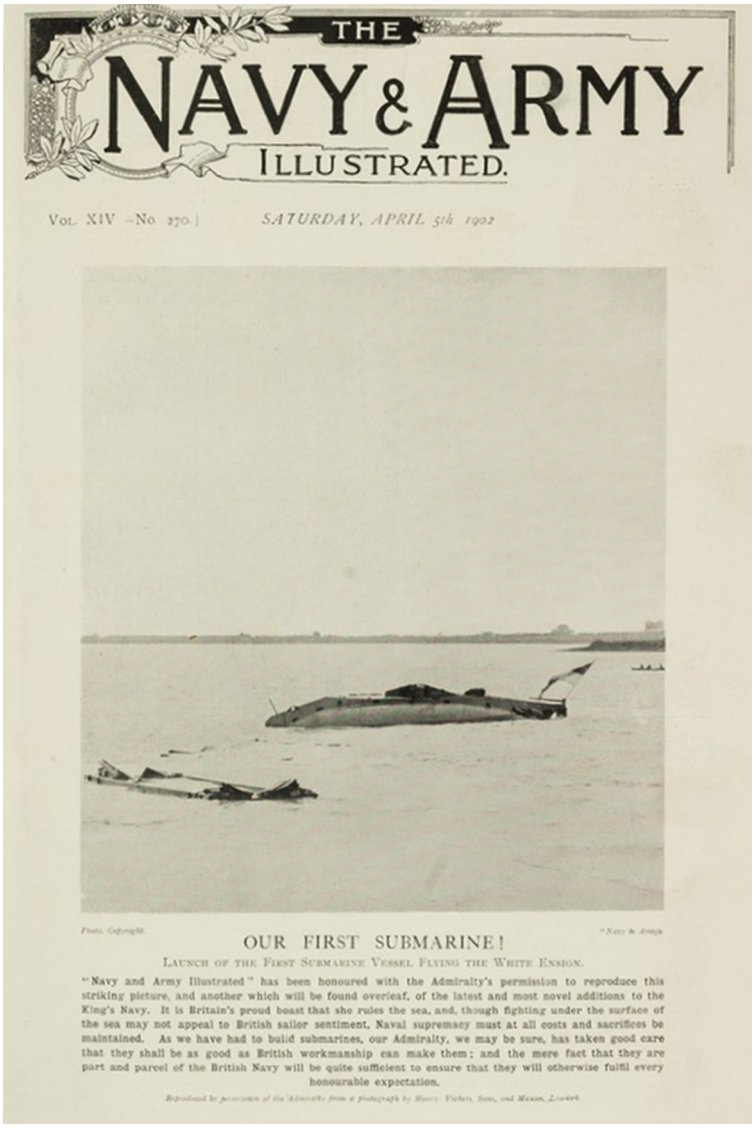
- Royal Museums Group Greenwich displays a hull model (SLR0111) in the Sea Things Gallery and depictions of the Holland class submarines, including a drawing of a Holland-type submarine in Portsmouth Dock No. 6.
- Hansard UK Parliamentary Archives hold material on Holland submarines and decisions to focus effort and resources on developing submarines[84]
- The British Newspaper Archive includes numerous entries for interesting stories of the development, ordering, building, testing, service history and loss of the Holland submarines (including Derby Daily Telegraph (17/3/99), Scarborough Evening News (9/5/99), The Weekly Dispatch (London) (11/8/12), Hull Daily Mail (12/8/12), and Leicester Evening Mail (10/08/24).

Holland Digital Survey

To enrich audience experiences of *Holland 1* and *Holland 5*, new visual digital data was created to enable audience engagement testing through an immersive viewer. These data included a laser scan of the exterior and the interior of *Holland 1* for the immersive viewer (see **FIGURE 10_02**) and a new photogrammetry survey of the *Holland 5* wreck site (see **FIGURE 10_03**).

FIGURE 10_07
Our First Submarine! The Navy and Army Illustrated, April 5th 1902.

Credit: Navy and Army Illustrated.
Source: Wellcome Collection
CC BY-NC 4.0.



THE NAVY & ARMY ILLUSTRATED.

Vol. XIV.—No. 270.] SATURDAY, APRIL 5th 1902

OUR FIRST SUBMARINE!

LAUNCH OF THE FIRST SUBMARINE VESSEL FLYING THE WHITE ENSIGN.

"Navy and Army Illustrated" has been honoured with the Admiralty's permission to reproduce this striking picture, and another which will be found overleaf, of the latest and most novel additions to the King's Navy. It is Britain's proud boast that she rules the sea, and, though fighting under the surface of the sea may not appeal to British sailor sentiment, Naval supremacy must at all costs and sacrifices be maintained. As we have had to build submarines, our Admiralty, we may be sure, has taken good care that they shall be as good as British workmanship can make them; and the mere fact that they are part and parcel of the British Navy will be quite sufficient to ensure that they will otherwise fulfil every honourable expectation.

84 https://hansard.parliament.uk/Commons/1899-03-13/debates/b7705b2b-282f-41d9-8879-63df10241865/NavyEstimates1899%E2%80%931900

Holland Hackathon

A competitive Hackathon was set up involving 15 students from science, humanities, business, art, creative and digital practices at University of Portsmouth to work in teams. They were tasked to co-design an innovative interactive interface to link and improve access to the 'new' Holland archival collections. They also explored what engages different people about data and heritage aspects of museum and submerged historic wrecks, and the implications for the way nations protect and provide access to them.

A second phase developed this concept into a working digital interactive prototype in collaboration with NMRN Submarine Museum in Gosport. The new visualisation interactive, called the Holland Submarine Fleet Explorer (Prototype), with the generous support of NMRN staff, was tested on Submarine Museum visitors to collect their feedback **(FIGURE 10_08)**.

Key findings were:

- Very low pre-existing awareness of the presence of Holland 1 at the museum, and the role of Irishman John Philip Holland. Zero knowledge that Holland 5 exists or that Holland 2, 3 and 4 were in the first Royal Navy submarine fleet.
- Visitors found experiencing the Holland Explorer (Prototype) positive because they could dive into themes through their own interests and navigate directly to certain stories. Visual media in the prototype was particularly favoured.
- A key point of engagement was around people (eg John Holland, Captain Bacon, the first crews of the submarine fleet).
- Key visitor learnings were: increased awareness of the existence of the five submarines, Holland 5 under water, how they were found, the story of the raising of Holland 1 and its journey to Gosport.
- School children engaged well with the experience and the text. As the Explorer was not specifically designed for children, this countered research team expectations.

FIGURE 10_08
The University of Portsmouth team hosting a Holland Submarine Explorer (Prototype) testing session at the Royal Navy Submarine Museum.

10.2.3 Maritime Archaeology Trust Needles Voyager

Maritime Archaeology Trust designed the Needles Voyager Interactive to provide new ways for audiences to explore Needles maritime archaeology. Voyager digitally connects collections relevant to the Needles Protected Wrecks, nearby non-protected wrecks, crashed aircraft and maritime shoreside features **(FIGURE 10_09).** Visitors can explore an interactive map geographically to discover maritime archaeological stories. These are based on sources (reports, photos, audio, video, 3D models, linked sites) or themes such as individual ships, artefacts, ship types, shipbuilders/yards, ship owners, documentation, crews, passengers, ports or cargo.

Development benefited from a simultaneous project (Fathoming the Future) where volunteers digitised MAT archive material and developed new digital, significantly enhanced outputs. Content was enriched by audio articles, site summaries, digitised historic reports and a Needles wreck-inspired poem in text and audio form. Local contributions include an extensive collection of artefact photographs from the Needles excavations from the Isle of Wight Museum Service and historic photographs and postcards of the former Alum Bay Pier from the Carisbrook Castle archive. This demonstrates potential for linking local archive sources.

MAT's database benefited from a new 'archives links' table which includes data from the Unpath'd Waters collections sample. Clicking on these links opens a new Voyager window to online content, without leaving the application, and connects Needles sites to related online archive material:

- HERR data through Heritage Gateway
- TNA entries
- Lloyds Register Foundation documents – plans and surveys
- Royal Museums Greenwich – photos and archive
- ADS Unpath'd Waters Portal entries
- CITiZAN entries
- Wrecksite.eu entries
- Crew List Index Project
- Specialist websites for different vessel types such as Naval-history.net, NavSource, U-boat.net, Tyne Built Ships, RNLI archives.

The Voyager is available online[85]:

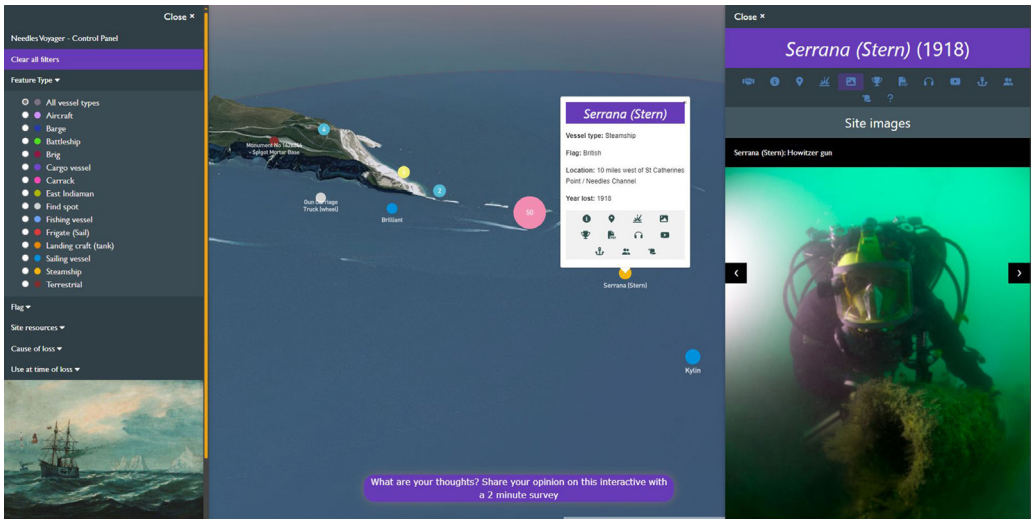


FIGURE 10_09
The Needles Voyager showing the stern section of the Serrana wreck selected with an underwater diver image being viewed (MAT).

85 https://unpath.maritimearchaeologytrust.org/

CITiZAN and Needles Voyager

Maritime and coastal features in the Needles Voyager were cross-referenced with CITiZAN's dataset to find links. For example, sites with a narrative link to the *Campen* (a Dutch East India Company vessel) included the *Vliegende Draeck* (CITiZAN Id: 58462) which accompanied Campen and was fatally damaged on the same passage and subsequentially beached at Yarmouth. Linking Needles Voyager features to the broader CITiZAN dataset increased the narrative depth of Voyager and provided the public a broader understanding of the subject feature. The inclusion of the CITiZAN dataset within Voyager significantly increased viewers to CITiZAN's dataset, a good vindication of public engagement with Voyager.

Analogue Archives and Needles Voyager

MAT's Needles/Solent/Channel wreck datasets were enriched by detailed exploration of physical archives to enhance the Needles Voyager interactive by curating new shipwreck stories. This helped us map where online access to digital data ends and where analogue archives have the potential to enrich identities of place and people.

The selection criteria for Needles wrecks were:

- Located within a 2.5km radius of the Needles wreck site
- History appealing to audiences
- Prior Solent/Channel relationship (built/habitual visitor)
- Scarce related digital/analogue data available
- Representative vessel classification (RN/commercial/type/size)
- Representative date range

The selected Needles vessels wrecks based on the criteria were:

- *Campen/Kampen*: 1627 Dutch East India (Vereenigde Oostindische Compagnie, VOC) yacht or pinnace
- HMS *Looe*: 1705 5th Rate frigate
- HMS *Incendiary*: 1780 fire ship
- *Queen Charlotte*:1815 troop ship
- SS *Serrana*: 1918 cargo and passenger ship
- *Anglo Saxon*: 1879 Channel Island brig

A detailed report of the rich stories uncovered about these six wrecks during this enhancement process can be found in https://doi.org/10.5281/zenodo.14837162. Four records are now available on the Voyager from ADC on VOC Kampen, HMS Looe, HMS Incendiary and SS Serrana[86].

Publicly Testing the Needles Voyager

Embedded within Voyager is a feedback survey based on Unpath'd Waters' project-wide evaluation questions developed as part of Work Package 5 (see **Chapter 14**), with additional research questions to help achieve the research aims of the People and the Sea work.

Of the 99 survey responses completed 64% were from the SWC, 23% online and 12% on the Discovery Bus. SWC's larger number of surveys is likely due to some free open days where staff were specifically encouraging survey responses, with paper-based versions also available. Detailed information is included in the supporting Research Report: what follows is a summary of the results.

86 https://unpathdwaters.org.uk/dive-in-to-the-needles-voyager/

Where gender was indicated, there was an almost equal female/ male split. A good spread of ages responded: 4 under 16, 6 = 16–18, 6 = 19–25, 8 = 26–35, 16 = 36–45, 14 = 46–55, 12 = 56–65, 17 = 66+. Of ethnicity responses, the vast majority were British or English (many choosing White British); one indicated European. Under employment status there were 11 students, 18 retired, 37 employed full time, 14 employed part time, 1 not in work.

Asked if Voyager provided something different from what they had experienced before, 82% either 'agreed' or 'strongly agreed', 14% were neutral, with four respondents either 'disagreeing' or 'strongly disagreeing'. This indicates that access to shipwreck stories in this format provided a new experience for many.

92% of respondents agreed or strongly agreed that the Needles Voyager allowed them to explore new shipwreck stories. A considerable range of dates and types of wrecks were mentioned as popular, with some preference for First and Second World War wrecks. Of the two better-known Protected Wrecks *(Pomone* and *Assurance*) only *Pomone* was mentioned in comments. There was no obvious preference related to associated linked resources or material.

In terms of types of information available on Voyager, 'wreck and site information' was most popular, with 'people', 'artefacts' and 'photos' also popular. Neutral or negative feedback was very low (3% of respondents).

60% of respondents agreed or strongly agreed that 'Voyager was made for me', suggesting that they found information or stories that resonated with them. 33% were neutral, and 7% disagreed. 20% had difficulties using Voyager. Suggested improvements included having instructions on use (it does), date and wreck name search function, adapted for mobile devices, and visual design modifications. However, improvements could be made here.

Asked if they were moved by the Needles Voyager 85 responded, 5 disagreeing (6%), with 41 neutral (48%) and 39 agreeing or strongly agreeing (46%).

10.2.4 Archaeology on the Seabed: Audience-Driven Narratives

Archaeology on the Seabed (AotS) sought to explore the interests and reactions of specific individuals from diverse backgrounds to themes relating to wrecks within the Solent sample area. Five global geographic themes were identified (South Asian connections; Caribbean connections; African connections; Far and South East Asian connections; South Sea and Australasia connections) and one environmental theme (Environmental damage and risk).

Historic England records of shipwrecks and recorded vessel losses within the territorial waters of the Solent, Isle of Wight and inshore areas formed the base dataset. Data enhancement used online sources, including Lloyd's Register Foundation archive of ship plans and records and the Crew List Index Project for crew and other records. Specialist online searches were undertaken for selected themes. Wreck and loss records relevant to each theme were then enhanced using these data.

Co-creators recruited through internet searches and word of mouth for all the themes, except the last, were not from a White British background. For example, a volunteer from the African Women's Forum was sought in respect of the African and Caribbean connections theme through that organisation's website. Five co-creators were recruited through community groups or word of mouth. This was a different audience recruitment method to the systematic approach adopted for our three main target audiences (see **Chapter 6**), and in retrospect this was an opportunity to deploy a more systematic approach that was missed.

These volunteers critically examined the existing historic record and co-created new narratives. Each volunteer selected wrecks or losses from a theme that interested them, and commented on the enhanced assessment of each vessel, to identify what was engaging and significant to them and the groups or communities with which they identified. This occurred through an online person-to-person discussion between the co-creator and the researcher, who subsequently sent a summary of the notes to the co-creator for approval.

Although a small study, it has demonstrated considerable scope to enhance our knowledge of shared maritime archaeology and its significance by working with new and diverse voices. Salient findings are summarised here.

Two of the contributors (British South Asian background, with prior interest in maritime heritage) selected one wreck, the HMS Sphinx (launched in Bombay Dockyard and lost in the Solent in 1846),

because of familial ties to the Parsi Wadia family who operated the dockyard. They referenced the Indian contribution to the Royal Navy (30 ships), the era of trade between Britain and India at the time, the potential to link maritime and terrestrial monuments, and the lack of stories about the Indian crews on board British ships.

One contributor, a member of the African Women's Forum, with a strong connection to Portsmouth, was interested in the ability of maritime heritage to provide Black role models for young people in the city, and was concerned that the current national record paid insufficient attention to the associations between the ships and Black people. Personal, community and ethnicity connections are important, and ethnicity and national identity are significant drivers of interest in maritime heritage in sections of the UK public.

Contributors who engaged with the Environmental damage and risks theme, all White British, were recruited through environmental lobby groups, and were interested in understanding historic wrecks in terms of their impact upon the environment. Interest was expressed in drawing parallels between historic wrecks and the contemporary environmental campaigns and it was felt that the existing national heritage records did not provide enough information to determine which wrecks might be of interest.

10.2.5 New Engagements, New Forms of Significance

The analysis of how people reacted to the different engagement case studies, and how this was evaluated can be found below in **Chapter 15** and **Section 16.2**. A summary of how we achieved our research aims is presented here.

The different case studies developed by the People and the Sea team provide convincing evidence of what engages people with wrecks. This combined genuine discovery, improved access to otherwise inaccessible sites, much enriched exploratory routes both in terms of the context of a wreck site (where/when and what else may lie nearby) and in terms of the depth of available knowledge about it. It also demonstrated an appetite for a range of media by which to access the collections (text, video, oral, images etc). Of great significance was the appetite for the people-centred stories – the wrecks are hooks for much richer information about the people whose lives revolved around or were touched by them. This was particularly notable in the conversations with members of South Asian groups, where familial ties were key. Some audiences responded well to, and offered, provocation – a challenge to think about new narratives. We were struck in this context by the interest in non-heritage values, such as environmental concerns.

It was noteworthy that those selecting favourites in the Needles Voyager case study did not pick the most well-known and well-publicised of the wrecks – *Pomone* and *Assurance*. Instead, they picked out other far less well-known stories. This suggests that engagement is self-driven not 'marketing'-driven and that the enhanced choices through connected collections permitted these selections.

The lessons from wrecks in museums is the complexity of the relationships between observer/experiencer and the totality of the wreck. A museum wreck's physicality is one thing (scale was mentioned in the context of *Mary Rose*) but its temporal trajectory (conceived, built, launched, travelled, lost, found, recovered, conserved, displayed, experienced) and the people and things associated with it (stories, artefacts) are clearly another vital set of engagements, for which museums are well-equipped to reveal. We can show that undertaking this with wrecks below the water works, perhaps not as well, but certainly to a much greater extent than is currently possible.

The work may in the future have significant implications for how wrecks are selected for protection, and how, once protected, their significance might be shared. For example, in England and Wales, the Protection of Wrecks Act 1973 Act is used where a wreck is seen to be worth protecting "on account of the historical, archaeological or artistic importance of the vessel". In Scotland, the Historic Marine Protected Areas are designated to "help preserve our most important marine historic assets and to celebrate and communicate their heritage value so that everyone can appreciate these assets and act responsibly." Both of these devices focus on importance. Combining collections provides a challenge and opportunity to think about what kinds of importance might influence the selection of a candidate for protection in the future, and what role the public could play in that process.

The conclusion is surely that we are absolutely bringing Protected Wrecks and their stories, alongside other known wrecks, into far greater focus for a much greater audience.

11. Voyages of Discovery 2 – Science and the Sea

11.1 Introduction

Michael Roberts and Rory Quinn

The aim of Unpath'd Waters Work Package 3.2 'Science and the Sea' was to investigate ways of enhancing our current understanding of Underwater Cultural Heritage (UCH) by integrating collections of marine scientific data with the historic record and maritime related collections. Using the Irish Sea as the principal setting with a smaller, more focussed study area located to the west of the Isle of Man (IOM) known to contain several unknown wrecks and missing vessels as an 'Unpath'd Waters Project Pilot', our aims were to:

- Integrate scientific data (principally multibeam sonar) with maritime archives (loss records, vessel plans, newspaper reports etc) to increase the proportion of identified and confirmed wrecks in the study area.
- Apply scientific data at regional and local scales to develop a preservation potential model quantifying and incorporating risk factors to aid in the prediction of site-specific development trajectories.
- Utilise marine collections and maritime archives to develop new/novel narratives focussed on vessels newly identified/confirmed through this research or listed as missing in the study area.
- Develop novel applications for combining marine scientific data with the historic record to improve knowledge and management of UCH.

The offshore, shelf sea marine environment, with water depths ranging from 30m to 250m, contains numerous sunken vessels. The UK's Exclusive Economic Zone (EEZ) contains more than 9,800 charted wreck sites (UK Hydrographic Office open licence data 2021[87]). Most of these sites have been surveyed and documented at least once since the introduction of sonar survey technology in the early 1970s. However, a significant proportion (>30%) still remain classified as 'unidentified' or 'unknown'. Some 3,000 of these lie in the Irish Sea.

Between 2012–2023 Bangor University surveyed 583 shipwreck sites located in the Irish Sea region. Data from 273 of these surveys were used to help determine wreck identities (McCartney 2022). The study demonstrated that as well as vessels classified as 'unknown', a significant proportion of wrecks have been incorrectly identified, and that confidence in shipwreck identification could be significantly enhanced by combining wreck survey data with relevant historical archives. 67 previously unknown wrecks (24.5%) were identified and 62 wrecks (22.7%) had their identities revised – a total of 47.2% modified.

A substantial amount of marine survey in the Irish Sea has also been undertaken via the INFOMAR programme[88], which has primarily focussed on areas within the Irish EEZ, providing data coverage from over 480 wreck sites.

Wreck sites are primarily examined from a navigational safety perspective. However, a dramatic increase in the use of offshore communication and energy infrastructure development has led to a demand to improve knowledge and management of Underwater Cultural Heritage (UCH) assets within areas scheduled for development. In addition, there are growing concerns about the potential 'toxic legacy' shipwrecks may pose to marine wildlife and the nearshore marine environment. For these and other reasons, numerous policy documents relating to the cultural heritage of the Irish Sea note the importance of enhancing our knowledge of these wrecks.

---

87 Available via https://www.admiralty.co.uk/access-data/marine-data
88 https://www.infomar.ie/

The Science and the Sea team have attempted to build on this earlier research using new surveys on a sample of 122 charted wreck sites situated to the west of the Isle of Man (IOM). The resultant data has provided us with a unique opportunity to further refine this field of research **(FIGURE 11_01)**.

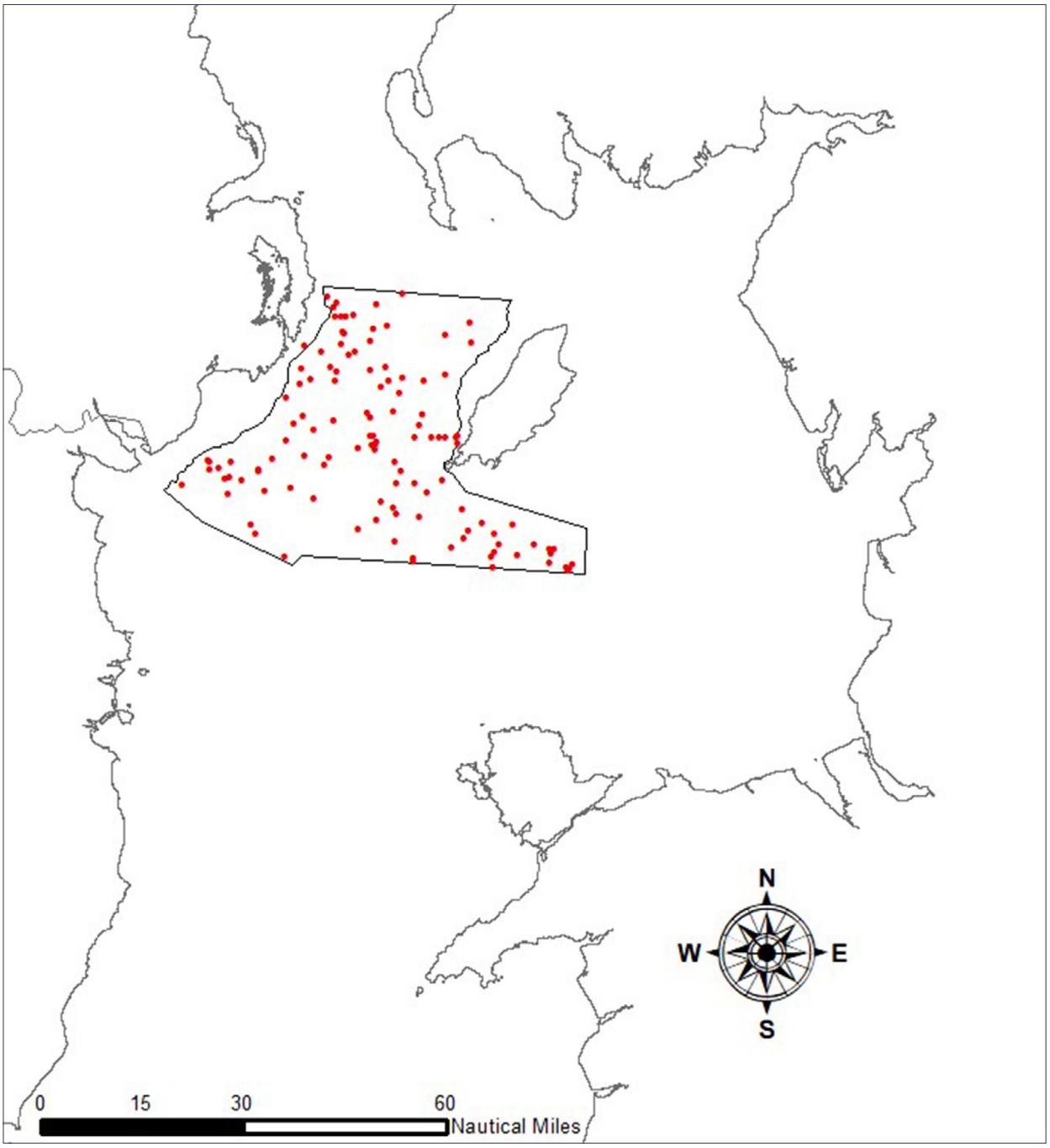


FIGURE 11_01
Isle of Man study area and charted wreck sites surveyed in 2020/23.

11.1.1 The Irish Sea and Isle of Man Study Area

The Irish Sea, bounded by the land masses of Ireland and the United Kingdom, is relatively sheltered and open south to the Celtic Sea and north to the Malin Sea. Central depths range from 80m to 200m. It consists of the deeper 300km long and 30–50km wide north-south St George's Channel to the west, with shallower embayments to the east. Being open-ended the channel receives Atlantic Water and influences from the north through the North Channel and from the south via the Celtic Sea and St. George's Channel. Two large islands are located to the east of the main channel, the Isle of Man and Anglesey. The study area is shown on **FIGURE 11_02**. (Bathymetric data is from EMODnet[89]).

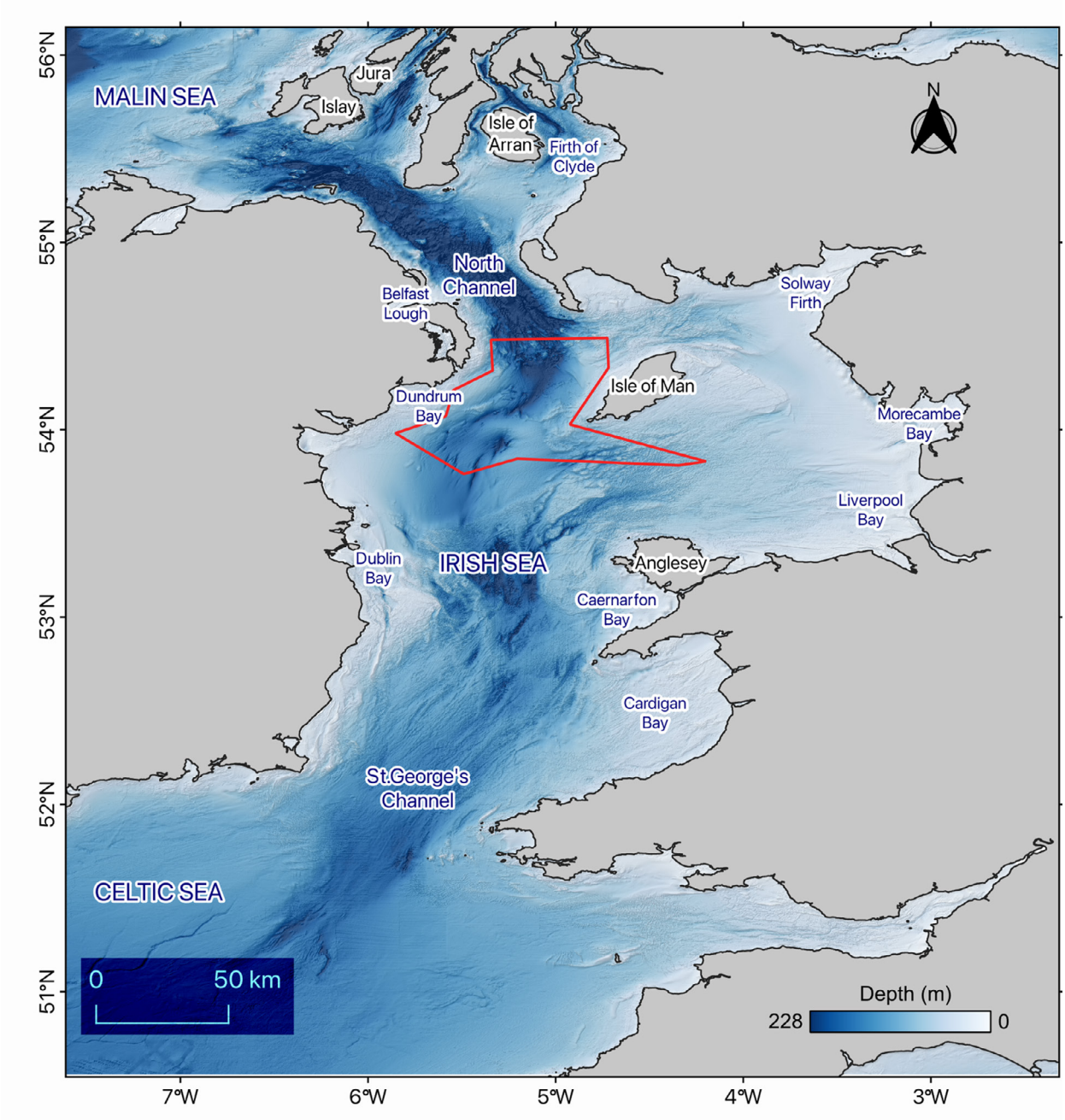


FIGURE 11_02
Bathymetric variation in the case study 1 study area. The case study area around the Isle of Man is highlighted by the red polygon.

89 https://emodnet.ec.europa.eu/en/bathymetry

Away from coastal regions and fluvial inputs, the Irish shelf seafloor comprises a layer of mobile sediments, predominantly reworked glacial and postglacial sediments (van Landeghem et al., 2009). Over most of the region, semi-diurnal tides are the dominant physical process (Howarth, 2005). Tidal range varies from 10m in Liverpool Bay on the largest springs, to regions of very small tidal range at amphidromic points near Arklow (Howarth, 2005). In the weaker tidal regions, the seabed comprises sand and mud, with a large depositional centre in the western Irish Sea (Western Irish Sea Mud Belt), where deeper water and weaker tidal currents have resulted in the accumulation of approximately 40m of Holocene mud (Coughlan et al., 2021).

A pronounced seasonal cycle in temperatures distribution in the Irish Sea results from vertical exchanges and heat input at the surface (Howarth, 20115). The annual mean temperature varies between 10 and 11°C, coolest in February and March and warmest in August. Salinity decreases from 35ppt at the southern end of St. George's Channel to 34ppt in the North Channel (Howarth, 2005).

Pressures on the environment arise from fishing, trade, industrial and urban waste, hydrocarbon extraction, and development of offshore renewables and leisure activities (Sharples and Holligan, 2004).

11.1.2 The Irish Sea Wreckscape: An Historical Characterisation

Julian Whitewright and Michael Roberts

The Irish Sea is full of shipwrecks. Its location as the main north-south seaway up the western side of Great Britain, and with shorter east-west routes to and from Ireland mean that archaeological evidence for seafaring in the Irish Sea dates to prehistory. In later periods, coastal shipping routes, fishing and longer distance voyages to-or-from ports like Liverpool, Belfast, Dublin, Cardiff, Swansea or Bristol added further layers of seafaring activity linked to increasingly global systems of trade and communication.

By way of illustrating the extent of what can be termed the Irish Sea 'wreckscape' the UK Hydrographic Office (UKHO) lists c. 3,000 wrecks and obstructions in its database for the area **(FIGURE 11_03)**.

Providing a historical overview of the Irish Sea wreckscape is challenging due to the fact that the Irish Sea is split among six states (the four UK nations, Ireland and the Isle of Man). We therefore use a single national dataset, the shipwreck data of the National Monuments Record of Wales (NMRW)[90], as the lens for this purpose. This dataset also has wider UnPath'd Waters links through its use as a training dataset for our AI/machine learning work (see **Chapter 9.1**).

The Welsh territorial sea area within the Irish Sea is one that has been used since the earliest times. There is evidence for prehistoric settlement along the Welsh coast, giving indirect evidence for prehistoric seafaring activity. In south-east Wales fragments of Bronze-Age boats have been found at Caldicot, followed by the Romano-Celtic vessel from Barland's Farm. Evidence for Viking-Age voyaging exists in the place names around the coast of west Wales, and in a sword-hilt found far offshore on the Smalls reef. The archaeological remains of medieval vessels have been recorded in the Menai Straits at Pwll Fanog, and recovered from Magor Pill in Gwent. Most spectacularly of all, the Newport Medieval Ship[91] remind us of the great size that sea-going ships could reach in the periods before the loss of such vessels was well recorded.

The records of shipping losses from the post-medieval period, and especially the 1700s onwards reflect a wide variety of size, shape and activity. Two kinds of vessel are record in the NMRW – non-specific/functional and specific vessel types, totalling 106 different ship-types. The most common types in each category are shown in **Table 11_01**.

90 https://rcahmw.gov.uk/national-monuments-record-of-wales/
91 https://www.newportship.org/

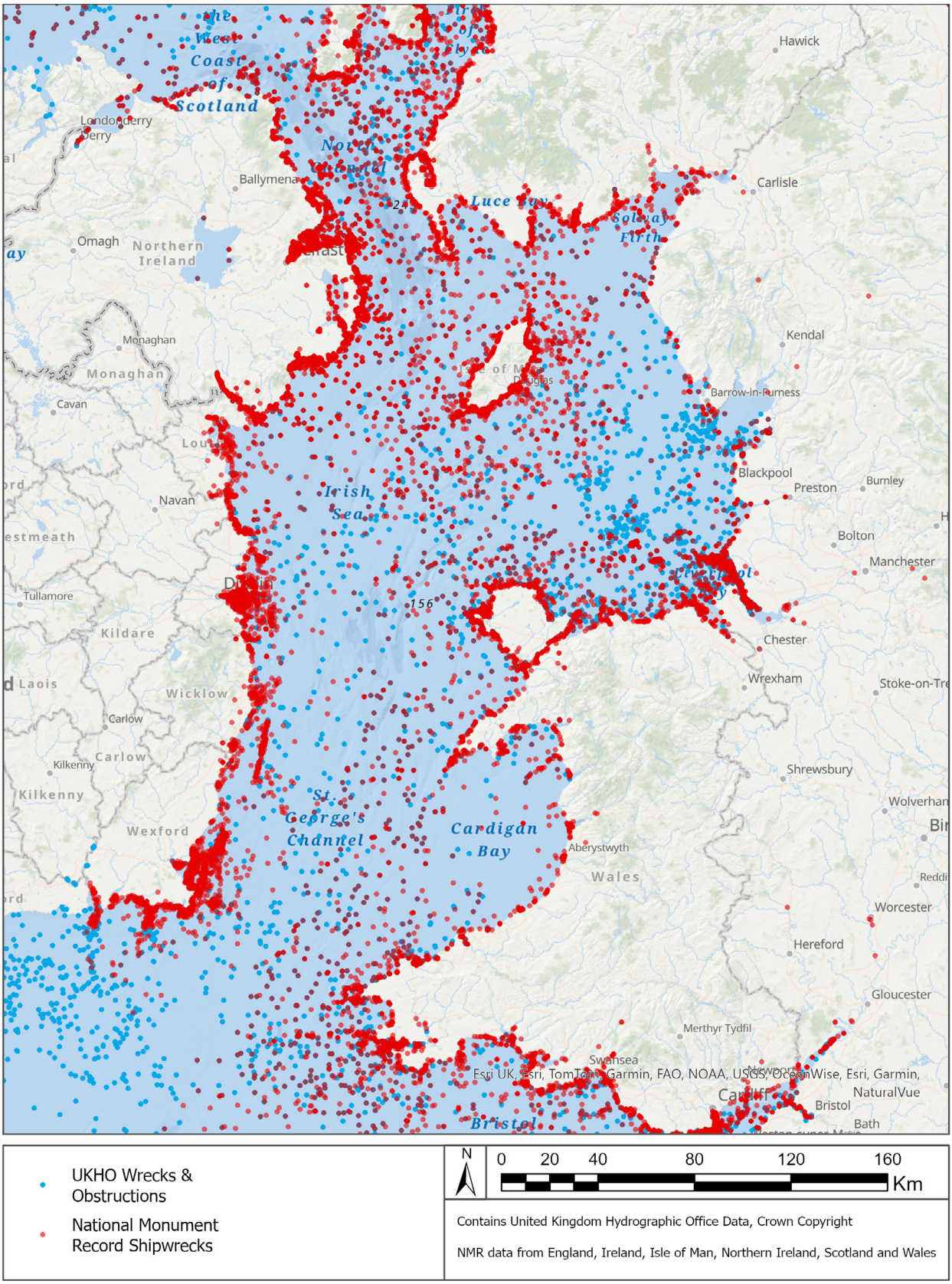


FIGURE 11_03
UKHO Wrecks & Obstructions within the Irish Sea.

Non-Specific losses		Specific losses		Specific Wrecks	Wreck %
Craft	954	Schooner	927	42	5%
Cargo Vessel	339	Sloop	457	6	1%
Packet	179	Screw Steamer	346	149	43%
Pilot Vessel	72	Smack	331	2	1%
Trawler	65	Brig	219	5	2%
Collier	58	Barque	195	29	15%
Fishing vessel	49	Ketch	162	5	3%
Tug	44	Brigantine	134	9	7%
Passenger vessel	39	Full-Rigged Ship	83	12	14%
Ferry	20	Flat	82	3	4%

TABLE 11_01
Commonest Non-Specific and Specific vessel-types listed within the NMRW as identified during analysis of the data collection.

The table illustrates the range of reasons with which people set sail in the past (non-specific) and gives an insight from the late 18th to early 20th Century of the range of ship-types engaged in the movement of goods, people and ideas in the Irish Sea. It is of note within **TABLE 11_01**, that 43% of the vessels identified as screw steamers in the NMRW are associated with a wreck, but that only 5% of schooner losses are associated with a corresponding set of archaeological remains. Thirteen out of the 16 U-Boat / Submarine losses (not shown in **TABLE 11_01**) within the NMRW are wrecks, rather than documented losses.

Focusing on the distribution of four ship-types (schooners, screw-steamers, barques, and flats) **(FIGURE 11_04)** provides a useful oversight of the differences that might be expected across the rest of the Irish Sea. The differences in distribution and underlying reasons for such differences are instructive. As the commonest ship-type in the NMRW, schooners are distributed around the Welsh coast as well as at many offshore locations, reflecting their role in trade and transport during the 19th Century, and the importance of local, and medium distance voyages. Barques are the most common large ocean-going, long-distance sailing ship in the NMRW, and are largely distributed in north and south Wales, relating to the ports of these vessels; Liverpool in the north, and Cardiff or Swansea in the south. Screw-steamers are found in offshore locations: many of these ships were sunk by U-Boats in the First and Second World War. Flats were notable for their part in the trade along the north Wales coast and around Liverpool Bay, and their distribution within the NMRW is strikingly reflective of this. Vessels lost during the First World War constitute the majority of vessels in the Irish Sea (McCartney 2022).

Such a brief sketch is very much one of the potential of maritime archaeological remains within Wales, and by extension the rest of the Irish Sea area. Everything has the potential to exist within the archaeological record of the Irish Sea wreckscape, from prehistoric watercraft, through to 20th-Century steel wrecks. The incomplete nature of the known record merely reflects the potential of what is still to be found through future surveys or following sediment movement on beaches and estuaries.

This potential is explored a series of case studies from the northern part of the Irish Sea, around the Isle of Man, where we have explored improved methods to provide new identifications and information about the shipwrecks located there. We also offer the beginnings of a preservation potential model for these wrecks by combining historical and environmental datasets.

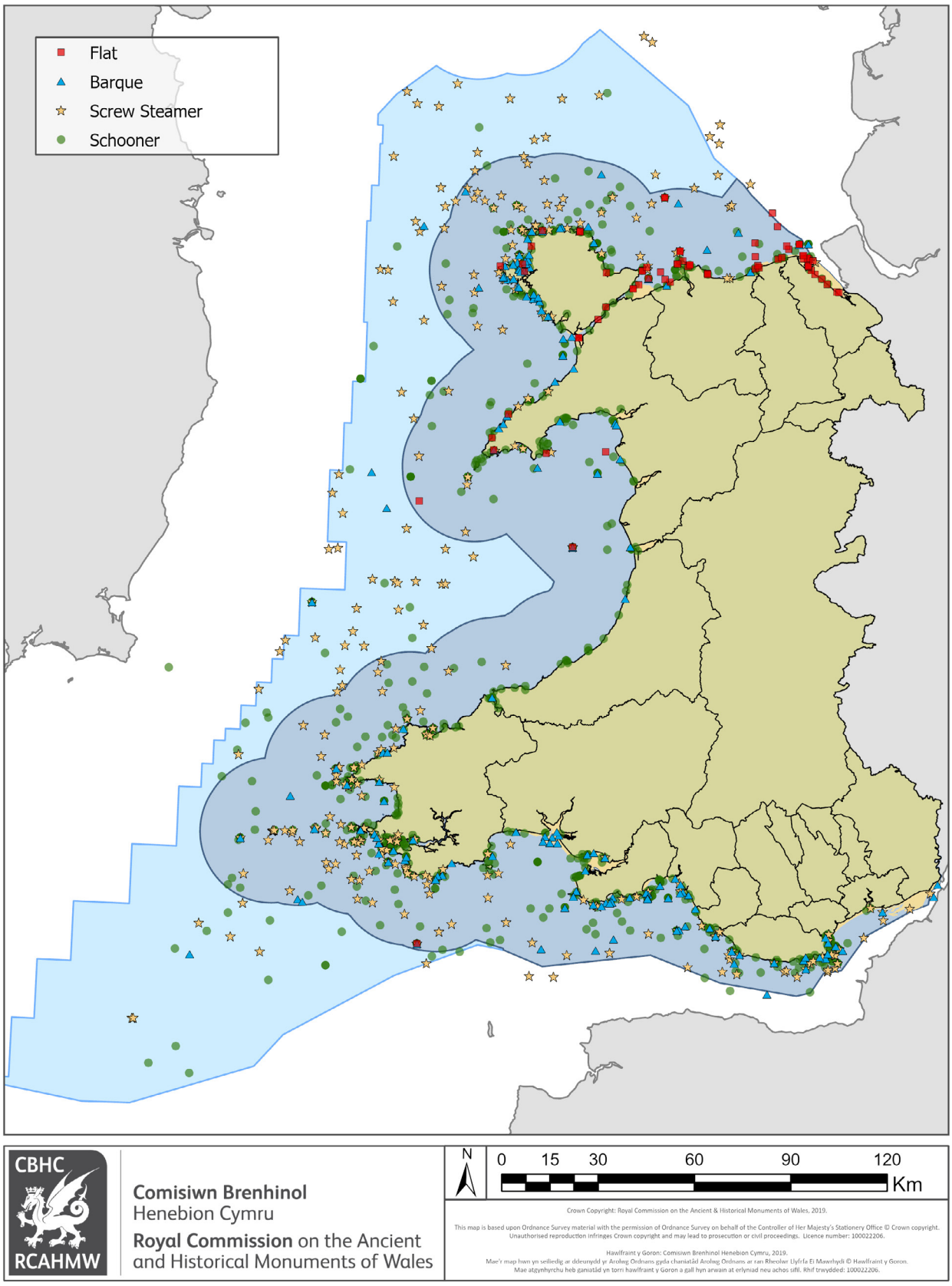


FIGURE 11_04
Spatial distribution of schooners, screw-steamers, barques and flats within the NMRW.

© Crown Copyright: RCAHMW.

11.2 Case Study 1: New Discoveries Around the Isle of Man

Michael Roberts with Lara Band, Wes Forsyth, Deanna Groom, Sarah Saunderson, Julian Whitewright, Phoebe Wild

The first case study chosen to test and demonstrate the power of connected collections was our attempt to identify known and surveyed wrecks on the Irish Seabed which were either unidentified, tentatively identified or possibly wrongly identified.

11.2.1 Approach and Methodology

Within the study area there are 188 records in the UK Hydrographic Office Wrecks and Obstructions dataset, 122 of which are 'live' and 91 are named wrecks. Removing vessels that sank less than 60 years ago, for ethical reasons, left 64 named wrecks. To these were added four more thought to have sunk within the study area, according to Lloyd's War Losses and Lloyd's Casualty Returns (Lloyd's 1990).

An initial study as to the current state of knowledge of wrecks in the selected area was undertaken. In addition to this, a list of candidate vessels, known or thought to have been lost in the study area was developed. This was a significant challenge since there is no established method for collating a definitive list of vessels lost in any specified geographical area. Numerous archival resources and collections would need to be researched to ensure a meaningful and realistic proportion of candidate vessels could be identified[92]. Efforts were therefore focused on larger vessels (>40m in length) made of iron/steel that were lost in the study area between the late Victorian era and mid-20th century. Where the date of loss was known, all the vessels were lost in the period 1857–1961. Multibeam sonar (MBES) data of wrecks was converted into grid model form for dimensional analysis and a series of georeferenced digital terrain models (DTMs) were generated.

For the selected vessels, we drew together archaeological, technological, and historical sources. We adopted the 'ship biography' proposed by Wessex Archaeology in 2004 (BULSI: a shipwreck assessment based on five factors which represent all phases of a ship's career covering: Build, Use, Loss, Survival, and Investigation). This approach provided a means to systematically begin searching the UK's archive network to discover what information was available about each vessel.

Two more themes were added – communal value and wider historical. In this case, communal value has been taken to include ways that people draw sensory and intellectual stimulation from a site (aesthetic value) along with the meanings that a site may have for people (Historic England 2008). This also fitted with the wider Unpath'd Waters aim of reaching new audiences, in particular non-coastal communities who are less likely to identify with maritime cultural heritage and cross-disciplinary natural science and cultural researchers.

Two approaches to the identification process were taken.

Loss/Survival Approach

Used for vessels without a suggested identification, the multibeam echosounder (MBES) imagery for a wreck allowed gathering of key information (dimensions, proportions, shape of the hull, stern and/or bow, deck arrangements (if the vessel was upright), and other features (e.g. funnels, superstructure). These first impressions provide an initial indication of the type of vessel. These indexing factors were then matched to existing wrecks data and documentary references to losses in the vicinity from the UKHO Wrecks and Obstructions data set (UKHO 2024b), and the National Inventories (Isle of Man, Northern Ireland, and Wales). Once these potential identities have been compiled, more detailed research was undertaken into their technical specifications, and the wreck on the seabed compared to any surviving photographs, paintings, ship models, and shipbuilders' plans and yard books.

92 One primary reason why Unpath'd Waters was proposed as a project.

Build/Use/Loss Approach

This equally fruitful approach was used where a (supposed) identification for a wreck already existed. Information gathered on a vessel's technical specification and appearance plus any details of damage suffered during loss was compared with the MBES data for the existing identification. A search as described within a 12nm radius would then be undertaken to check for any other potential candidates.

For both approaches the process is iterative and may result in more than one possibility.

11.2.2 Sources (Scientific Datasets, Collections/Archives, Resources)

Online Resources

A spreadsheet of resources used during our research is contained in the supporting Research Report, many of which are available online. For each vessel a search across Canmore, Coflein, and the IoMHER and HERoNI viewers was the starting point to ascertain the extent of the national record. The freely downloadable Wrecks and Obstructions data set (UKHO 2024b) was also a valuable resource.

The Lloyd's Register Foundation Heritage & Education Centre (LRFH&EC) provides scanned ship plans and survey documents as well as scanned copies of Lloyd's Register of Ships, Lloyd's Register of Yachts, Lloyd's of London Missing Vessels Books and Casualty Returns (aka Wreck returns). H&EC's plans supported researchers aiming to identify shipwrecks through matching information and measurements obtained through sonar survey to archival records. Archaeologists on site benefitted from the information contained in the Register Books and survey reports, where information about materials, components, equipment and repairs contributed to tracing the life of vessels.

Several other online resources provided immediate access to useful technical information, including the secondary sources at Wrecksite.eu and Uboat.net. Three of the major UK centres of shipbuilding activity have online databases for ships built in their region (Clydeships, Sunderlandships and the Aberdeen City Archive). Crewlist (the Crew List Index Project) provides scans of the Mercantile Navy list as well as records of British seafarers. Crewlists can also be accessed via the 1915 Crew List project (Royal Museum Greenwich) and the National Archives portal Discovery.

Online collections at the British Newspaper Archive, Welsh Newspapers (National Library of Wales) and Trove, the National Library of Australia's research portal, held information about launches and ships trials, ship specifications, arrivals and departure from ports, and incidents in a ship's life such as going aground and collisions. For locally well-known and well-regarded ships and crews there may be contemporary newspapers articles and obituaries that provide information about an individual crewmember's background. Family history research platforms such as Ancestry and Find my Past (paywalled but free to access in libraries) provide opportunity to explore an individual's life in more detail. Biographical details may also be found in The Commonwealth War Graves Commission (CWGC) casualty database.

Information scattered across the internet included webpages of the Royal Fleet Auxiliary Historical Association, enthusiast websites[93], Rolls of Honour[94], local museum websites[95], and digital, searchable publications[96].

Physical Archives

The National Archives at Kew provides a rich source of information on the context in which the ships were operating, plus individual vessel biographies and losses:

- BT 165 (Board of Trade – Registry of Shipping and Seamen: Ships' Official Logs), for example, covers the period 1902–1919, and contains crewlists, details of voyages, and day to day management.

---

93 For example, www.customscowes.co.uk
94 For example, www.masonicgreatwarproject.org.uk
95 For example, www.merseamuseum.org.uk
96 For example, The Life-Boat', The Journal of the Royal National Life-boat Institution (https://lifeboatmagazinearchive.rnli.org/)

- ADM 137/3965 – ADM 137/4019 (Enemy Submarines: particulars of attacks on merchant vessels in home waters) and ADM 137/1362, ADM 137/1514 – ADM 137/1517 (Irish Sea: German Submarines) provides access to eye-witness accounts to submarine attacks during the First World War.
- BT 365 Board of Trade and successors: War Risks Insurance Records allows detailed interrogation of what might otherwise only appear as passing references 'general cargo', see the StoryMap for SS Kafue (Saunderson, 2024b).
- Port of London (and other port) Shipping Registers with records of ownership and financing[97].

Significant maritime archive holdings can be found at many of the major shipbuilding centres and major port cities (e.g. Tyne and Wear Archives and Newcastle Discovery; The Scottish Maritime Museum, Irvine; the Scottish Business Records Centre, Glasgow University; Merseyside Maritime Museum and Archives Centre and Liverpool City Council Archives Centre).

Port Shipping Registers and Port Fishing Boat Registers are held within regional archive services. Port Registers can be especially informative about smaller vessels, which formed the core of the coasting trade and fishing industry, and which were not insured at Lloyd's.

Other physical archives include the Royal National Lifeboat Institution (RNLI) archive at its headquarters at Poole, where services rendered to wrecked vessels has been researched and collated by station by the Lifeboat Enthusiasts Society.

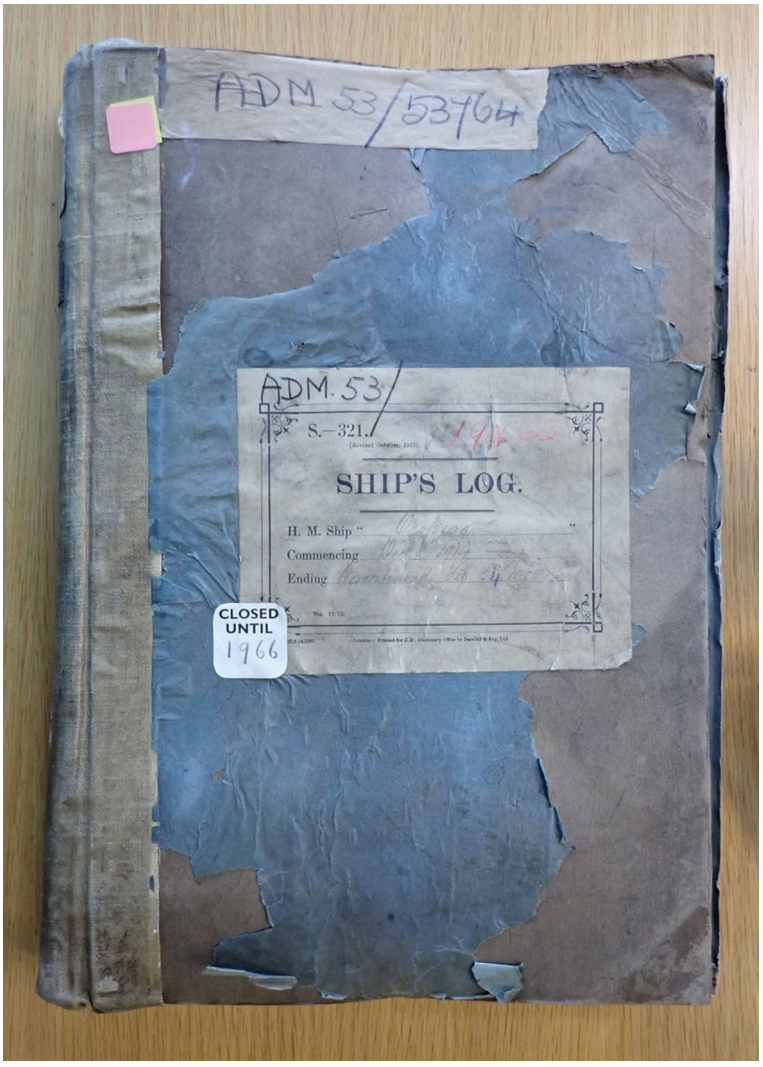


FIGURE 11_05
Naval vessels, such as Oropesa/HMS Champagne, may have surviving Ship's logs. One can see exactly what patrolling entailed on the frontline of the Northern Blockade of Germany during 1915–1919.

ADM 53/53775 OROPESA; The National Archives.

97 For example, TNA CUST130/1 (1818–1820) – CUST130/213 (1964–1965)

Independent Researcher Holdings

Collaboration with informal project partners was particularly helpful: we were able to retrieve information for US based naval historian Michael Lowrey who in turn supplied us with positional excerpts from scanned U-boat logs that he holds. Another informal project partner, Isle of Man based diver, maritime historian and originator of the IoMHER wrecks data Adrian Corkill provided invaluable input early on with his hypotheses on wreck ID, which helped us locate further archive sources.

Visual Material Essential for Seabed Wreck Identification

An extensive range of ship plans are available via the Lloyds Register Foundation website. Large collections of visual material are held (e.g. at Royal Museums Greenwich or the Harland and Wolf archive at the Ulster Transport Museum). They remain problematic for researchers because of lack of accessible catalogues. Some photographic collections are available online (e.g. Cumbria Archives' Sankey Collection, the Allen Collection, Dundee City Archive, Australian National Maritime Museum). Other collections (e.g. National Museum of Wales) require contact with the collections team. One of the largest photographic collections (World Ship Society) has an online searchable catalogue but does not provide digital prints or sell photographs from its collections. Postcard publishers (e.g. Francis Frith and Judges) are digitising their historic collections and making the images available at a cost.

Ship models catalogues and image collections also exist online (e.g. Glasgow Museums, Science Museum Group, Imperial War Museum) but regional and local maritime museum collections, and businesses such as shipping and insurance companies, have models which cannot be found through online searches.

Wrecks Data and Bangor University Multibeam Echosounder Data

The UKHO Wrecks and Obstructions data set (UKHO, 2024b) contains textural descriptions of sites from observations made during surveys by Royal Navy Vessels and survey contractors from the Civil Hydrographic Programme. It also contains reports of sinking in Notices to Mariners; reports of temporary buoyage placed by Trinity House and harbour authorities whilst the vessel has been judged a navigational hazard; reports of dismantling and wreck clearance; and reports of salvage under Government contract by companies such as Rizdon Beazley.

The information contained in the Wrecks and Obstructions data set includes the dimension of the sonar contact, its long-axis orientation, whether the wreck is upright and the height of the wreck above the seabed in relation to the safe navigational clearance. Dimensional information is especially important in terms of initially identifying wrecks on the seabed.

The Bangor University multibeam survey programme (2012–2023) created an unprecedented collection of high-resolution sonar data from 786 surveys at 583 charted wreck sites in the Irish Sea. The data was obtained during a series of research projects on board the 35m Research Vessel *Prince Madog* and smaller inshore survey vessel *Macoma*.

The multibeam acquisition software, plus free viewers such as Fledermaus 8.6.1 have tools which allow features to be measured and the site's height above the seabed to be gauged.

11.2.3 Results and Vessel Identification Examples

The results of information identified for each vessel researched during Unpath'd Waters were collated into MS Word documents containing key information about the vessel, its unique identification numbers plus links to sources and extracts of key information. Summary information has been provided to the IoMHER, RCAHMW, and HERoNI for further enhancement of their records.

By August 2024, of the 113 unconfirmed wreck sites within the study area:

- 25 (22%) previously unknown or unconfirmed have been identified, re-named or confirmed as a direct consequence of Unpath'd Waters research.
- 49 (43%) of surveyed sites identified or confirmed as being geological features.
- 5 (4%) of surveyed sites identified as being debris or unidentifiable.
- 34 (30%) of surveyed wreck sites remain unknown or unconfirmed and require further investigation.

The following case studies (a – d) have been chosen to illustrate methodology, resources and archives encountered during the research undertaken as well as highlighting the opportunities and challenges. Further case studies and an extensive list of resources consulted during the research for each case study can be found in **00.0000/zenodo.00000000**. Some case studies have been published as ArcGIS based StoryMaps[98].

a) SS *Maja* (Lara Band)

Overview

SS *Maja* was built in 1883 in Sunderland by SP Austin & Son for Johnson Brothers & Co. Originally named Western Star (Official no. 86975), the 1,452-ton iron screw steamer was sold in 1885 following the bankruptcy of Edward Smith Johnson (BNA, HHT&N, Wear Built Ships). The steamer changed hands several times, was renamed Neva in 1891 under C.M. Norwood & Co, London and reregistered with Official no. 4489 in 1907 following acquisition in 1905 by Rederi Ab Karnan, Helsingborg. In 1917 Neva was acquired by Rederi Ab Tertia, Gothenburg, under Director Ivar Lignell, likely the famed yacht racer and tennis player, and renamed Maja (Gothenburg University Library, LRFH&EC, Project Runeberg, Wear Built Ships). On 11 October 1918 *Maja*, chartered by the Italian Government and en-route from Glasgow to either Rochefort or Blaye, France, was torpedoed and sunk by UB 126. Nine crew members died (Adrian Corkill pers. comm, TNA, U-boat.net, Wear Built Ships, Wrecksite).

The UKHO Wrecks and Obstructions data set lists two positions for *Maja*: UKHO 5056 is marked as "dead" however and points to UKHO 5075. This is mirrored in Canmore and HERoNI. HERoNI record SWR105 also refers to the wreck as 'Maga or Maja'.

Associated UKHO and Historic environment record numbers				
UKHO	HERoNI	Canmore	IoMHER	Coflein
5075	SWR105	323098	-	-
5056 (dead, see 5075)	SWR106	323080	-	-

Method and results

Initial sources and archives approached included Wrecksite, U-boat.net and regional shipbuilding database Wear Built Ships. The details of the shipbuilding yard, construction date, dimensions, and previous names from these then helped identify plans and entries in Lloyd's Registers of Shipping. Accounts of the sinking based on sworn interviews with the Swedish Master Soot-Tissel and Norwegian Boatswain Olaf Olsen (TNA ADM 137/1517) describe how the ship broke in two and sank immediately following a torpedo strike on the boiler room.

MBES data for UKHO 5075, visualised in Fledermaus Viewer 8.6.1, showed that this wreck was intact. It was also too long and incorrectly proportioned compared to the shipbuilders' plan and Lloyd's Registers. It was clear therefore that UKHO 5075 could not be *Maja*.

In ADM 137/1517, there are two positions for *Maja*'s sinking: "54.12.30.N, 5.36.00.W" (Soot-Tissel, 416) aligns with UKHO 5056; the Boatswain's "15 miles east of Ardglass [...] position only approximate" (Olsen, p425) matches UKHO 5075 in distance if not precise direction.

To search for *Maja*, the UKHO Wrecks and Obstructions data set was loaded into QGIS 3.30.0. Given wrecks are typically found within 12 nautical miles (NM) of their reported position, an elliptical search zone was created encompassing UKHO 5075 and UKHO 5056 (the E-W dimension narrowed based on last known direction and the influence of a southward current on the Irish Sea's western side.

After discarding dead records, foul ground and wrecks right on the coast edge, 28 candidate wrecks were left. The MBES data was visualised digitally then compared with archival information. Only one candidate matched *Maja*'s size, proportions, construction details, and damage: UKHO 5064. Halfway between UKHO 5075 and UKHO 5056, this position was also only 1NM southwest of the position UB 126 recorded for the attack in the KTB (Kriegstagebuch; Michael Lowrey (pers. Comm.,1 May 2024)[99].

98 www.unpathdwaters.org.uk/science-and-the-sea
99 https://storymaps.arcgis.com/stories/82d22c489ba149e596c94ff1afa8f630

Identifying UKHO 5064 as *Maja* facilitated re-appraisal of the identity of UKHO 5075. After further research we concluded that UKHO 5075 was HMS *Stephen Furness*, whose sinking resulted in the loss of 101 lives but whose position had never been ascertained (Case Study (b) below).

b) HMS *Stephen Furness* (Phoebe Wild)

Overview

HMS *Stephen Furness* was launched in 1910 by Irvine's Shipbuilding & Drydock Co. Ltd., West Hartlepool **(FIGURE 11_06)**. It was built as a 1,712-ton passenger vessel, but by 1917, was being operated as an armed boarding cruiser by the Royal Navy. On 13th December 1917, *Stephen Furness* was travelling from Lerwick to Liverpool but was torpedoed and sunk by UB-64, approximately 15 miles from Contrary Head, Isle of Man. The vessel sank in just three minutes and 101 crew were lost. The UKHO does not record a location for *Stephen Furness*, although the admiralty records the sinking position as 54° 15'N 5°07'W. A review of the multibeam data for this area shows that there are no suitable candidates for *Stephen Furness* in the immediate vicinity of this position. Additionally, several graves of sailors from *Stephen Furness* are located on the north Welsh coast after having been washed ashore. This is over 70 miles from the Admiralty sinking location: an investigation into the ocean dynamics that brought the sailors to Wales was necessary.

Current identification numbers				
UKHO	**HERoNI**	**Canmore**	**IoMHER**	**Coflein**
-	-	-	1724	-

Method and results

The National Archives included a description of the sinking by Lieutenant PS Simmonds, one of the few survivors of the attack. He stated 'the ship's position when torpedoed was Lat. 54° 15 N. Long. 5° 7W' and that the ship sank in three minutes. Review of multibeam data at this location indicated that there are no seabed remains at this site, nor in the immediate vicinity, matching the dimensions of *Stephen Furness*. Alternative sources suggest that the position provided by PS Simmonds was actually the position that survivors were picked up by the trawler Elite, over two hours after the sinking. The *Stephen Furness* sank elsewhere – nearby, but not at 54° 15'N, 5°07'W.

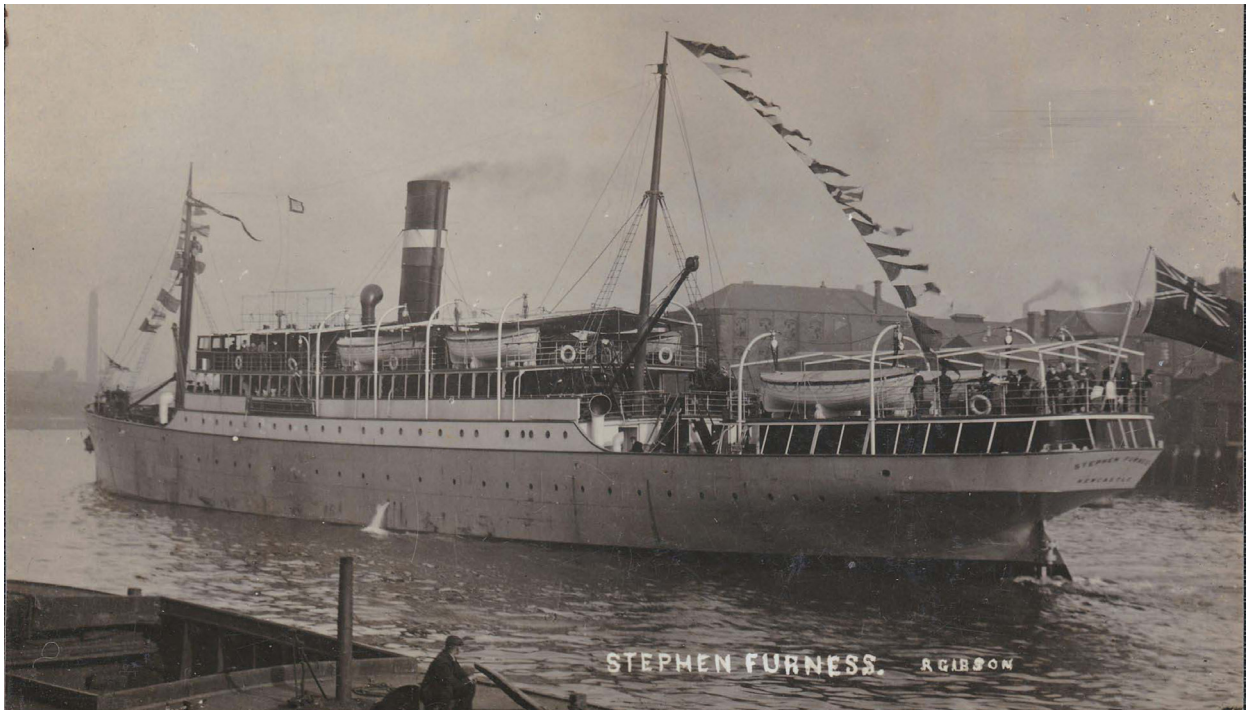


FIGURE 11_06
HMS *Stephen Furness* c 1914, photograph by R Gibson.

We reviewed therefore evidence from the U-boat commander's war diary or Kriegstagebuch (KTB). The KTB entry for UB 64 on 13th December 1917 described sighting a 'large, green painted auxiliary cruiser', and the subsequent torpedoing and sinking of the vessel in three minutes (Kriegstagebuch; Michael Lowrey (pers comm,1 May 2024). The positions recorded in the KTB were reviewed against multibeam data for the area. Less than three kilometres northeast of the position of UB64 when it torpedoed *Stephen Furness*, is a wreck (UKHO 5075) **(FIGURE 11_07)**. Previously identified as *Maja* (sunk in 1918), this identity was disproved by other research (see above). The dimensions of UKHO 5075 match those of the *Stephen Furness*: it suggested strongly that UKHO 5075 is the Stephen Furness.

Another line of evidence supports this proposition. A handful of sailors from the *Stephen Furness* are commemorated at different sites on the Isle of Man and north Welsh coast. Five sailors washed up on the Isle of Man (40 miles east of the sinking location) and are buried at Douglas Cemetery, while four sailors were washed ashore on the north Welsh coast some 100 miles southeast of the sinking position around a month after the *Stephen Furness* sank. The fact that the bodies were washed up so far from the sinking position was a puzzle, and so we investigated the hydrographic and aeolian factors that caused this, by modelling mathematically the behaviours of particles released from the site of UKHO 5075, using historical Met Office wind data and tidal data (see **Section 11.4** below). Data from the 42 days from 13th December 1917 was used to inform particle tracking modelling. The particle tracking accurately demonstrates the route of the bodies that washed up on the Isle of Man and north Wales, and lines up with the dates that the bodies were discovered. The particle tracking results further reinforce the proposition that UKHO 5075 is the wreck of *Stephen Furness*.

We therefore conclude that UKHO 5075 is the wreck of the *Stephen Furness* and represents the final resting place of the majority of crew of this vessel. Significant media interest was generated by this story when it was made public 6th November 2024[100].

FIGURE 11_07
The HMS *Stephen Furness*, MBES Survey, Bangor University.

100 eg https://www.bbc.co.uk/news/articles/cq528ql6yego

c) SS *Moyallon*: Wartime Emergency Building Programme (Julian Whitewright)

Overview

The *Moyallon* (IMO or Official Number: 14248) was a screw steamer, launched at Paisley in 1919. The ship was 432gt, 142ft (43.3m) in length, 25.1ft (7.65m) wide, and 11.4ft (3.5m) in depth. It was configured with the machinery aft, the bridge amidships and a raised quarterdeck. Extensive historical documentation on the *Moyallon* is available from the Lloyds Register (Figure 11_08). The *Moyallon* foundered on 16th September 1924 off Stumble Head in Pembrokeshire. A detailed account of the sinking is given in the resulting Board of Trade Inquiry. A wreck, UKHO ID 9855, was subsequently located and examined by the UKHO in 1980, ascribed a surveyed length of 48m, and given the identification of *Moyallon* by the UKHO. This identification was later incorporated within the NMRW entry for the vessel when the maritime component of the NMRW was assembled.

Associated UKHO and historic environment record numbers				
UKHO	**HERoNI**	**Canmore**	**IoMHER**	**Coflein**
93302	-	-	-	NRPN 273191
9855	-	-	-	NRPN 800297

Method and Results

The correlation of the wreck of the *Moyallon* with UKHO 9855 was not in question until the wreck was resurveyed (UKHO in 2019, Bangor University in 2021). Improvements in seabed survey since 1980 led to a dramatic increase in its recorded length from 48m to 76m. It was therefore clear that UKHO 9855 was far too large to be the *Moyallon*. A review of available evidence noted the presence of a wreck, UKHO 93302, newly discovered by the UKHO's Civil Hydrography Programme in 2020, 2.5 nautical miles east-southeast of UKHO 9855. Reference to the detailed wreck survey data held by the UKHO indicated that UKHO 93302 had a surveyed length of 42.9m, a close match to the *Moyallon*'s 43m. Other details, such as the location of machinery at the aft end of the vessel, disposition of the holds, etc. also matched the plans of the *Moyallon*. On this basis the location of the *Moyallon* within the NMRW was altered to that of UKHO 93302, in turn leaving UKHO 9855 as an unidentified wreck, pending investigation of other documented losses in the area.

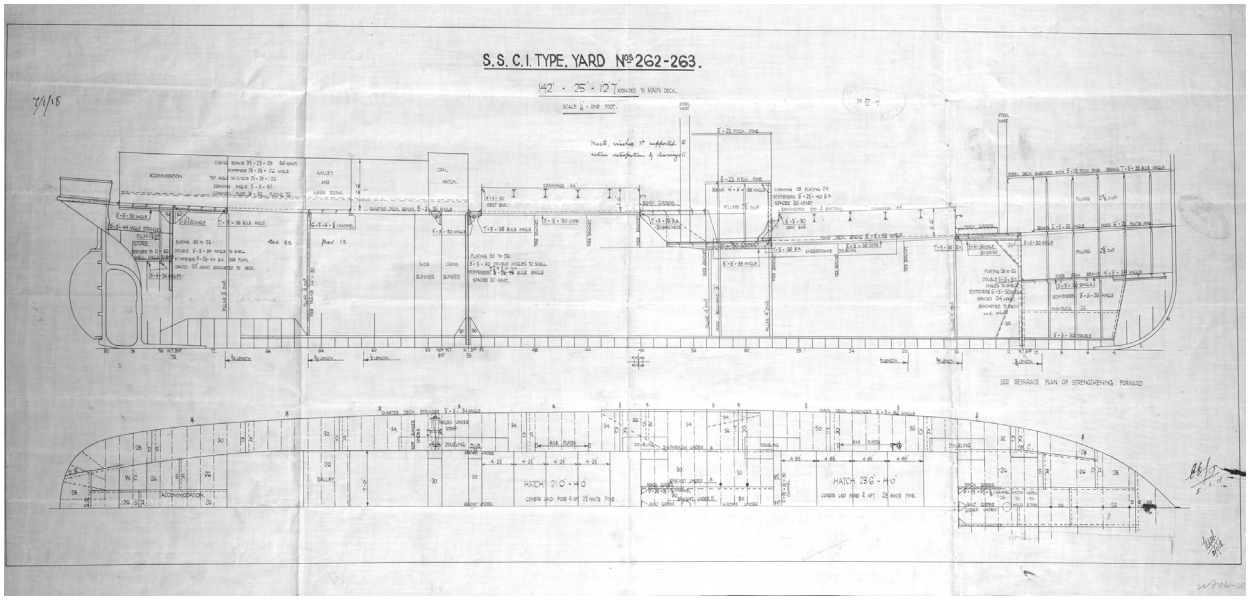


FIGURE 11_08
Profile & Deck Plan for SS *Moyallon*, 29th December 1917.

d) SS *City of Mobile* (Wes Forsythe)

Overview

The *City of Mobile* was built for Bucknall Steamship Lines in 1912 at the yard of Workman Clark in Belfast. Originally named SS *Kentucky*, the vessel was renamed *City of Mobile* in 1927 when it came under new owners **(FIGURE 11_09)**. At 6,590 tons, this steamship was designed for general cargo and passengers (Lynch 2004). After a series of international voyages, the *City of Mobile* was requisitioned by the Ministry of Transport for use in the Second World War. On 16th September 1940 the vessel was proceeding from Glasgow to Liverpool carrying 1,450 tons of general and military stores, in addition to 35 tons of petroleum on deck (Larn 2002). It was attacked and bombed by German aircraft in the Irish Sea.

The sources relating to the position of the vessel suggest it was not sunk immediately but struggled on a distance before succumbing. Nevertheless, the final position of the shipwreck varies according to source, as does the depth of water it sank in. The UKHO designated the wreck site 5090 upon detection by echo-sounder in 1975. They estimated the dimensions of the relatively intact and upright ship based on the acoustic signal, as 100m long, 18m wide and 12m high. The wreck was lying in 72m of water on a sandy seabed. Other sources suggest different coordinates and depths of up to 92m.

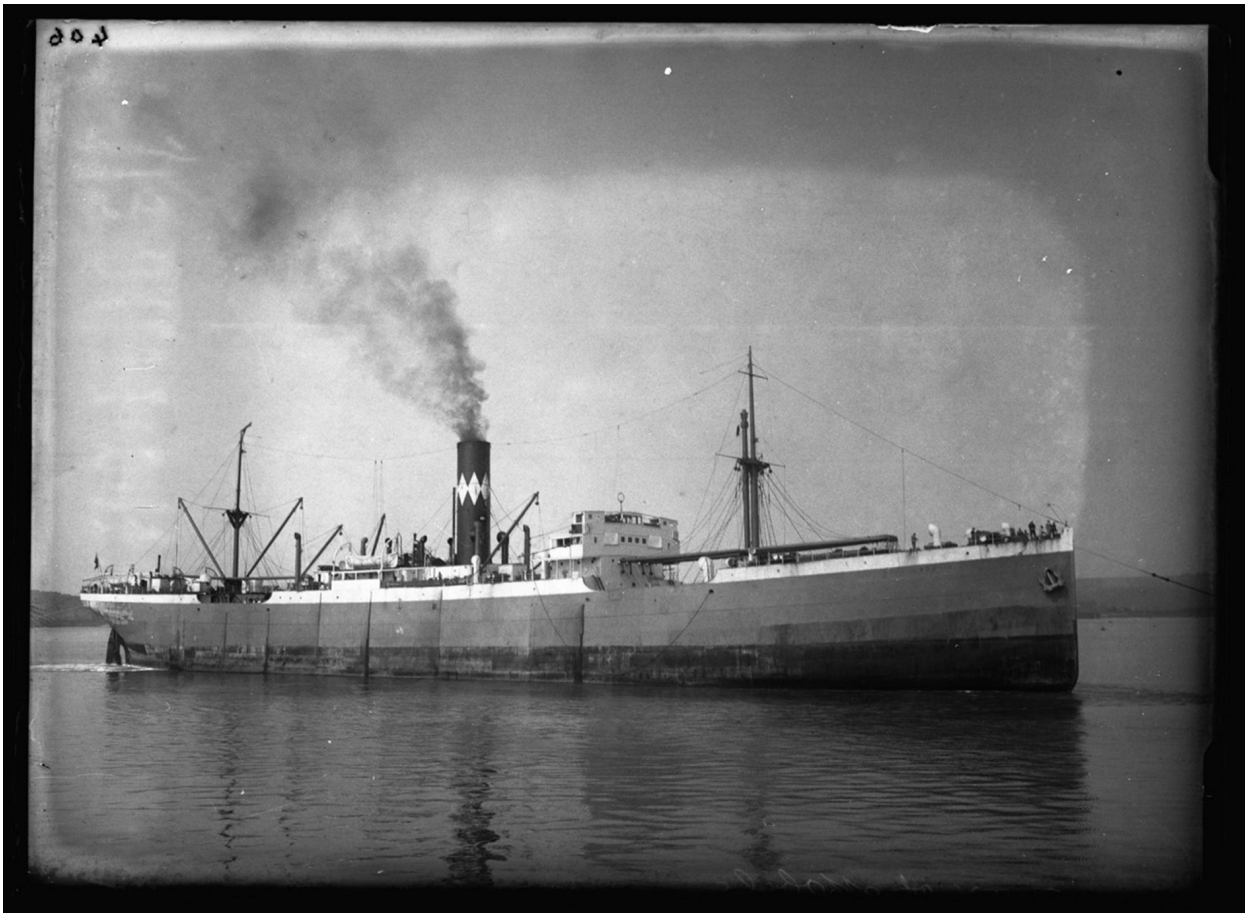


FIGURE 11_09
Starboard broadside view of SS *City of Mobile* entering Cardiff, c.1936.

By L.W. Hansen, Museum Wales 79.76I/204.

Method and results

More recent multibeam echosounder survey undertaken by Bangor University re-imaged the wreck site at a considerably higher resolution **(FIGURE 11_10)**. The survey revealed the wreck was 135m long, much closer to *City of Mobile*'s documented length of 136.3m and lying in 72–75m of water (MNL 1930). This survey was also able to pinpoint the wreck's position off the Co. Down coast more accurately and reveal details of the local topography and its position on the edge of the deeper water basin of the Irish Sea. *City of Mobile* is therefore a case of a wreck site tentatively identified, which can be granted a greater degree of certainty and clarity by subsequent survey, as well as understanding the surrounding area and the forces acting on the site. However, unlike the SS *Moyallon* the documentary sources supporting research into the vessel are a work in progress. Important repositories, such as Lloyds Register records, are not yet available digitally. The availability of plans and descriptions of ship features are particularly important in wreck identification as primary sources can help correct erroneous information and lend greater confidence to the progress and conclusions of research.

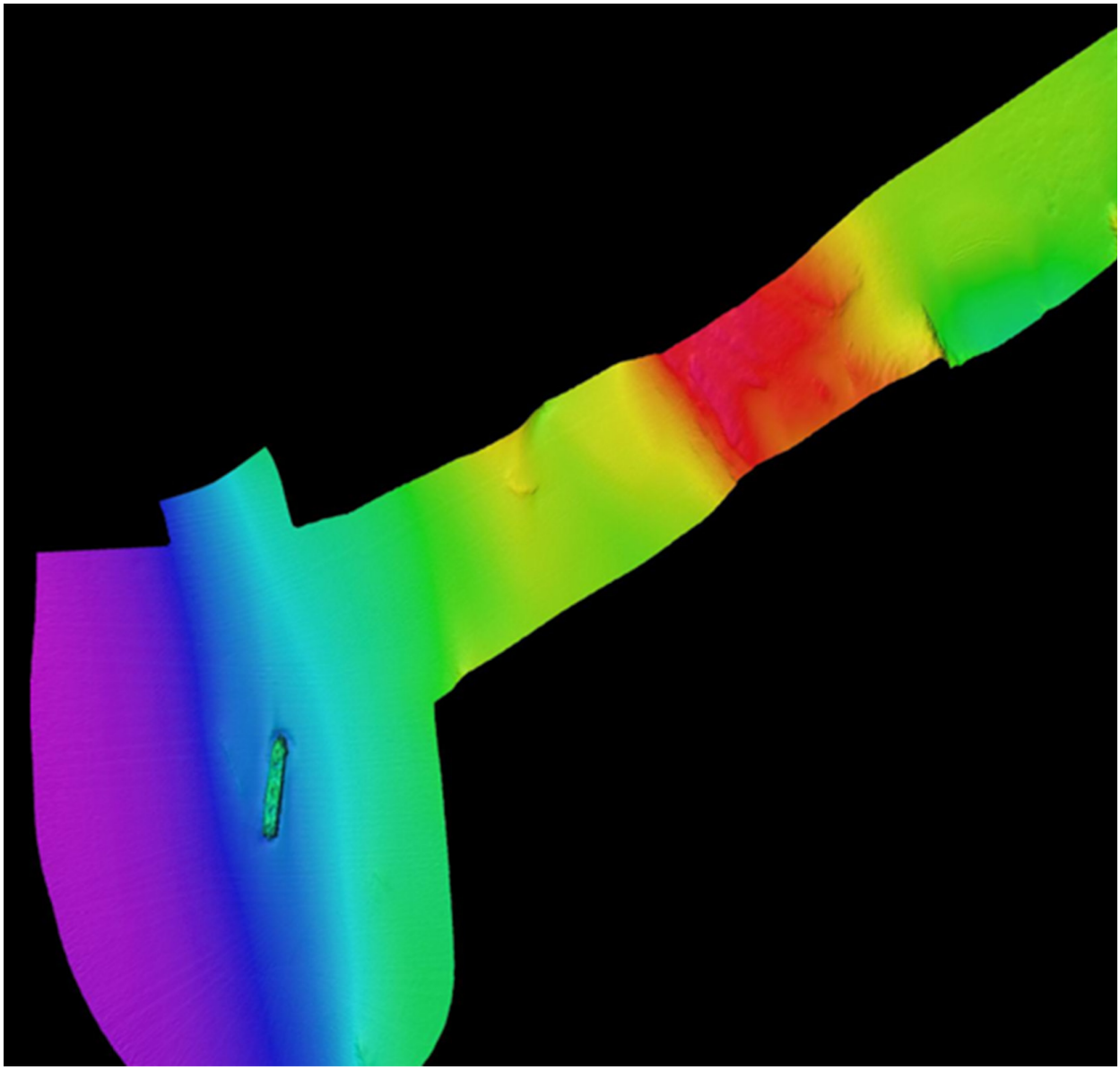


FIGURE 11_10
MBES image of the *City of Mobile* within the wider seabed environment.

Bangor University.

11.2.4 Beyond Identification: Stories Emerging from Scientific Enquiry

The deep dives into collections and archives required in attempts to resolve wreck identifications resulted in important observations about the power of connected collections to enable new narratives and lines of research enquiry. In the following examples, the aim of securing an identification was not necessarily achieved; instead significant insights into under-represented histories, human loss, and the brutality of war emerged. These stories have not been evaluated in the same way as our work on the Solent **(Chapter 10)**, or the public exhibition **(Chapter 15)**, but provide additional evidence of the potential of a national collection to cross disciplines and engage new audiences.

i) SS *Peshawur*: Colonial Legacies (Lara Band)

Overview

SS *Peshawur* (IMO 121223) was a 7,634-ton refrigerated cargo ship designed for Far East and Australian service and built in 1905 by Barclay, Curle & Co. Ltd., Glasgow, for The Peninsular and Orient Navigation Company. Requisitioned by the Admiralty as HM Squadron Supply Ship No. 1, *Peshawur* then served with H.M. Transport from May 1915. *Peshawur* was torpedoed by U-96 and sank off Ballyquintin Point, Co Down, Northern Ireland, on 9th October 1917, while en route from Sydney, Nova Scotia to France with general goods (BNA, Wrecksite, RFAHA, RMG).

Either 11 (Wrecksite) or 13 (P&O) of the 125 onboard lost their lives. Research explored gaps in archival records and also uncovered a handwritten list of the belongings of Lascar seafarer, Shafkhan Caderbux Khan, who took his own life in 1910 (TNA). This informed a StoryMap (Band, 2024)[101] examining archives, colonialism and institutional racism.

Associated UKHO and historic environment record numbers				
UKHO	**HERoNI**	**Canmore**	**IoMHER**	**Coflein**
5068	SWR071	323091	-	-
5066 (dead, see 5068)	-	323089	-	-

Method and results

Initial sources for *Peshawur* (e.g. HERoNI, Canmore, wrecksite.eu, U-boat.net, naval-history.net, the regional shipbuilding database (clydeships.co.uk), Royal Museums Greenwich and Lloyd's Registers online) provided details on wreck location, construction details, dimensions, and history. The sinking of SS *Peshawur* after two torpedo strikes is detailed in TNA (ADM137/1362, ADM137/1365, and ADM137/4002), and in U-96's KTB. MBES survey data for UKHO 5068 shows an intact wreck on its side, matching archive details for dimensions and damage. With no other likely candidates within a 12NM radius, UKHO 5068 is considered to be the correct identification for *Peshawur*.

Initial sources disagreed on the number of crew lost. The CWGC casualty database lists 11 crew members, (two commemorated at Tower Hill and nine (named) individuals on the 'Bombay 1914–1918 Memorial, Mumbai'). Interviews with *Peshawur*'s Master (TNA ADM 137/1365, ADM 137/1362) report 13 killed: the winchman, third engineer, and 11 'British Indian Natives'. The Mercantile Marine Awards Committee's deposition (in TNA ADM 137/1365) also states there were 13 casualties. An officer from HM Yacht *Albion III* (in ADM 137/1365) which assisted *Peshawur*, reports the winchman, 3rd engineer, and nine 'lascars' killed, with two 'lascars' needing immediate medical attention.

101 https://storymaps.arcgis.com/stories/0db8a87ac88e40498684461f02617345

Research into the life history of *Peshawur*, particularly in relation to the numbers and identity of lost crew, exposed a broader pattern of omission and erasure of seafarers from the Global South. Crewlists in *Peshawur*'s logbooks (TNA BT 165/465, and others in the same series), standard issue at the time, name seafarers signed on under 'European articles'. For 'Lascars and Asiatic Seamen' only a total number is given: their names are only recorded in discipline, injury or death, as for Shafkhan Caderbux Khan. The colonial hierarchy that deemed these lives less important, or valuable, is mirrored in the Imperial War Graves Commission's decision to exclude "native" seafarers from the "British and foreign European" memorial at Tower Hill (Siblon, 2016; CWGC/1/1/9/E/12 (WG 998/2 PT.1)). References to difficulties in verification of names, the inability to distinguish Indians and East Africans and, for expediency, letting West African seafarers names 'slip into' the eventual memorial at Mumbai shows how entrenched this attitude was (ibid.).

While records for Lascar seafarers may be in the National Archives of India (see Ahuja 2012), gaps in British archives for *Peshawur* highlight colonial and racial biases in historical documentation. The CWGC has an ongoing project to review inequalities in commemoration though the initial report does not mention the Merchant Navy (CWGC 2021). The lack of detailed records for non-European seafarers distorts the British Empire's maritime history, downplaying the equal contributions of Lascars and other seafarers. The Tower Hill Memorial, a physical and very public manifestation of an archive, reflects and perpetuates the whitewashing of the Merchant Navy's war effort. Exposure of archival silence through the lens of *Peshawur* (Band 2024) aims to present a historical narrative that recognised the contribution of all who shaped our maritime world.

ii) HMS *Champagne*: the northern blockade and cutting off essential supplies to Germany (Deanna Groom)

Overview

The *Oropesa* (IMO or Official Number 114781) was a passenger steamship built by Harland & Wolf, Belfast, in 1895. The ship, one of eight built in the 1890s for the Pacific Steam Navigation Company, was taken into Admiralty service and converted to an auxiliary armed merchant cruiser for the 10th Cruiser Squadron enforcing the Blockade of Germany in the seas between Iceland, Norway and Shetland. In 1916, the vessel was transferred to the French Navy and renamed *Champagne*. It was transferred back to the Royal Navy in January 1917. The ship was torpedoed in the Irish Sea by German submarine U-96 with the loss of 58 men on 9th October 1917. The vessel was struck on the starboard side, in the engine room.

Associated UKHO and historic environment record numbers				
UKHO	**HERoNI**	**Canmore**	**IoMHER**	**Coflein**
-	-	-	1137	-

Method and Results

Essential technical and configuration specifications for possibly identifying the wreck on the seabed are given as length 421ft (121m), breadth 48.8ft, and depth 33ft; steel hull; three decks; two triple expansion steam engines, cylinder dimensions 23 ½in, 38 ½in, 64 ½in and 48in stroke; dual shaft, twin propellors. Searches for profile plans and mid sections were frustrated. None could be found at the Harland and Wolf collection at the Ulster Transport Museum, none yet digitised with the Lloyds Register Foundation Collections, or from the National Maritime Museum, Greenwich. However, three picture postcard views of the vessel at La Rochelle were found. These show a plumb bow; counter stern; hull islands of raised one profile, superstructure over a third of its length reflecting its passenger function; raised bridge to the fore of the superstructure (no flying bridges), large ventilators around funnel; two masts with cargo handling jibs/booms; single large funnel; railings and covered walkways along the sides.

The detail contained in the Isle of Man HER record flagged that the vessel had been zigzagging at time of loss on a mean course N, 21˚E, at a speed of 13 knots. The Court Martial inquiry held into loss provides eyewitness accounts and, most importantly perhaps, charts submitted as evidence of the vessel's approximate course and the pattern of zigzags it was undertaking **(FIGURE 11_11)**. The loss location is variously given in sources as off Chicken Rock Lighthouse; off Dundrum Bay, and Lat 54 17N, Long 5 10W.

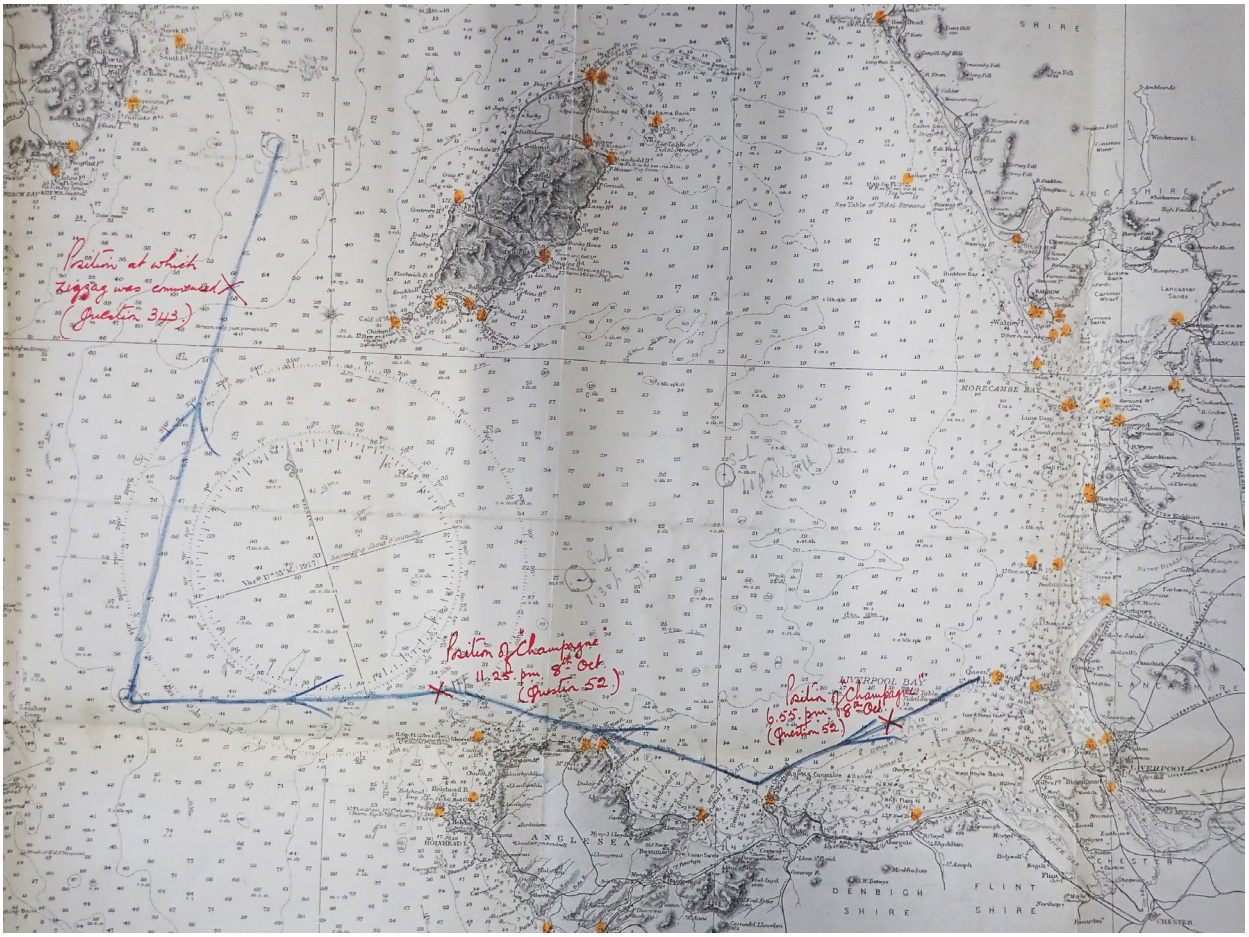


FIGURE 11_11
Chart enclosed with Court Martial documents showing the approximate course of HMS *Champagne* up to the moment of sinking (TNA ADM116/1613).

Within a five-mile radius of the loss position given at the Court Martial, the UKHO wreck data contains 13 candidates, of which 12 are certainly or almost certainly not the HMS *Champagne*. The only one that might fit the dimensions of the wreck is UKHO 5058. The appearance of the wreck corresponds to the configuration and imagery of a standard freighter of the day with two holds aft. The catastrophic damage to the bow (possibly broken off) makes the overall length dimension difficult to ascertain **(FIGURE 11_12)**.

The cluster of reported losses and wrecks in this location makes confirmed identification difficult without more detail multibeam survey and ROV/AUV inspection. Overall, our present conclusion is that the remains of HMS *Champagne* are still to be found.

The integration of the various collections to help identify the *Champagne's* whereabouts revealed much more about the vessel's wartime role. The blockade of Germany and its allies was part of the strategy which brought their defeat. The British blockade included the 10th cruiser squadron (of which HMS *Champagne* was part) which grew from a force of eight to forty ships. This blockade was brutally effective: through such measures the National Health Office in Berlin calculated that 763,000 persons has already died as a result of the blockade by December 1918 (Vincent 1985). The list of prohibited goods included anything from arms, warships, aircraft, animals, and implements and materials to make munitions. The conditional lists of contraband which could be confiscated were food stuffs, forage, field, gold, silver, vehicles, hides, rubber and glycerine. When stopped by the *Oropesa* and others of the 10th Cruiser Squadron, a vessel unable to produce a Navicert or certificate from British consulate at the place of loading, would be manned by a Prize Crew and sent into port (TNA ADM137/53764) (Grainger 2003: 15).

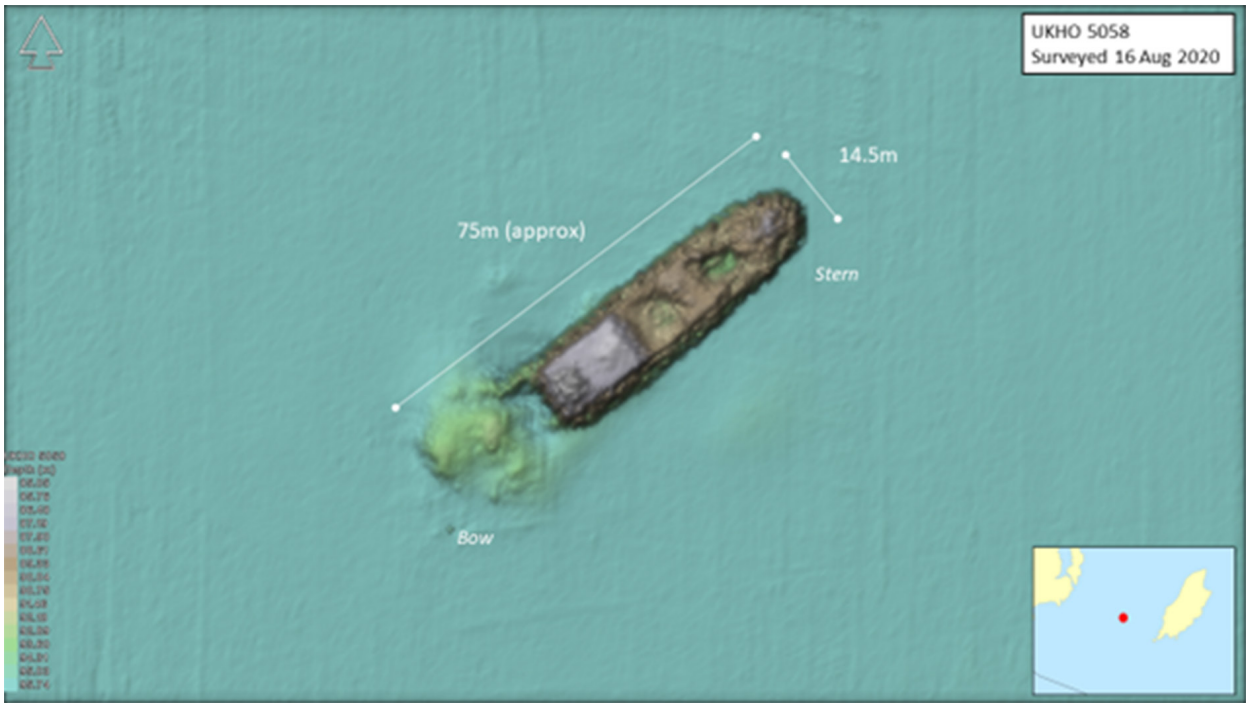


FIGURE 11_12:
The multibeam echosounder of UKHO 5058 in approximately the right reported loss location for HMS *Champagne*.

Discussion

This research revealed human stories associated with wrecks. Richness of and contradictions in eyewitness accounts, such as that between the Master and Boatswain of *Maja*, hint at difficult working relationships (TNA ADM 137/1517). The poignant list of Shafkhan Caderbux Khan's personal effects (TNA BT 165/465, see case study, above) includes '1 necklace (nuts)', a possible misidentification of prayer beads and hesitation in the First Mate's handwriting when writing 'Puggari' (probably pagri/pagari, a turban) suggesting he's trying to understand another Lascar seafarer as he goes through the belongings shines a personal light on both shipboard and colonial relations. Insight into these onboard relationships has significant potential for making maritime cultural heritage more appealing to a wider audience.

Many thousands of seafarers of Black, Asian, and diverse ethnicities were employed in the mercantile marine. Their contributions to the First and Second World Wars, and the wider maritime world, has begun to have significant recognition (see e.g. Ransley, N.d,; Siblon 2016). Many lived in seafaring communities around Britain's coast, and their histories have significantly contributed to the cultural diversity and richness of port cities, enriching both their heritage and social fabric. The search for identification of the wrecks has also allowed us to explore difficult histories, such as the differing treatment on board for crew serving on European Articles, and those on Asiatic Articles, as well as the entrenched racism and colonialism that meant seafarers of different ethnicities were commemorated on different war memorials, something previously highlighted by John Siblon (2016) and revisited in *Peshawur*'s StoryMap (Band 2024). The lens of SS *Peshawur* illuminated how archives and the reuse of archives can perpetuate the circumstances in which they were created (Derrida, 1995; Mbembe 2002), and how careful researchers need to be of amplifying this. The attribution 'Indian Merchant Service' may have been added across the CWGC database later to justify the policy of separate memorials (Fjordr, 2017), yet there seems to be no reference to this Service in any published material online other than those that point back to the CWGC casualty database. Indeed, discussions for the formation of an Indian Mercantile Marine began only in 1923 and were still under discussion in 1930, two years after the Tower Hill Memorial was unveiled (IMM Committee, 1924; Hansard. HC. Deb. 27 January 1930).

The importance of particular industries has also been highlighted – for example the South Wales coal industry through the story of SS *Dalewood.* The Jute industry features strongly in the story of the SS *Kafue*, through the machinery and accessories carried by the vessel and destined for the Jute factories of Bengal, which highlights the link to the Jute industry of Dundee (Saunderson, 2024b).

Including selected case studies as StoryMaps[102] has created a public facing showcase for different aspects of this research. Through these we have demonstrated both methodologies for integrating scientific survey with archival research and the breadth of stories that can be written about shipwrecks through deep dives into archives.

11.3 Case Study 2: Investigation of Particle Dispersal in the Irish sea from a Shipwreck Location

Soizic Garnier and Peter Robins

11.3.1 Summary

The likely final resting place of HMS *Stephen Furness* (see **11.2.3** above) established by combining historical documents with scientific data derived from multibeam sonar scans, provided the project team with an opportunity to examine the merits of utilising other records and collections to further refine our understanding of historical events. It is known that the vessel sank rapidly after being torpedoed at 4.30pm on 13th December 1917, it is also known that several casualties from the vessel washed ashore approximately 130 km to the south on the Welsh coast approximately one month later. This study investigated whether these casualties could have been transported from the Northern Irish Sea to the Welsh coast within a one-month timeframe. By coupling a hydrodynamic model to simulate tidal dynamics during that period, with a dataset of atmospheric conditions (wind measurement from the Meteorological Office historical database) and a Lagrangian particle tracking model, we explored the pathways of particles released at the time and location of the shipwreck to simulate the dispersal of bodies.

---

102 https://unpathdwaters.org.uk/science-and-the-sea

The study found that, with a wind-drift coefficient of 2%, nearly 40% of released particles ended in areas where records of causalities' burial were found in Wales within a timeframe consistent with burial dates.

11.3.2 Method

We followed a multi-stage modelling framework to produce the forcing conditions required for the Lagrangian particle tracking model. Bodies were assumed to remain at the surface, influenced by both surface currents and wind-driven drift. Surface currents were obtained from a hindcast of the Irish Sea from December 1917 to January 1918, using the open-source model TELEMAC 8.5 (Hervouet 2007). By incorporating surface currents from the TELEMAC hindcast and wind drift data from the Met Office historical database, the trajectories of particles, originating from the shipwreck's release location and time, were computed using the Lagrangian particle tracking model OpenDrift.

Hydrodynamic Model

TELEMAC-3D solves the three-dimensional Naiver Stokes equations of momentum and continuity on an unstructured finite-element grid, which is well-suited for resolving complex coastal and island features found in the Irish Sea. Bed friction was parameterised using the Manning's Law, with a bed roughness coefficient of 0.03. To simulate turbulent dissipation, we used the Smagorski turbulence model (Smagorinsky 1963), which is the recommended scheme for non-linear flows. Intertidal regions were handled using a wetting and drying algorithm (Breugem 2022), with a minimum depth set to 0.05 m. After a sensitivity test, a constant computational time step of five seconds was selected to ensure numerical stability whilst accurately resolving tidal dynamics. TELEMAC-3D uses a prismatic mesh structure. The horizontal resolution of the unstructured grid was approximately 1,000 m at the open-ocean boundaries, increasing to less than 50 m along the coastlines. Three equally distributed vertical layers were defined using the sigma vertical coordinate system. EMODNET bathymetry data, available at approximately 100 m resolution, was interpolated onto the grid. At the three open boundaries, the hydrodynamic model was forced with tidal velocities and elevations, with boundary conditions provided by the globally assimilated tidal atlas, TPXOv9. The model was run for 45 days, starting on 1st December 1917.

Wind Observations

Wind data was extracted from the digital library and archive of Met Office Historical Data Record [103] to capture wind conditions from December 1917 to February 1918. Daily wind speed, measured using Beaufort scale, and direction, indicated by cardinal points, were collected at several strategic locations. The wind speed and direction data were converted into vectors components and interpolated on the same grid used for running the TELEMAC model.

Lagrangian Particle Tracking Model

Dispersal of bodies from the shipwreck was simulated using the particle tracking model OpenDrift (Dagestad et al. 2018). OpenDrift combines forcing from the TELEMAC hindcast surface currents with a wind drift component derived from Met Office historical data to drive the advection of particles within the Lagrangian particle tracking model. A range of wind drift coefficients was tested, with scenarios transferring 0%, 1%, 2% and 3% of the wind speed to particle velocity. Additionally, sub-grid-scale particle diffusion was included, with a diffusivity coefficient of 10 m2s-1, appropriate for a grid resolution of approximately 2 km (Okubo 1971). Particles were subject to stranding upon interaction with any land boundary, after which they were considered inactive. Starting on 13th December 1917, 2,000 particles were released every hour over a 1 km radius from the shipwreck location for 24 hours, resulting in a total of 48,000 particles. Their trajectories were recorded every hour until 24th January 1918.

103 https://digital.nmla.metoffice.gov.uk/

11.3.3 Results and Discussion

Environmental Conditions

The Irish Sea, particularly in its central channel, experiences a weak but persistent tidally-driven residual northerly flow (Bowden 1980). Topographic constraints interact with the tides to generate strong stirring, which is visible around the Isle of Man, south of Dublin Bay, and near the Anglesey and Llŷn peninsulas. At the date of the sinking, a spring tide was beginning. Wind direction and magnitude present high variability, and we anticipate that surface currents are significantly influenced by wind-driven circulation, and likely following a similar pattern. Evidence indicated a persistent southerly wind near the proposed shipwreck location for 30 days following the sinking, creating an opposite circulation direction to the northernly tidally-driven residual flow.

Particle Trajectories

With a zero wind-drift factor, approximately 37% of the released particles eventually strand on the Scottish and North Irish coasts of the North Channel, with a few reaching the southern shore of the Isle of Man.

With a wind drift factor of 1 %, particles accumulate south of the Isle of Man. Only 7% of the particles become stranded, primarily in areas with strong tidal residuals. The majority (83%) end up on the southern shore of the Isle of Man, with 16.4% and 0.6% stranding near the mouth of Strangford Lough and the northern shore of Anglesey, respectively.

With a wind factor of 2%, particles first reach the Isle of Man around 17th December 1917. Subsequently, the wind shifts, pushing particles southwards. When the wind changes its direction to the west, particles are driven towards the coast of Dublin, where they remain until 5th January 1918. Another wind shift then pushes particles eastwards, bringing them to the Llŷn peninsula by 10th January 1918, followed by aggregation along the Welsh coast around the 15th January 1918. In this scenario, 99 % of the released particles become stranded: 18.1 % on the southern shore of the Isle of Man, 35.5 % on the Irish coast and 39.4 % on the Welsh coast.

With a wind factor of 3 %, all particles become stranded. The majority (99.9 %) are stranded on the southern shore of the Isle of Man within a few days of the sinking. The remaining particles strand later along the Irish shore, with none remaining active by 2nd January 1918.

The burial dates for casualties between 11th and 24th January 1918 on the Welsh coast **(FIGURE 11_13)** aligns with the scenarios with a 2 % wind drift coefficient as presented on **FIGURE 11_14**. The dispersal study showed that 39.4 % of stranded particles became stranded on the Welsh shore between the 10th and the 24th of January 1918, suggesting the possibility that shipwreck casualties could have been transported across the Irish sea and washed ashore in Wales. However, it is important to note that this study does not account for uncertainties, such as the lack of knowledge of the appropriate wind-drift coefficient, or the interpolation of wind observations, which were based on daily measurements from only 10 sites, with only one from the Irish coast.

This single test case shows the potential value of mathematical modelling using historical archival data both for ship losses and for wind and tide. It acts as further supporting evidence for the identification of UKHO 5075 as the HMS *Stephen Furness*.

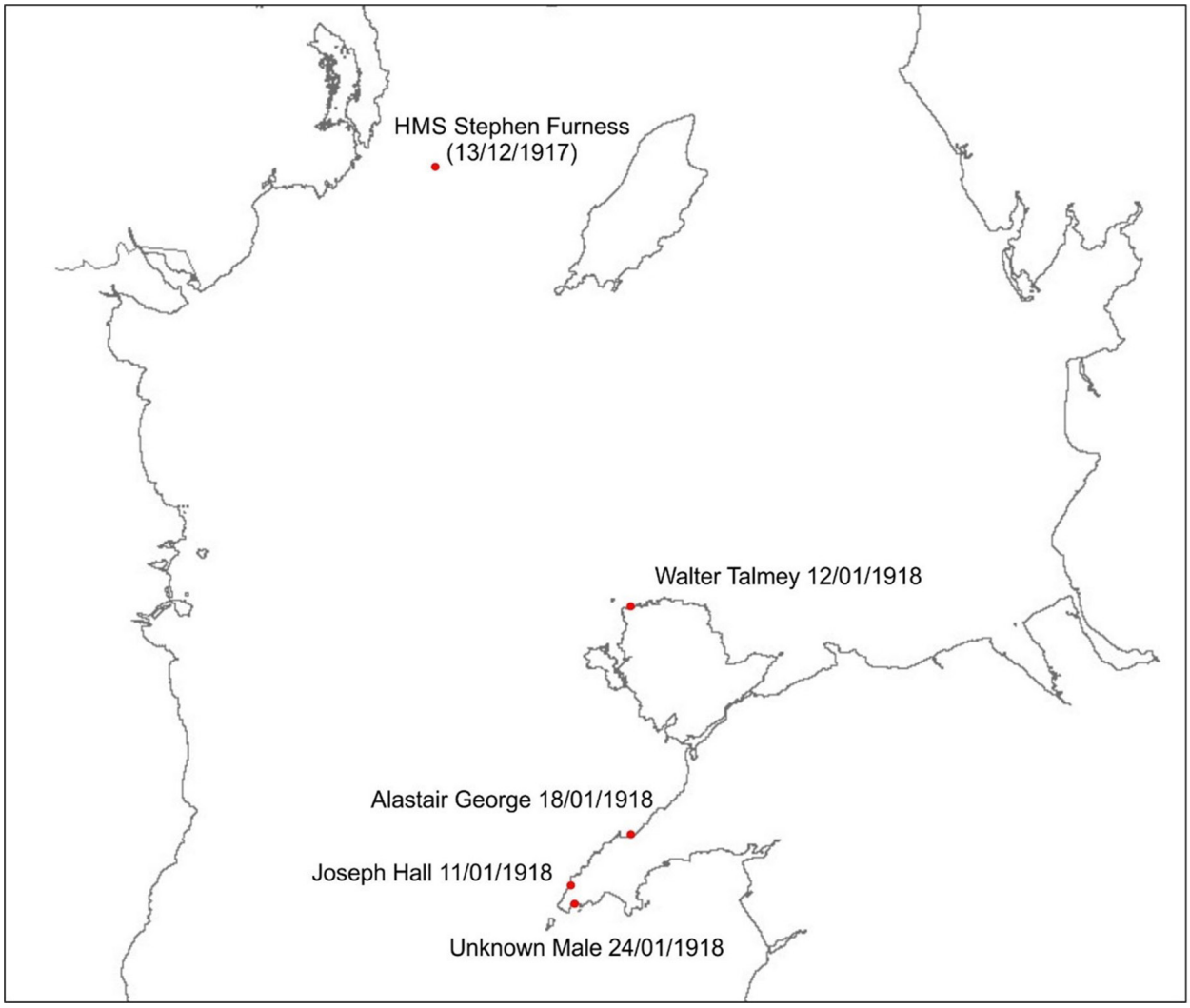


FIGURE 11_13
Burial dates and locations of sea casualties potentially linked to the shipwreck site.

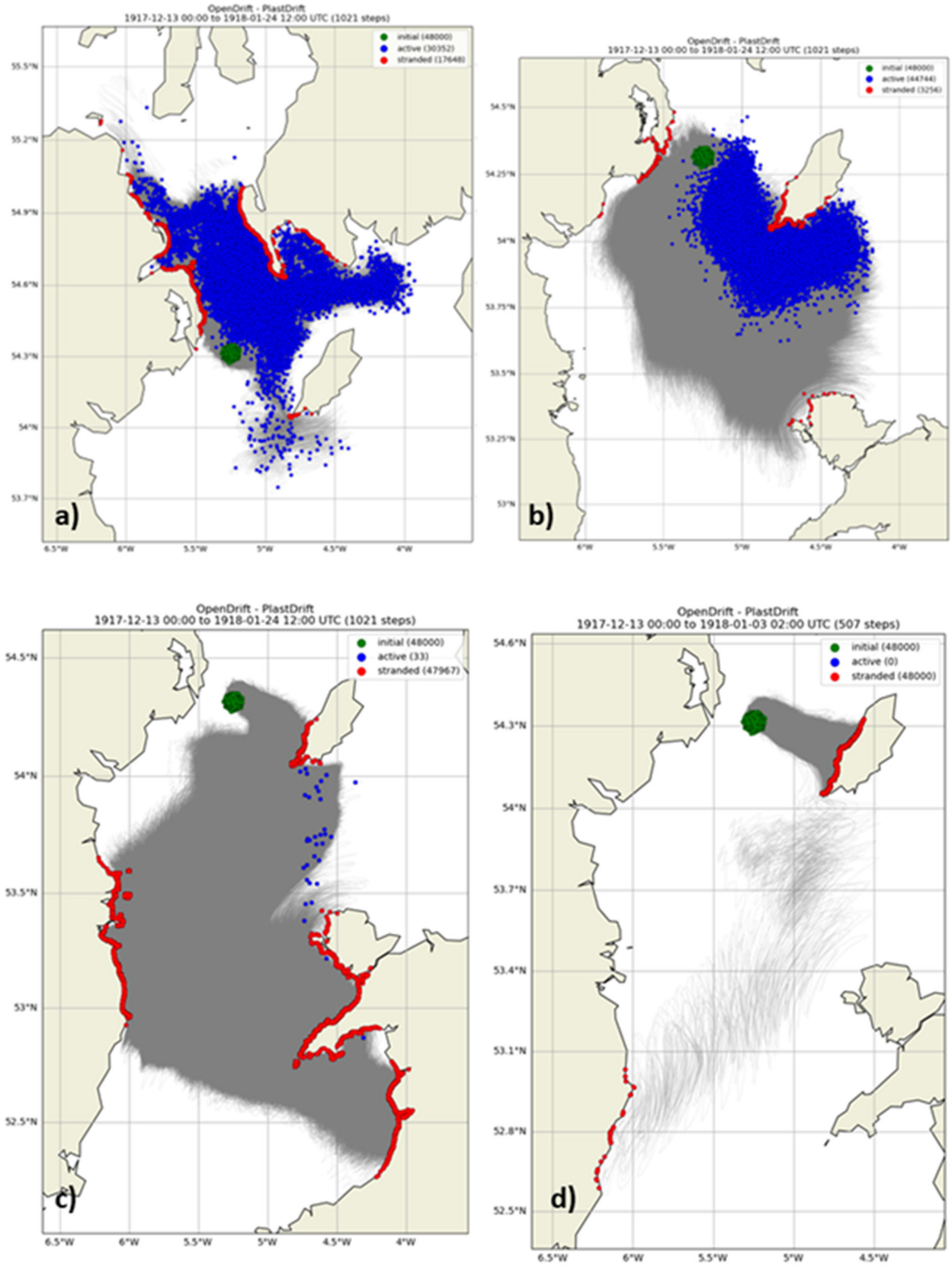


FIGURE 11_14
Spread of particle trajectories released at a 1km radius from the shipwreck location on 13th of December 1917 using a wind drift factor of 2%.

11.4 Case Study 3: Wreck Site Formation Processes, Risk Assessment and Wreck Trajectories in the Irish Sea

Rory Quinn

11.4.1 Introduction

Unpath'd Waters set out to investigate the preservation potential of Irish Sea wrecks, with a view to underwater cultural heritage (UCH) management. Historic wreck sites are at risk in response to increasing anthropogenic and natural factors. Human impacts include trawling and ocean engineering (subsea cables, pipelines, turbines), while physical, chemical and biological processes acting in the water column and seabed naturally deteriorate wreck sites. Climate change is magnifying these natural effects. Combining survey data from wrecks with environmental variables, we can model the preservation potential of these wreck sites and assess potential risks. The main modelling technique we use to investigate site formation, risk and future trajectories is weighted overlay modelling (also termed multi-criteria analysis).

Shipwreck site formation research encompasses the processes by which wreck sites are created and preserved (Oxley and Keith, 2016) and provide valuable insights into the factors that influence the formation and preservation of wrecks and associated artefacts (Gregory et al., 2024). Post-depositional site formation processes are those that affect long-term site preservation. These are commonly divided into natural processes (N-transforms), caused by the ambient physical, chemical and biological processes occurring in the natural environment and cultural processes (C-transforms), related to human intervention (Oxley and Keith, 2016). In this study we use a combination of key N- and C-transforms **(TABLE 11_02)** to model site formation, risk and site trajectories of shipwrecks in the Irish Sea.

Data	Source	Reference	Resolution	Unit	Averaging
Depth	EMODnet	EMODnet (2022)	Multiscale	M	-
Sediment	EMODnet	EMODnet (2022)	Multiscale	Folk 7 class	-
Temperature	BioOracle v.2.0	Assis et al. (2017)	9.2 km at equator	°C	2000–2014
Dissolved oxygen	BioOracle v.2.0	Assis et al. (2017)	9.2 km at equator	mmol/L	2000–2014
Salinity	BioOracle v.2.0	Assis et al. (2017)	9.2 km at equator	-	2000–2014
Current velocity	BioOracle v.2.0	Assis et al. (2017)	9.2 km at equator	m/s	2000–2014
Fishing intensity	EMODnet	EMODnet (2022)	5.5 km	h/km2/month	2015–2018

TABLE 11_02
Summary of the open-source data used in the modelling.

11.4.2 Data Sources

Data analysis was conducted in QGIS v3.16 Hannover and incorporated data from two portals **(TABLE 11_02)**: the European Marine Observation and Data Network (EMODnet)[104] and Bio-ORACLE[105]. EMODnet consists of more than 160 organisations assembling marine data, products and metadata to make these fragmented resources more available to public and private users relying on quality-assured, standardised and harmonised marine data which are interoperable and free of restrictions on use. Bio-ORACLE is a set of GIS rasters providing marine environmental information for global-scale applications (Tyberghein et al., 2012). In 2017 Bio-ORACLE v2.0 was released, containing benthic layers (Assis et al., 2017), which have been incorporated into this project. Models produced with benthic layers are more meaningful than their surface equivalents when studying the preservation of archaeological materials on the seafloor.

Two national shipwreck databases were used in the analysis. Data for the Republic of Ireland were sourced from the INFOMAR Project, a DECC funded joint programme between the Geological Survey Ireland and the Marine Institute, surveying the unmapped marine territory off Ireland. The wreck sites contained in this database have all been surveyed using multibeam echosounders[106]: Data for the UK were downloaded from the Admiralty Marine Data Portal[107].

11.4.3 N-Transforms and C-Transforms Used in Modelling

The methodology for deriving weighted overlay models is shown in **FIGURE 11_15**.

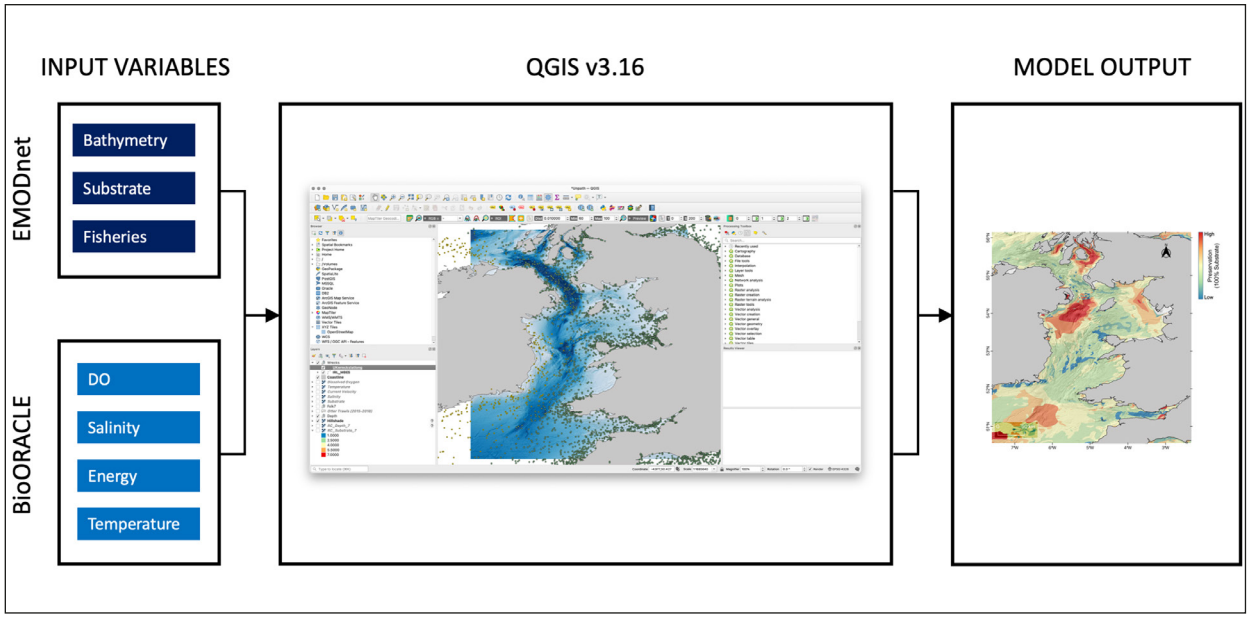


FIGURE 11_15
Flow chart of the methodology used to derive the weighted overlay model.

104 http://emodnet.eu
105 http://www.bio-oracle.org
106 https://experience.arcgis.com/experience/3f2815ec89e745d2b65630429d06385c/
107 https://datahub.admiralty.co.uk/portal/apps/sites/#/marine-data-portal/items?tags=GlobalWrecks

Depth (N-transform)

Depth (see **FIGURE 11_02** above) is considered to influence the preservation state of wrecks, with deep water wrecks generally believed to survive in better condition than similar vessels in shallow water. Deep wrecks tend to survive longer than shallow wrecks, as they are partially isolated from anthropogenic influence and generally experience lower energy environments.

Substrate (N-transform)

Sediment type **(FIGURE 11_16)** influences the preservation of archaeological material; generally fine-grained sediment offers more protection and preservation potential than coarse sediment. Substrate is arguably the most important variable in assessing site formation, as substrate controls many of the other environmental variables. Bottom type has chemical and immediate physical effects on wreck material, controlling burial of archaeological material and therefore access of oxygen, seawater and sulphate-reducing bacteria to wrecks. Six substrate classes, defined on the basis of Folk (1954) (mud, sandy mud, muddy sand, sand, coarse sediment, mixed sediment) and one additional substrate class (rock and boulders) was included by the project team.

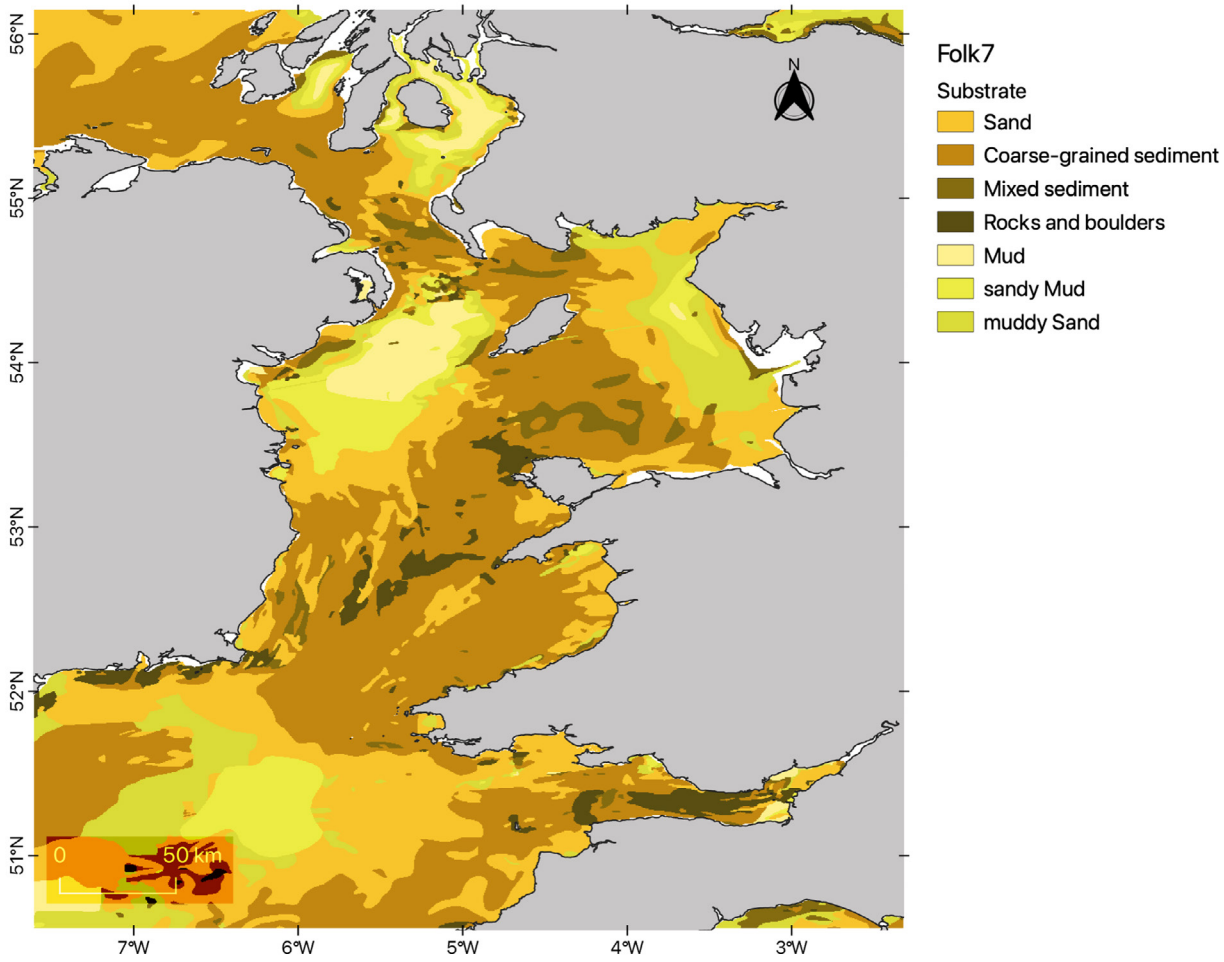


FIGURE 11_16
Substrate data in the Irish Sea.
Substrate data: EMODnet.

Benthic current velocity (N-transform)

The energy regime at the seafloor is a significant factor controlling the stability and preservation of archaeological material. Currents exert shear stresses on the seafloor **(FIGURE 11_17)**, and archaeological material resting upon it.

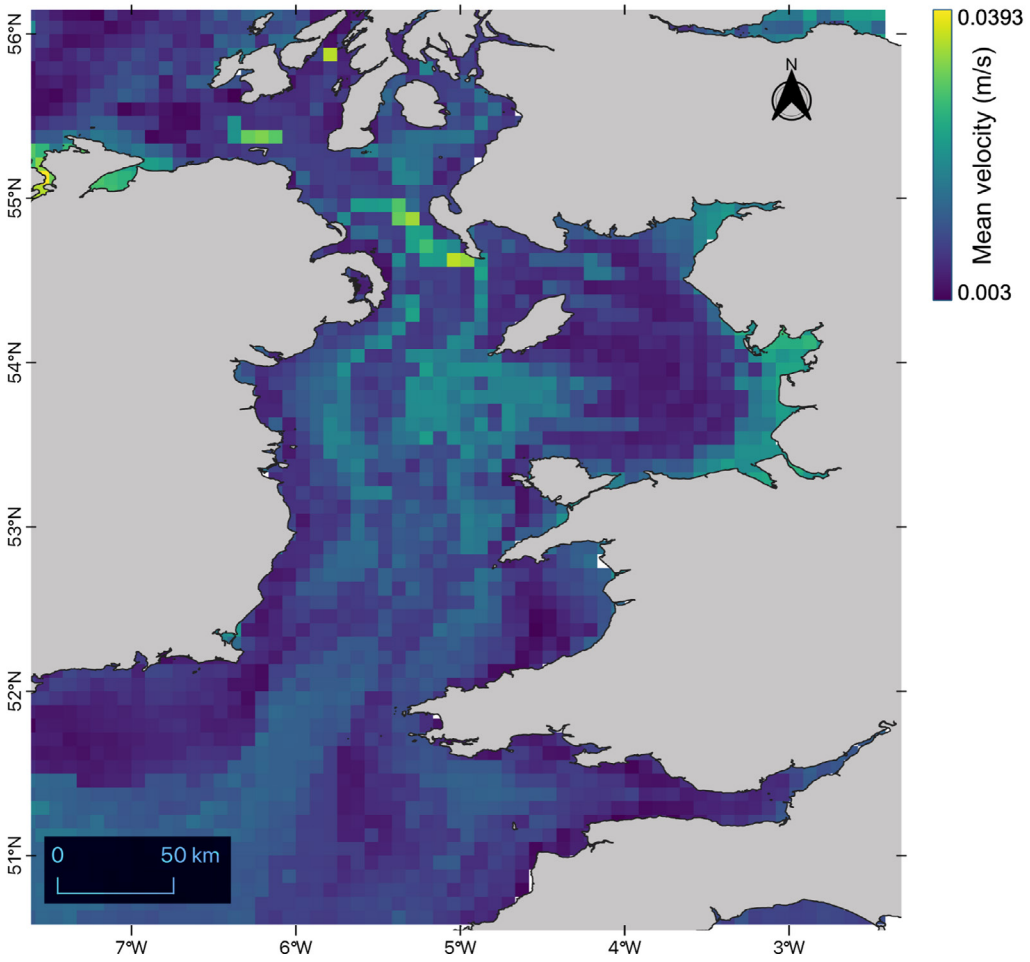


FIGURE 11_17
Mean benthic current velocity.
Data: Bio-Oracle v2.0

Benthic temperature (N-transform)

Water temperature **(FIGURE 11_18)** is an important variable in determining the rate of marine growth, corrosion of metal objects and the bio-deterioration of organic material (McCarthy, 2000).

Salinity (N-transform)

Water salinity **(FIGURE 11_19)** has a pronounced effect on the stability of metal objects, ceramics, and biological growth (McCarthy, 2000), e.g. controlling the environment favoured by bacteria and fungi that have a marked effect on the deterioration of wood.

Benthic dissolved oxygen (N-transform)

Oxygen **(DO; FIGURE 11_20)** availability influences the preservation potential of metal and wooden wrecks. For example, wooden parts of shipwrecks tend to be well-preserved only when exposed on the seabed to water with low oxygen content (e.g. Eriksson and Rönnby 2012) or when buried in dysoxic and anoxic sediments.

Bottom fishing intensity (C-transform)

Maximising social and economic benefits from fisheries and protecting UCH are management goals often viewed to be at odds with each other. Some researchers argue that wrecks are heavily impacted by commercial fishing practices (Brennan et al., 2016), others appear less convinced (Parham, 2017; Hickman, 2024). The main pressure on submerged wrecks from commercial fishing is defined by the physical abrasion of the seabed by bottom-contacting fishing gear. **FIGURE 11_21** shows the total fishing effort for otter trawls in the Irish Sea (2015–2018) as an example.

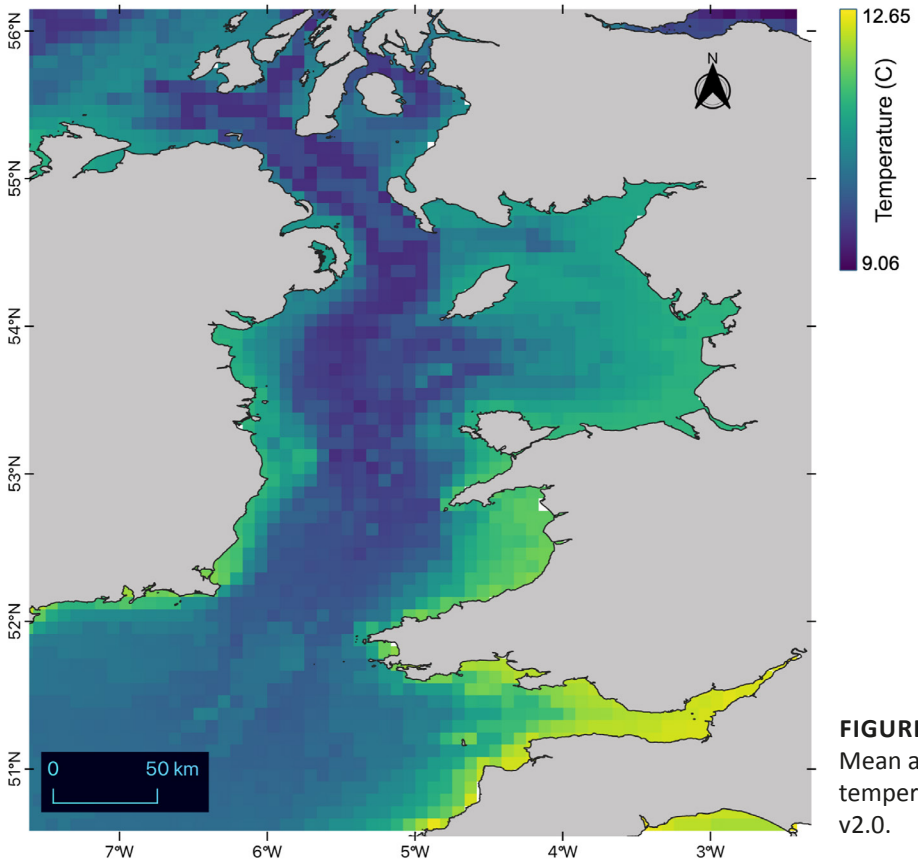


FIGURE 11_18
Mean annual benthic temperature. Data: Bio-Oracle v2.0.

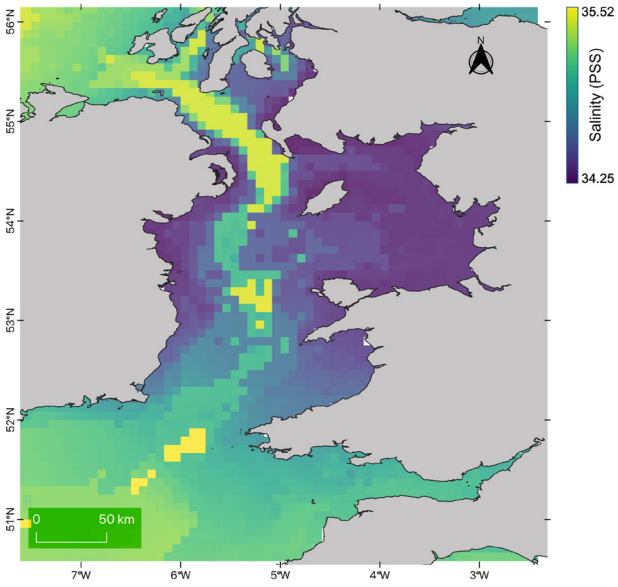


FIGURE 11_19
Mean annual benthic salinity (Bio-Oracle v2.0).

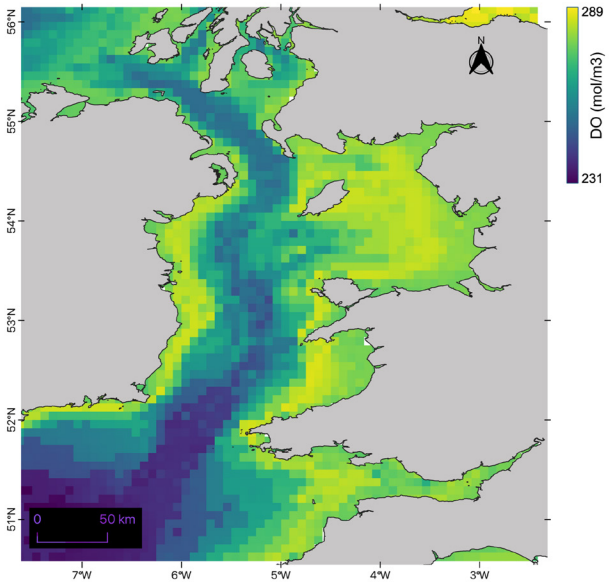


FIGURE 11_20
Mean annual benthic DO (Bio-Oracle v2.0).

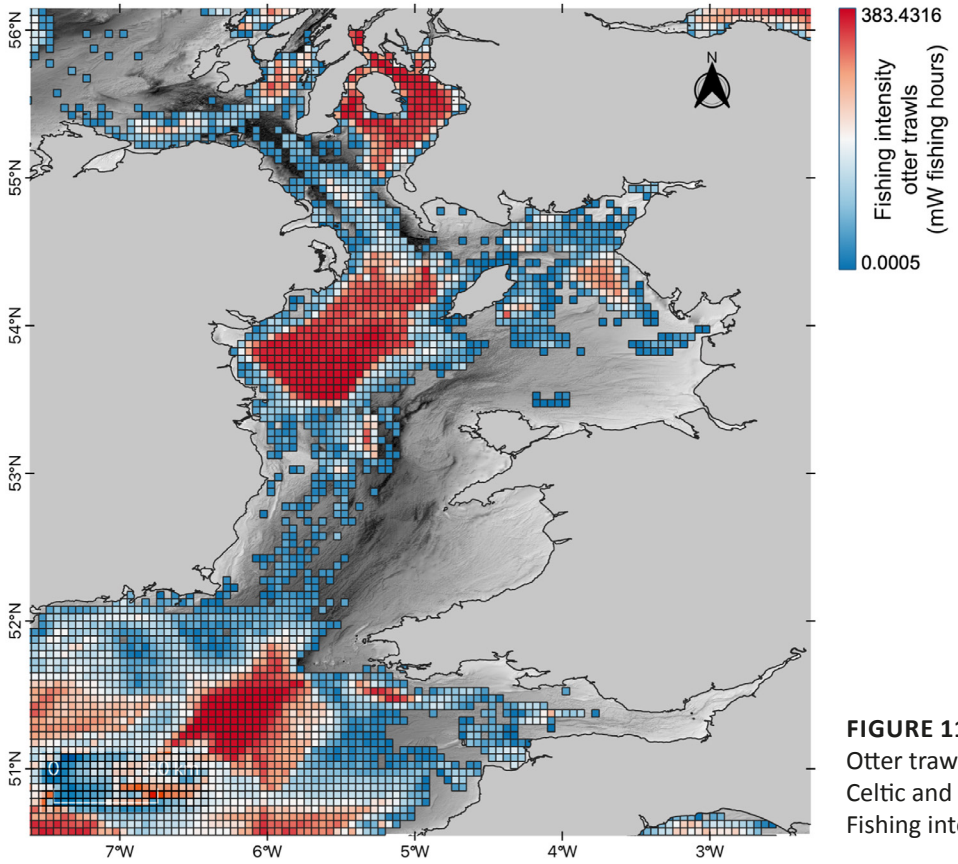


FIGURE 11_21
Otter trawl intensity in the Irish, Celtic and Malin Seas (2015–2018). Fishing intensity data: EMODnet.

11.4.4 Multi-Criteria Analysis Modelling

Preservation potential models were developed in QGIS v3.16 using the 'Weighted Multi-Criteria Analysis' plugin (Plugin ID 2069), using the environmental variables outlined above **(TABLE 11_02)**. Four preservation potential models were developed using C- and N-transforms **(TABLE 11_03)**.

Variable	Model 1	Model 2	Model 3	Model 4
Substrate	100%	50%	50%	14%
Depth	-	-	-	14%
DO	-	-	10%	14%
Salinity	-	-	10%	14%
Temperature	-	-	10%	14%
Velocity	-	-	20%	14%
Fishing intensity	-	50%	-	14%

TABLE 11_03
Variable weighting used in preservation potential modelling scenarios: model 1 for buried material; model 2 for semi-exposed material; model 3 for fully exposed material; model 4 all variables equally-weighted.

Model 1: UCH Buried Completely Beneath the Seabed

Model 1, the most basic of all four models, assumes the preservation potential of material buried beneath the seabed is dependent upon substrate conditions. The variable weighting is therefore 100% substrate. In most environments the seafloor itself is the most important factor in influencing the potential decay or preservation of a submerged shipwreck (Keith and Evans, 2016).

Model 2: UCH Semi-exposed at the Seabed

Model 2 assumes the preservation potential of semi-exposed and shallow buried material is dependent upon substrate conditions and seabed fishing intensity. The variable weighting in this model is: 50% substrate and 50% fishing intensity.

Model 3: UCH Fully Exposed at the Seabed

Model 3 assumes the preservation potential of fully submerged exposed material is dependent upon substrate and oceanographic processes that are key drivers in site formation. An assumption in this model is that fishers avoid UCH sites for fear of damage or loss to fishing gear (Hickman et al., 2024E). The variable weighting in this model is: 50% substrate, 20% velocity, 10% DO, 10% salinity and 10% temperature.

Model 4: Preservation Potential of UCH is Equally Dependent on all C- and N-transforms

Model 4 was developed to assess the contribution of each variable to site formation and preservation potential. Statistical inferences were drawn from the spatial correlation of the outputs, giving insights into the explanatory powers of each of the C- and N-transforms in site formation and site trajectories. All C- and N-transforms were weighted equally.

11.4.5 Risk Assessment

Data mining of the environmental variables at each wreck site was conducted in QGIS v3.16 using the Point Sampling Tool (Plugin ID 223). The results of the four models are presented below.

Model 1: Output for UCH buried Completely Beneath the Seabed

Model 1 predicts highest preservation potential for buried material in the Western Irish Sea Mud Belt, the Firth of Clyde, and east of Islay. In the area between Morecambe Bay and Solway Firth, and in the Celtic Sea to the south of St. George's Channel, high preservation potential is also noted. Lowest preservation potential is modelled for the seafloor northwest of Anglesey, parts of the Severn Estuary, the south coast of Ireland off Counties Waterford and Wexford, and to the west of the Llyn Peninsula.

Model 2: Output for UCH Semi-exposed at the Seabed

Model 2, for UCH partially buried in the seafloor, is almost the reverse of Model 1, with areas of low archaeological potential predicted in many of the high-preservation potential areas of Model. This can be explained by the fact that the fine-grained substrates which coincide with high preservation potential in Model 1 are the same areas targeted by commercial fishing in Model 2. Poorest preservation is predicted around the Isle of Arran, in the North Channel, the southern part of the Western Irish Sea Mud Belt, off Anglesey and the Llyn Peninsula, parts of the Severn Estuary and off the south coast of Ireland and into the Celtic Sea. High preservation potential is predicted in nearshore areas, away from commercial fishing grounds.

Model 3: Output for UCH Fully Exposed at the Seabed

Model 3 predicts highest preservation potential for exposed UCH in the Western Irish Sea Mud Belt, the Firth of Clyde, east of Islay, the area between Morecambe Bay and Solway Firth, and in the Celtic Sea to the south of St. George's Channel. Lowest preservation potential is modelled for parts of the Severn Estuary, the south coast of Ireland off Counties Waterford and Wexford, and in the North Channel.

Model 4: Output for Scenario where Preservation Potential is Equally Dependent on all C- and N-transforms

Model 4, where all C- and N-transforms are weighted equally, was developed to assess the contribution of each variable to site formation and preservation potential. Moderate to strong correlations are noted between preservation and the n-transforms: depth, substrate, DO and temperature. These relationships indicate that depth and substrate are two good proxies for preservation potential, and as both these parameters are included as fields in the UKHO wreck database, may be effective information for heritage managers.

Risk Assessment

Wrecks in the Irish Sea shipwreck databases are risk-classified according to Model 3. Individual wreck sites inherit their risk classification from the model output. The lowest risk sites are located around the Western Irish Sea Mud Belt, the Firth of Clyde, east of Islay, the area between Morecambe Bay and Solway Firth, and in the Celtic Sea to the south of St. George's Channel **(FIGURE 11_22)**. The wreck sites at highest risk are in the Severn Estuary, off the coast of Wexford, to the northwest of Anglesey, the west of the Llyn Peninsula, in the North Channel and off the northeast of the Inishowen Peninsula.

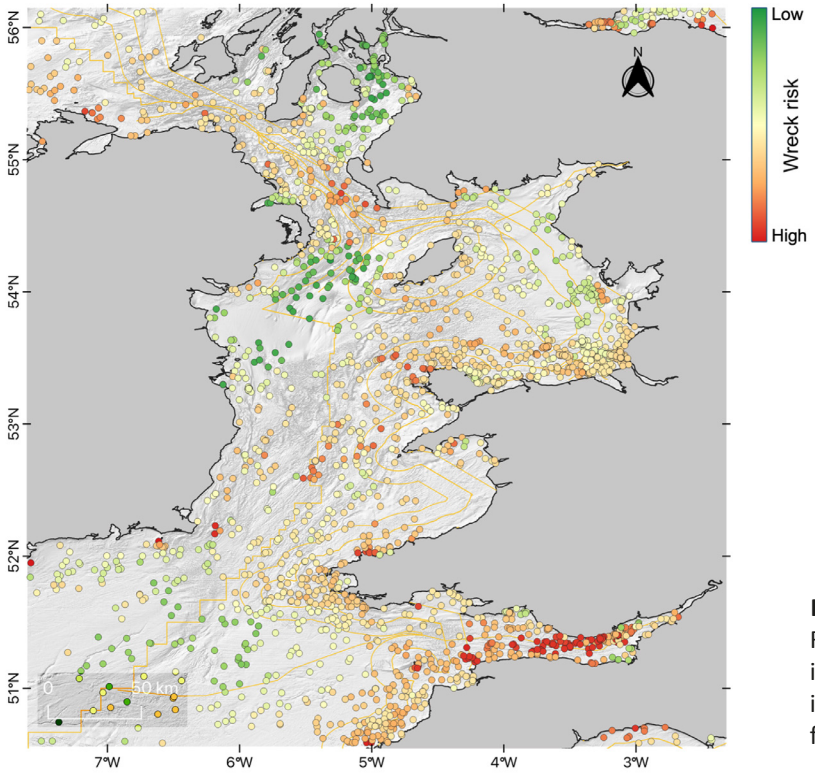


FIGURE 11_22
Risk categories for individual wreck sites in the Irish Sea derived from Model 3.

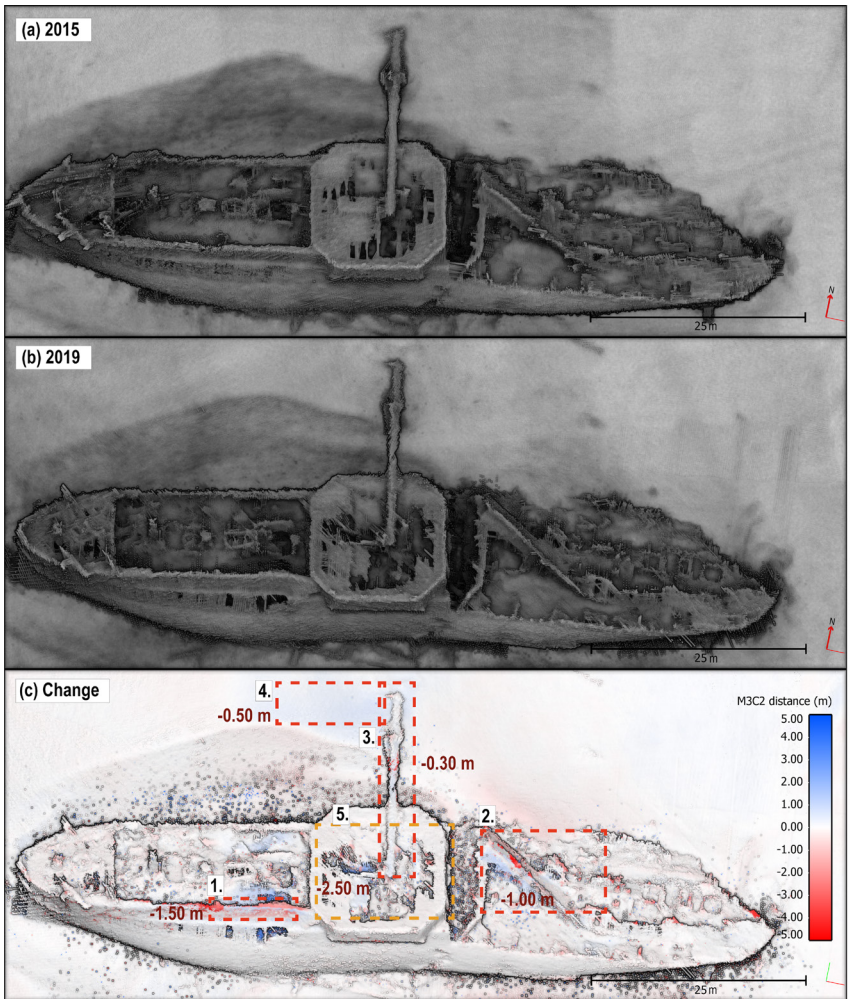


FIGURE 11_23
Structural change at the HMS Vanguard site. (a) point cloud of the 2015 survey, (b) point cloud of the 2019 survey, (c) difference model for the interval 2015–2019 (Majcher et al., 2022).

11.4.6 Wreck Trajectories

Site formation and future wreck trajectories are a function of physical, chemical, biological and anthropogenic processes:

$$\frac{dD}{dt} = \frac{dP}{dt} + \frac{dC}{dt} + \frac{dB}{dt} + \frac{dA}{dt}$$

Where D is disintegration, P represents physical processes, C represents chemical processes, B represents biological processes, and A represents anthropogenic intervention. In the Irish Sea, wreck site formation and future trajectories are therefore dependent on natural and anthropogenic forcing, governed by geological, oceanographic, chemical and biological processes, and human activities acting on a variety of spatial (from local to regional) and temporal scales.

Generalised Regional-scale Models

It is evident that site formation and future wreck trajectories in the Irish Sea are significantly influenced by water depth and substrate. Wrecks located in deep water and/or on fine-grained substrates are therefore predicted to survive longer. Conversely, wrecks in shallow water and/or on coarse substrates are projected to disintegrate more rapidly. These findings are backed up by other studies (e.g. Quinn, 2006; Keith and Evans, 2016), where substrate is identified as a key predictor in site preservation and evolution.

Site-specific Models

Although a conceptual model for wreck trajectories in the Irish Sea has been developed at a regional scale, this one-size-fits-all model can break down at a local scale, where linked hydro- and sediment-dynamics and/or high-impact short-lived events can cause significant changes to wreck systems over relatively short time periods. Two examples are illustrated below using multibeam echosounder (MBES) data collected over wreck sites in the Irish Sea.

The SS *W M Barkley* (lost 1918) site is a good example of where hydrodynamic forcing influences site formation at a sand-dominated location. Time-lapse MBES surveys conducted over four years allowed for the evaluation of long-term (2015–2019) and short-term (one week) change. Differences of −4.9 m and +3.0 m in bed elevation were observed over a four-year period associated with sand wave migration, and the reorganisation of sediment within erosional and depositional signatures at the site. In terms of area coverage, negative change (38.5% of the area) was more extensive than positive change (21.6% of the area), suggesting that the site is in a state of net erosion. The calculated mean bathymetric change (−0.17 m) also suggests net erosion. Interestingly, significant bathymetric changes are observed at the site even in the short-term (one week).

HMS *Vanguard* (lost 1875) demonstrates rapid structural change. The wreck was originally surveyed in 2015, and re-surveyed in 2019 (Majcher et al., 2022) using the same survey parameters. Five areas of structural change were captured in the resulting difference model **(FIGURE 11_23)**. These were: a bending of the portside gunwale, displaced downwards by approximately 1.5 m; one of the stern gunwales dropping 1 m towards the seabed; the iron mainmast lowering by approximately 0.3 m, associated with erosion of the seabed around its tip; and highly localised, but potentially high magnitude (−2.5m) changes registered on the upper surface of the box battery, possibly caused by plating falling into the hull (Majcher et al., 2022).

These case studies therefore clearly demonstrate examples of where the regional-scale conceptual model breaks down at a local scale: at a site-specific scale wreck trajectories can sometimes be interrupted by external triggers or forcing events, ultimately leading to more complex trajectories and material loss at earlier stages.

11.5 Science and the Sea: Discussion

The potential for combining scientific archives and datasets with historical collections is clear. It is possible without very expensive diving missions (human or ROV) to propose or correct vessel IDs. Increased access to digital records will enhance that capability. This is significant for four important reasons. First, establishing the last resting place of passengers and crew remains an important activity, for descendants and relatives, and for legal reasons. Second, hazardous cargoes which these ships may have been holding may be more quickly identified and management strategies put in place. Third, ownership, salvage rights and insurance issues may be clarified through such identifications. Finally, the heritage significance of such wrecks may be such that state legislation applies to their protection on cultural grounds. Devolution and the evolution of the UK's marine planning legislation, may mean that a vessel of special significance to northeast England or to Clyde and Scotland, may fall to the heritage management responsibility of Wales, Northern Ireland or to the Isle of Man. It is therefore important to retain an overview of the maritime past of the UK in ways that Unpath'd Waters has shown are possible.

Beyond such practical considerations, there is a clear interest from the public. There are other marine stakeholders with a passionate interest in underwater cultural heritage who also have a great deal to offer, such as sports divers, fishers, and volunteers at local museum and archive services. The importance of regional archive services at a vessel's place of build or its subsequent home port has been amply demonstrated. Wider still, we note the extent to which such news stories as that of the HMS *Stephen Furness* stirs public curiosity, empathy and interest. We have demonstrated the relevance of the emerging human stories which relate to different ethnic groups, their roles in history, their treatment and their interactions in trade, war and travel.

We still recognise that providing confirmed wreck identities remains difficult and some of our case studies elucidate the often conflicting or confusing historical sources. Access to certain archives is problematic further challenging such attempts, because of paywalls or licensing restrictions, lack of curatorial support, or (in the case of physical archives and collections) because of geographical separation from researchers and thus resources and logistics. We pick these issues up in more detail in **Section 17.2.1** (Analogue to Digital Connector).

Ultimately a phased approach that undertakes more detailed multi-beam echosounder surveys, diver or ROV/AUV inspection may be required to provide final positive identification. The excitement of seeing a wreck for the first time since it was lost in multibeam data will never diminish. Interpreting that data and providing context for both the life of a vessel, and the loss, continues to remind us of the importance of our maritime past.

We have also demonstrated the power of combined collections to help us model for the past and the future. The short case study on the modelling of the movement of bodies from the HMS *Stephen Furness* is necessarily scientific in its approach, but we also understand the underlying tragedy and story of commemoration which leads to the gravestone of Able Seaman Walter F Talmey in Llanfair-yng-Nghornwy churchyard. For the future, our work has set up a basis for considering how we might approach management of this collection – this wreckscape. Survey and excavation are limitingly expensive and will not be appropriate at all in the case of war graves, but time and tide will have their effect and a better understanding of what we might lose and how fast will surely help. A connected national collection will provide us with this possibility.

12. Voyages of Discovery 3 – Lands Beneath the Sea

Vince Gaffney, Simon Fitch, Rachel Harding, Phil Murgatroyd (University of Bradford)

This voyage aimed to demonstrate how the deployment of a wide range of collections and datasets could make it possible to explore a remarkable ancient world. 20,000 years ago, the space between what is now England, the north-western European coast and Scandinavia was dry land. This vast space was marked by hills, valleys, plains, marshes, lakes and rivers, and was undoubtedly the site of a rich ecosystem inhabited by human beings. Over the intervening two hundred centuries, the combination of climate change and isostatic readjustment after the last Ice Age has seen the inundation of this now-lost landscape by the North Sea. We sought to gather all the currently available information and create a simulation of this landscape which would be not only a key interdisciplinary research tool, but also a game-like tool to allow audiences to 'visit' the landscape at any time up to about 5,000 years ago when the sea eventually covered it all.

The approach consists of two elements: the Unpath'd Waters Simulation Data Package and the Unpath'd Waters, Undream'd Shores simulation. The Data Package consists of an updated map of the submerged landscapes under the southern North Sea, with all available source data. The Unpath'd Waters, Undream'd Shores simulation consists of two accessible pieces of software which use this data as a base for a simulation of this land between the end of the last Ice Age (20,000 years ago, or 20 ka) and its final inundation (5,000 years ago, or 5 ka). The Exhibition edition of the simulation was designed for public spaces and formed part of the Unpath'd Waters exhibition. The Home edition is a more detailed version of the simulation for home use.

12.1 Doggerland

At the height of the last glacial maximum at about 20,000 years (20 ka) ago, when global sea-level was 130 metres lower than the present, 20 million km2 of new territory was exposed around the world's continental margins. The European continent increased in area by as much as 40%, exposing more than 3 million km2 of new land. Once deglaciated, this vast territory persisted for thousands of years. In northwest Europe, the largest of these areas was in the southern North Sea and is often known as Doggerland. With an area approaching that of Great Britain, its coastal plains, low hills, lakes, river valleys, marshes, estuaries, shorelines and offshore islands, would have provided some of the most productive territory and resources available for human settlement and dispersal anywhere in the continent. From 16 ka onwards, progressive global warming and sea-level rise transformed and inundated this territory. By 6 ka, these unique landscapes had almost totally disappeared.

Investigation of these areas in Europe has generally involved the discovery and excavation of late Mesolithic and early Neolithic settlements and cultural deposits (c. 7–5 ka) in shallow water close to the modern shoreline and easily accessible to diver investigation. However, the subjects of all of these investigations are very late in date, belonging to the final stage of sea-level rise. We know almost nothing about the deeper, previously habitable areas of Doggerland and the communities that certainly lived there.

One recent approach has been to model landscapes in the North Sea from seismic data collected by the hydrocarbon industry and from research vessels using higher-resolution methods of geophysical remote-sensing and coring of sediments. This has resulted in mapping and dating of much older (>8 ka), more deeply submerged landscape features, including major river valleys, coastlines, marshes and lakes. We now have significant knowledge of the topography and environment of the areas, but this is a landscape largely without people.

Even with these advances, we still have only tantalising glimpses of this underwater landscape. Ongoing climate change and the massive expansion of offshore windfarms and other offshore industries will intensify in the coming years. The research community can and should provide better and more engaging methods to inform the public about the significance of archaeological landscapes they cannot see or visit, to provide researchers with novel ways to interact with this data, and to guide public policy on the location and management of the unique underwater cultural heritage of the North Sea.

12.2 The Sources and Collections

The data sources and collections which form a crucial component of the Unpath'd Waters data package are extensive and diverse. The following sections provide an overview of the primary sources that were instrumental in constructing the data package and developing the associated simulation models. These sources encompass a wide range of data types, including topographic, palaeoenvironmental, and archaeological datasets, all of which contribute to a comprehensive understanding of submerged landscapes.

12.3 Topographic and Relative Sea Level Data

The topographic and relative sea level data within the package are primarily derived from the BRITICE project[108], funded by the Natural Environment Research Council (NERC). This data, which includes digital elevation models (DEMs) and palaeocoastlines, was generated through glacio-isostatic models developed by Dr Sarah Bradley at the University of Sheffield, and colleagues. Covering the UK and its offshore continental shelf, the DEMs provide a detailed reconstruction of palaeo-sea levels over the last 20,000 years, with datasets available at 1,000-year intervals (example shown in **FIGURE 12_01**). This data is pivotal for visualising the changing landscape and relative sea level over time and includes ice extent information. The datasets are publicly accessible via PANGAEA[109] and are detailed in key publications by Bradley et al. (2023) and Clark et al. (2022). Within the Unpath'd Waters data package, these datasets are formatted as ASCII files.

12.4 Landscape Features

The landscape features layer in the Data Package is compiled from several sources **(FIGURE 12_02)**. The primary contributor is raw geophysical data obtained by the University of Bradford between 2015–2021, during the European Research Council-funded 'Europe's Lost Frontiers' project. This dataset is complemented by industrially acquired data, such as the PGS Southern North Sea 3D MegaSurvey, and data accessed through open access arrangements, including 3D seismic blocks from TNO (the Dutch Geological Survey), A15, and DEFAB. The 3D seismic reflection datasets are high resolution (meter scale), covering extensive areas and allowing for the imaging of large-scale drainage systems. Additionally, ultra-high-resolution Sparker and Parametric Echosounder data from Europe's Lost Frontiers project provide detailed imaging of subsurface features at a centimetre to decimetre scale, though lateral coverage is limited due to budget constraints. These various sources, supplemented with shallow subsurface geophysical data from the British Geological Survey (BGS), enable a robust interpretation of palaeo-land surfaces.

In the UK sector, features such as channels and peat deposits have been digitised from windfarm reports and academic literature, with each feature referenced within the data package. In the Dutch sector, geospatial data for the aforementioned features has been sourced from the Netherlands Enterprise Agency (RVO) and included in the package.

12.5 Palaeoenvironmental Data and Dating

The palaeoenvironmental and dating data within the package have been significantly enhanced by direct sampling efforts, including coring and dredging conducted by the Submerged Landscapes Research Centre. Since 2016, over 80 cores were collected from the North Sea, ranging from the Doggerbank in the north to the Belgian coast in the south. These cores, along with approximately 3m² of dredged material, have undergone various analyses, including pollen, SedaDNA, diatom, geochemical, and dating techniques such as C14 and OSL. Data from these analyses, including core photographs and dating results, which have been published (Gaffney et al, 2007) or are pending publication, have been incorporated into the Unpath'd Waters data package. This data provides critical insights into the palaeoenvironmental conditions of the North Sea region. Additionally, dates obtained from windfarm reports have been integrated, subject to any copyright or data usage considerations.

---

108 https://www.sheffield.ac.uk/geography-planning/research/geography/projects/britice
109 https://doi.pangaea.de/10.1594/PANGAEA.945729

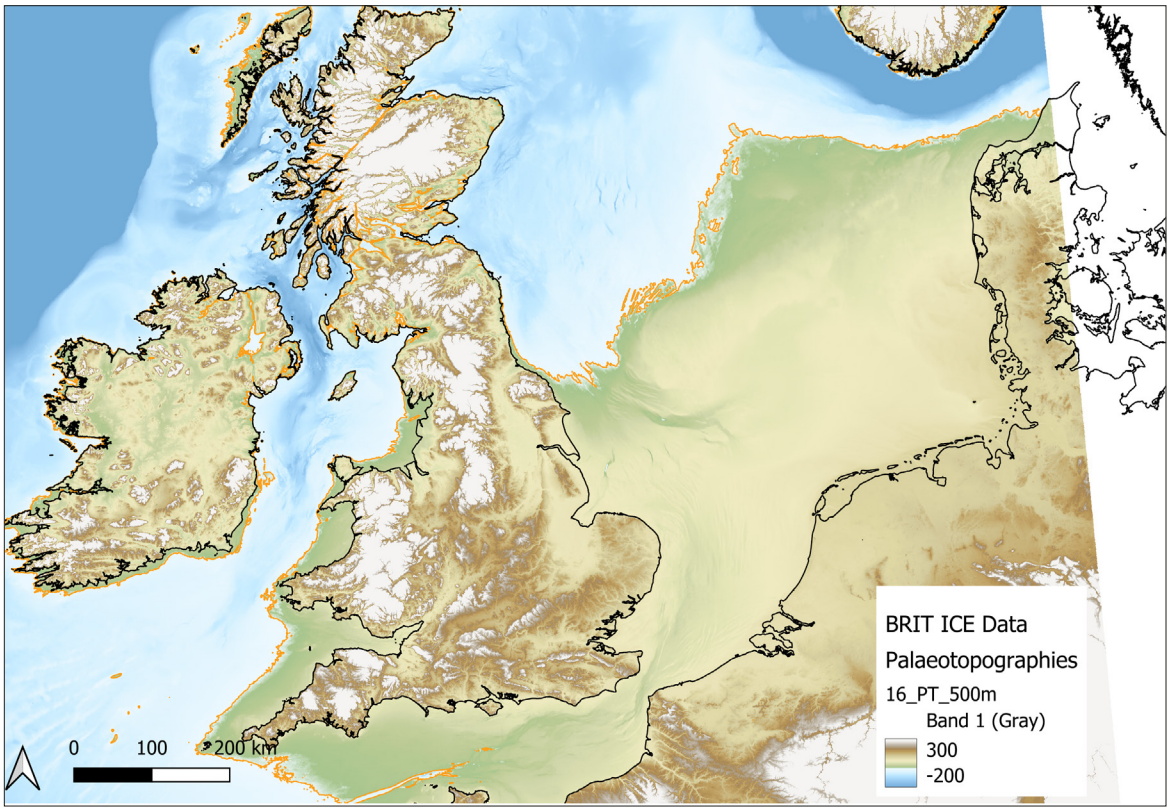


FIGURE 12_01
Example of palaeotopography and palaeocoastline (in orange) utilising the BritICE data at 16,000 years ago.

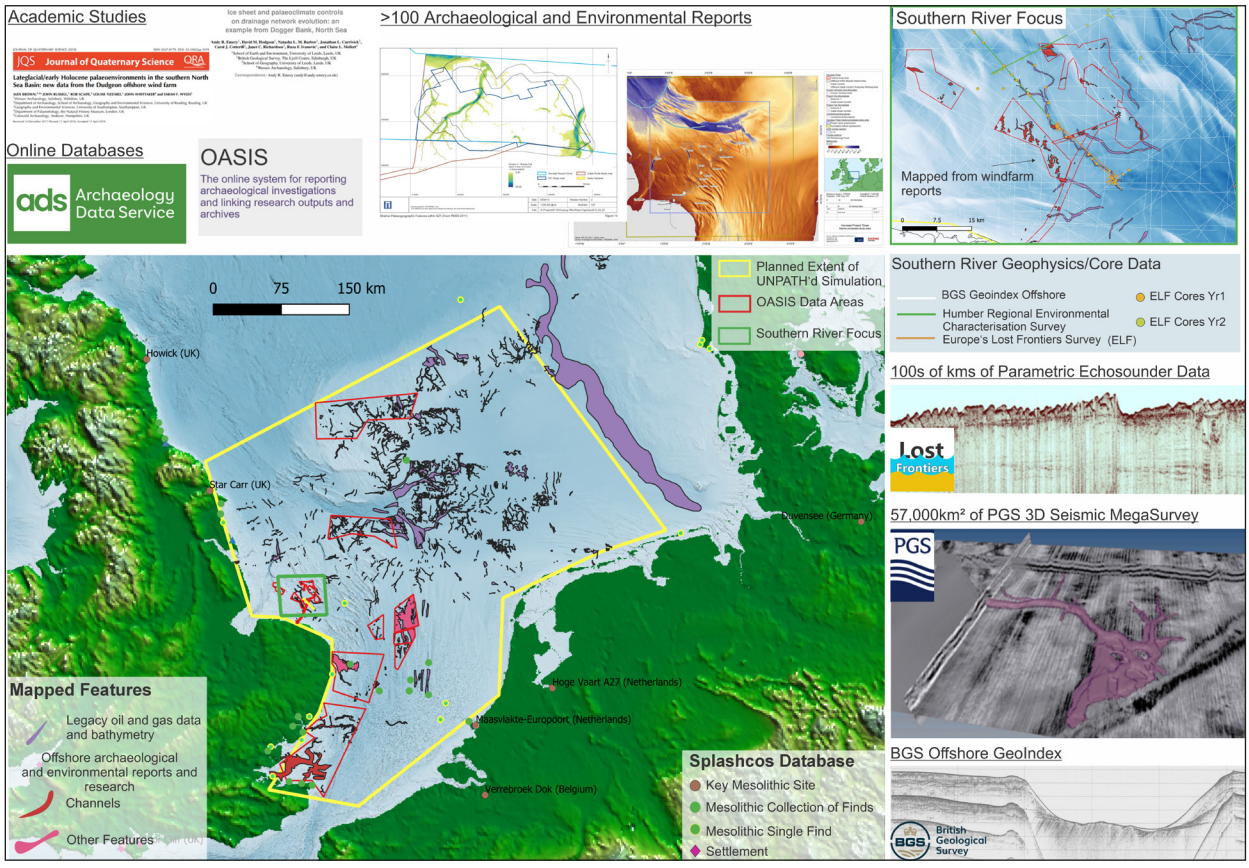


FIGURE 12_02
Data types utilised to map key features.

12.6 Archaeological Data

Archaeological data for the project have primarily been sourced from the SPLASHCOS viewer database[110], which consolidates information on submerged prehistoric archaeology and landscapes across Europe. This database, established under the European Commission's COST program from 2009 to 2013, serves as a foundational resource for maritime archaeological data. Supplementary data has been provided by archaeological finds from the Submerged Landscapes survey work conducted since 2016.

The combination of these diverse data sources within the Unpath'd Waters Simulation Data Package provides a comprehensive tool for exploring and understanding the submerged landscapes beneath the North Sea, offering valuable insights into their historical and environmental significance. A full list of sources used for this work will be available as part of the Unpath'd Waters data package.

12.7 The Challenge

The main challenges facing submerged landscapes archaeologists are a function of the relative inaccessibility of the landscape, both to scientists and the general public. The main research tools used in submerged landscape contexts are the collection of physical samples and the collection of geophysical data. Geophysical data was initially only available as a by-product of prospection for oil and gas deposits[111]. Since the Europe's Lost Frontiers project and the development of the Submerged Landscapes Research Centre at the University of Bradford, targeted data collection has been possible via collaborative research expeditions with the TNO and VLIZ. This has enabled us to direct geophysical prospection into areas with high archaeological potential. Physical samples have also been collected during these expeditions, yet the operation of a research vessel is expensive and can only be accomplished with the help of research funding and co-operative partners. Compared to terrestrial archaeology, which allows a number of low-cost methods of data gathering, bespoke marine archaeological data collecting is both complex and costly in both funds and resources.

The inaccessibility of the landscape also affects the audience for the research. There are no permanent residents of Doggerland who can identify these submerged lands as their homeland. This means there is both no natural audience for the research on geographical grounds and no automatic group of locals motivated to protect the archaeology that lies beneath the sea. Doggerland cannot be visited on school trips or as a tourist destination in the same manner as archaeological landscapes such as that surrounding Stonehenge.

With computer simulation we have a potential solution to both of these problems. Simulation can act as a virtual sandbox in which data can be integrated and scientific hypotheses can be tested, at comparatively little cost. It can also act as a means of dissemination, allowing users a glimpse of a land now inaccessible. It also allows a degree of freedom for users to focus on aspects that they personally find interesting. Simulation contains two advantages over the approaches used within different contexts in this project. A lot of what we know about Doggerland comes from comparative data from elsewhere. We find evidence of animals and plants in the physical samples taken from the seabed but the way that these imply a complete environment is derived from research on modern contexts in terrestrial landscapes. A GIS map of data points, while desirable and useful, will only contain part of what we know about the landscape. A virtual sandbox is a dynamic environment in which variables and behaviours can be changed, leading to different results. This promotes the idea that there are multiple, uncertain, yet possible Doggerlands which can be explored virtually.

110 http://splashcos.maris2.nl/

111 See https://www.bradford.ac.uk/archaeological-forensic-sciences/research/europes-lost-frontiers/

12.8 Methodology

12.8.1 Creating the Unpath'd Waters Simulation Data Package

Utilising the sources listed in the previous section, we have developed a Data Package to help users access geological and archaeological data relevant to the southern North Sea, focusing on the Late Palaeolithic and Mesolithic periods (from the post-Last Glacial Maximum to the early Holocene). During this prototype phase, we maintained broad criteria for feature inclusion, aiming to represent features that likely had surface expression at some point between the Late Pleistocene and early Holocene. It is important to note, however, that not all features had surface expression throughout this entire period, and the mapping represents an amalgamation of palaeogeography over time, rather than a single moment in history.

12.8.2 Feature Layer

Various external datasets described in the source section were imported into QGIS, typically in shapefile or raster formats. When vector files were unavailable, key feature maps were georeferenced from reports or academic publications, digitised, and incorporated. For features identified in geophysical data, industry-standard geophysical software, such as S&P Global's Kingdom and Schlumberger's Petrel, was used to visualise and interpret the data. Algorithms (known as attributes) were applied to the 3D seismic volumes to enhance the visibility of geomorphological features. In areas with relatively flat strata, 'time slices' were used to create a bird's-eye view of channel systems, allowing us to digitise the external edges of key features **(FIGURE 12_03)**. Where the strata were more complex, the layers were mapped, 'picked,' and made into grids, allowing attributes to be extracted. These digitised polygons were then exported as shapefiles, imported into QGIS, and integrated into the feature layer. We were able to interpret features down to a depth of about 70m using geophysical data, including some tunnel valleys, which were reused by Holocene channels and likely had surface expression during the period of interest. For earlier periods, many of these incised features would have been deeper, as they filled with sediment during the early Holocene sea-level rise, resulting in wider and shallower features.

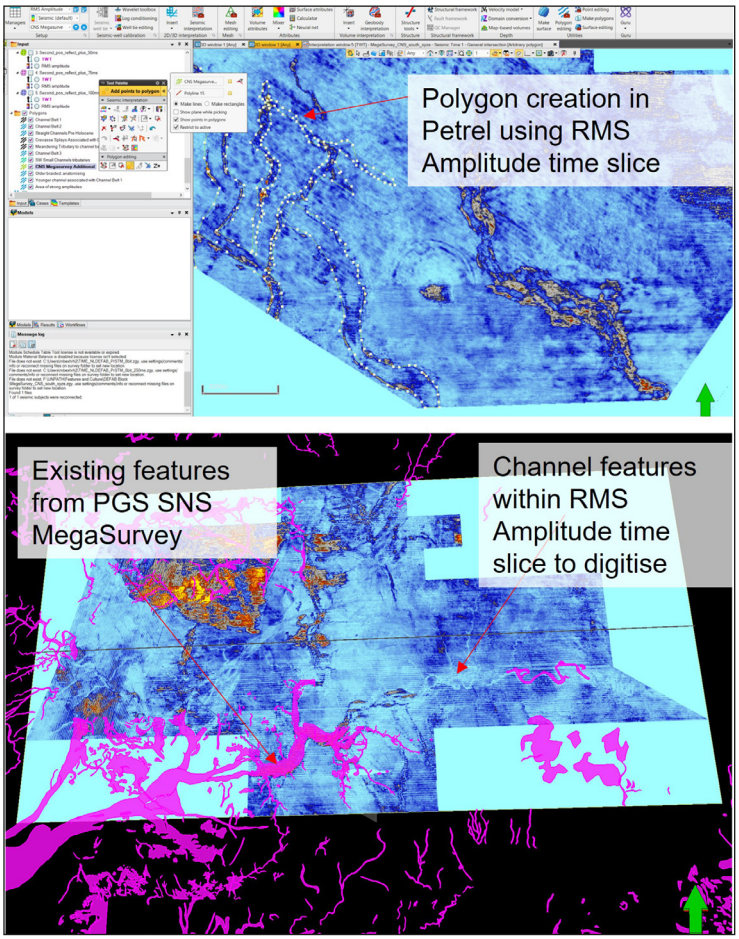


FIGURE 12_03
Example of the digitisation process using 3D geophysical data within Schlumberger's Petrel software, generously donated to the University of Bradford. The data shown is from the DEFAB block, open-access legacy oil industry data originally acquired by Fugro and available via the Dutch Oil and Gas Portal (https://www.nlog.nl/en).

The collection of external data, combined with the digitisation and interpretation of raw geophysical information, was completed in stages as new data became available. Each feature was merged to a single layer with a uniform attributes table and metadata. Attributes assigned include type, relative age, source URL, and access date. The final data package will be archived with the Archaeology Data Service.

This data package was used to develop the geological layers for the simulation. Since precise dating is unavailable for many features, they were combined into one layer and assigned an arbitrary depth of -5m, reflecting the average depth of channel features from the ERC-funded Lost Frontiers project. This depth is a general estimate – overestimated in some areas and underestimated in others. These features were then embossed (or burnt) into a zero-depth raster layer, creating a surface with negative features, which were added to the topographic DEMs, along with the sandbank removal layer **(FIGURE 12_04)**.

Within the dataset, we have also digitised key academic contributions hypothesising the locations of palaeochannels and drainage patterns across the southern North Sea during the period of interest (Amkreutz et al., 2022; Garcia Moreno, 2017; Hijma and Cohen, 2011) **(FIGURE 12_05)**. While these sources are included in the data package for reference, they were not used in the current simulation, as we opted to work only with raw, unextrapolated data for this version.

Incorporating these palaeogeographic reconstructions from academic research enables comparisons between the latest understanding of channel systems in the North Sea and existing models. Future work at the Submerged Landscapes Research Centre will use this collated dataset to produce an updated extrapolation of the drainage patterns. This will inform future simulations and assist in outreach efforts by updating palaeogeographic maps of Doggerland.

12.8.3 Other Data Types

In addition to features like channel systems, we have incorporated data from both internal and external sources related to paleoenvironmental analysis and the dating of Late Pleistocene and early Holocene strata. This includes information on peat deposits, which are valuable for sea level reconstructions and for reducing risk in wind farm placement. These data are provided as point vector files within the data package, with hotlinks to relevant images, URLs, and datasets.

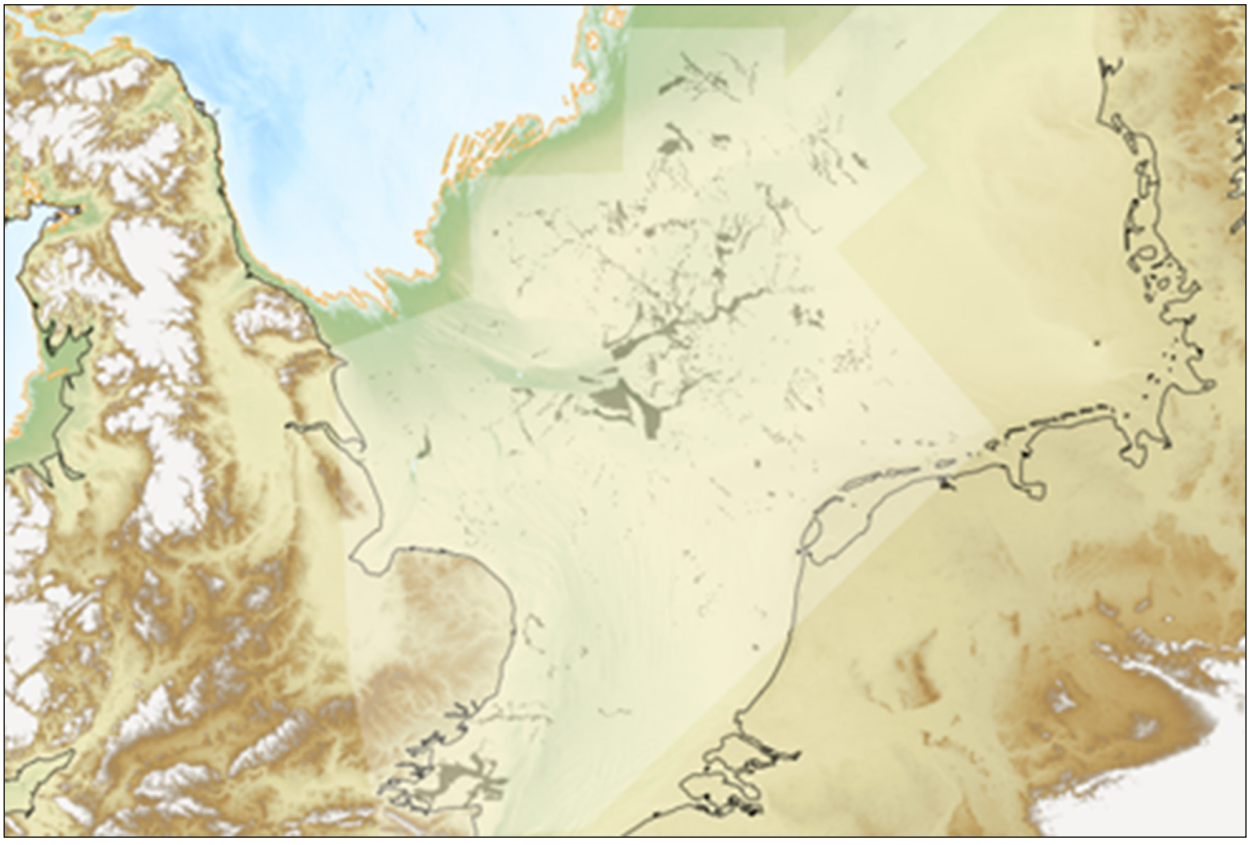


FIGURE 12_04
Feature layer with a 5m depth utilised in the simulation.

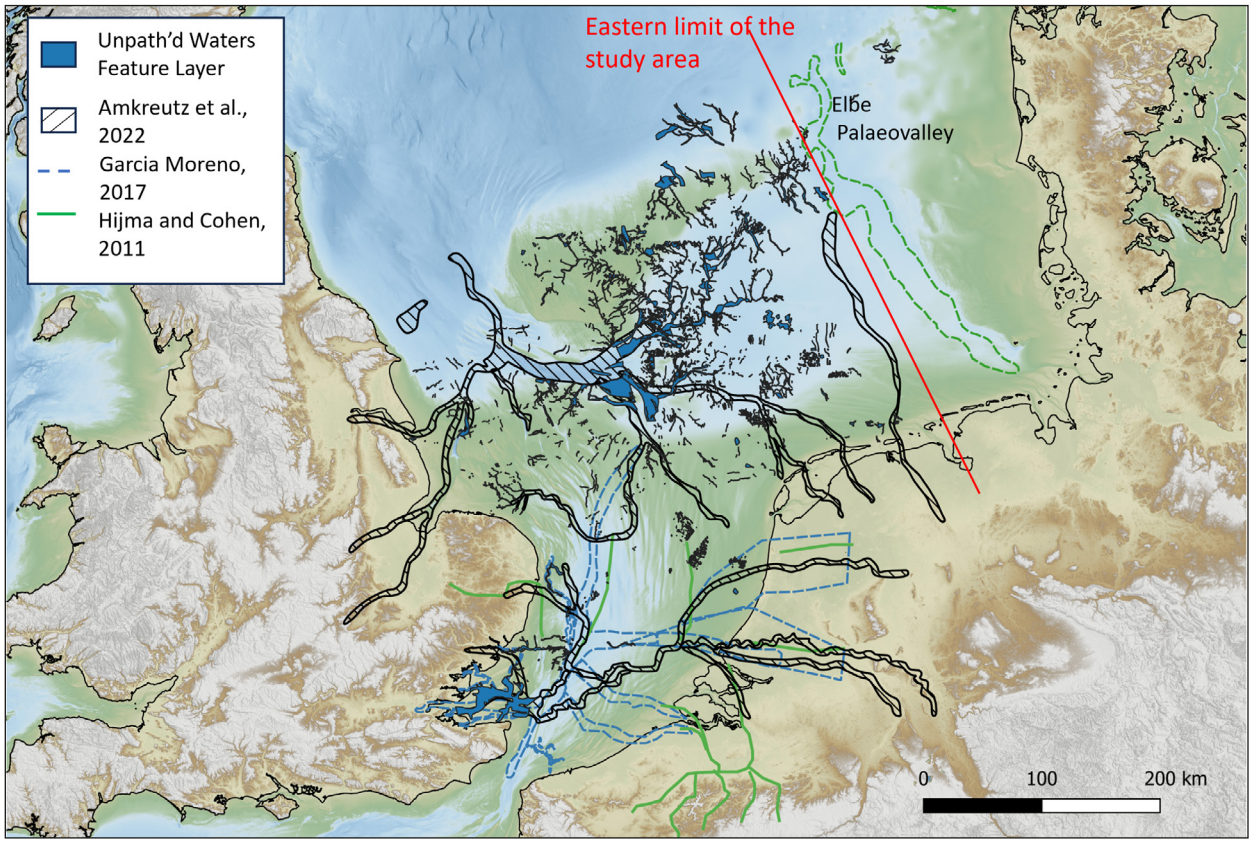


FIGURE 12_05
Comparison of academic sourced palaeogeophraphic reconstructions with the Unpath'd Waters feature layer. Background is GEBCO bathymetry utilising the WIKI 2.0 colour ramp to highlight areas which would have been land during the early Mesolithic at about 10,000 years ago (green) and which would have been marine (blue).

12.8.4 Removal of Modern Features for DEMs

Modern sandbanks are a key feature of the present-day bathymetry **(FIGURE 12_06)** of the southern North Sea. To more accurately represent the landscape prior to inundation and marine processes, these sand features must be removed to somewhat negate the effects of erosion and deposition that have occurred since the transgression of Doggerland. While it hasn't been possible to account for every small change due to limited data, future research will address this. However, where subsurface data is available – such as in the case study areas of the southern North Sea – we have been able to perform higher-resolution adjustments. For other areas, we have focused primarily on removing large-scale sandbanks and adjoining troughs.

This process has been carried out using smoothing tools within QGIS on the DEMs used in the simulation. These tools have been applied to smooth discrete areas without altering the broader gradients of the topography. The resulting ASCII files utilised in the simulation have had large positive features removed, and the surrounding areas have been smoothed to create a more uniform topography. Although this method is somewhat crude, it is a prototype that can be refined further and due to the low resolution of the DEM required for the simulation, (much lower than shown in **FIGURE 12_06**) this method works well.

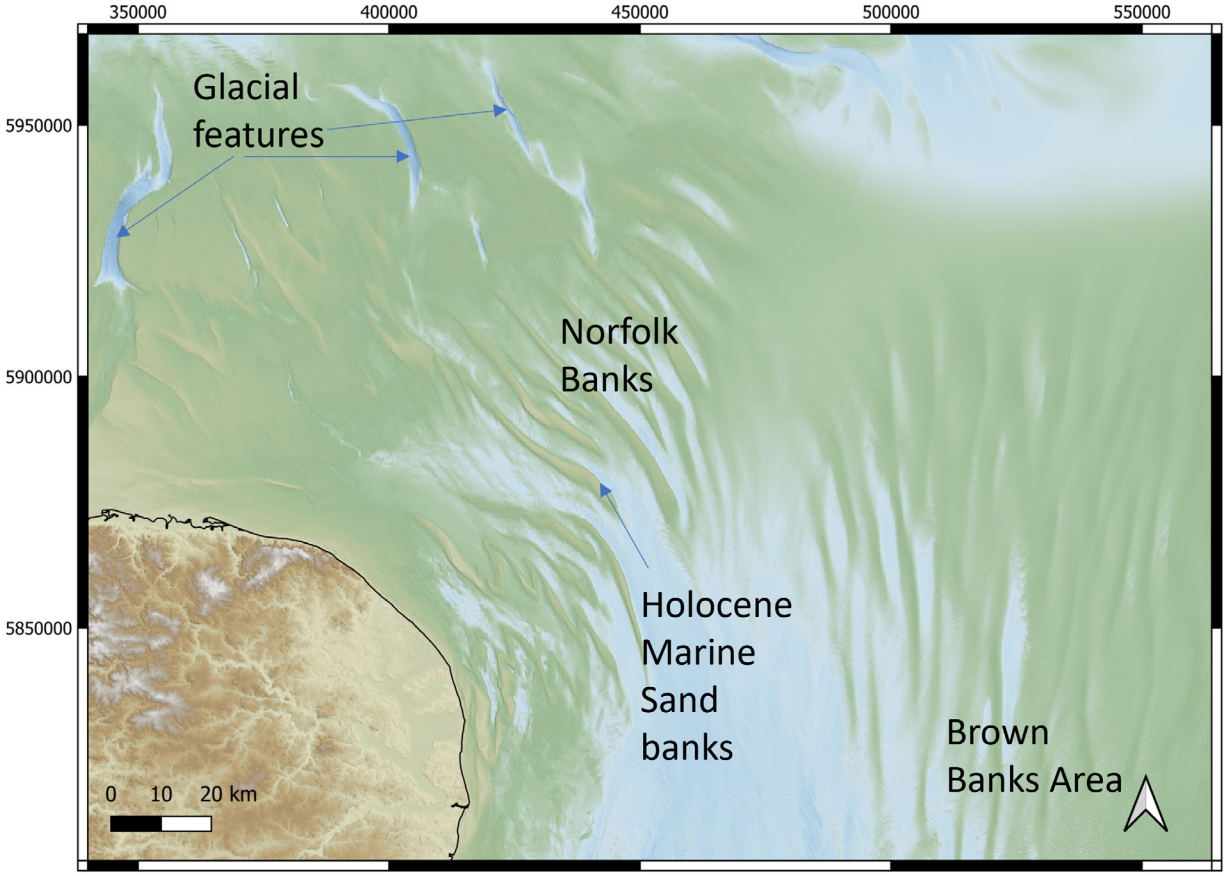


FIGURE 12_06
Present day Bathymetry of the southern North Sea. GEBCO 2021 dataset.

12.9 The Simulation

The simulation is a virtual sandbox in which the user can navigate and explore the data from and about Doggerland. It acts as a means of data integration and visualisation as well as allowing users to focus on the aspects which they find most interesting. It consists of three screens: the intro screen, the regional map and the local map.

The introductory screen serves as a welcome to the simulation. In the Exhibition version it gives a brief introduction to the project and the user controls. In the Home version it also allows the user to alter settings which affect the appearance and operation of the simulation.

The regional map **(FIGURE 12_07)** shows Great Britain, parts of Ireland and the southern North Sea. It allows the user to move forwards and backwards in time between 20 ka and 5 ka. The position of the land and sea changes based on the base data and the method of interpolation. Glaciers are shown between 20 ka and 15 ka. This data is based on that published by the BRITICE project, with modern sandbanks removed where possible. On this map, the user can select a location and time for the creation of a local simulation of the environment at that point in space and time.

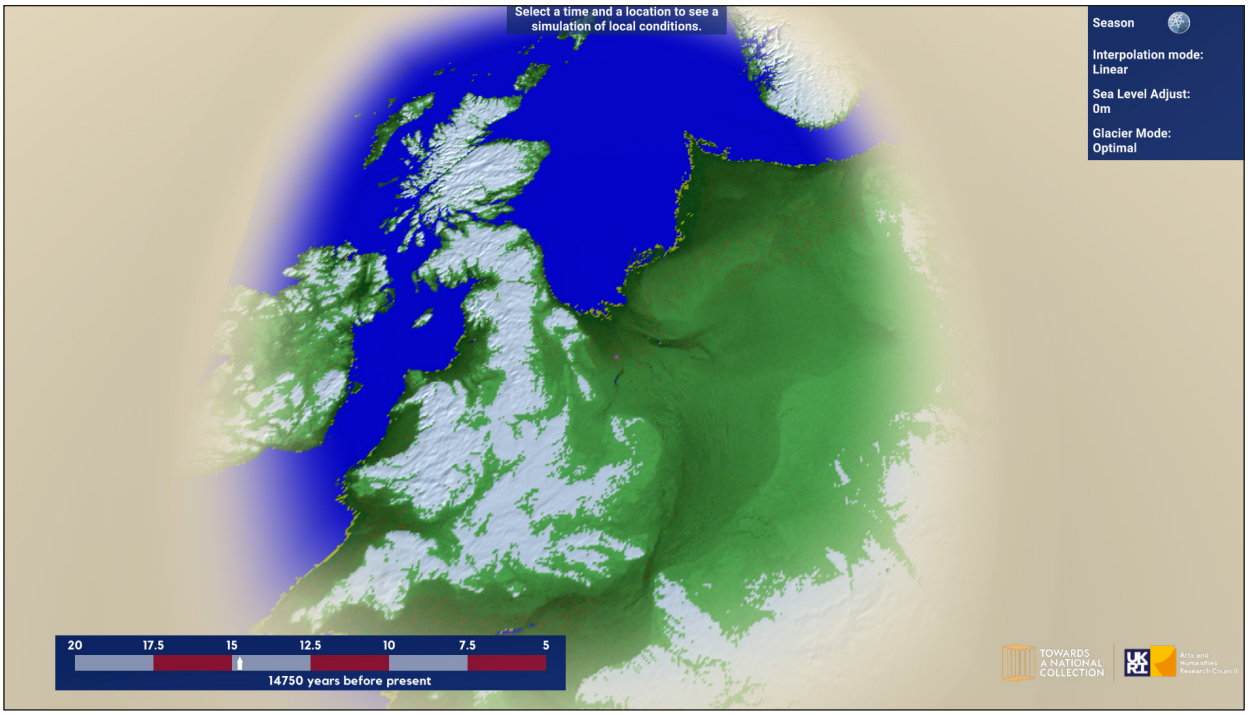


FIGURE 12_07
The regional map, showing the entire simulation area.

The local simulation uses the large scale, regional data, along with the features mapped by the team and a climate model to produce an approximately 20km x 20km area containing animals, plants and humans **(FIGURE 12_08)**. The environments are based on the work of the Europe's Lost Frontiers project, especially the sedimentary DNA analysis, which gives a more complex set of data than traditional methods (Gaffney & Fitch, 2022). Unless the environment is over 90% tundra, a single camp of humans is placed in a suitable location.

12.9.1 Design and Implementation of the Simulation

The simulation was implemented in the Unity development platform, due to the ease with which executable, robust code compatible with many Microsoft Windows systems could be generated. Unity is frequently used for the development of independent games and educational software and there are many learning resources available online. 3D models were created in Blender, an open-source modelling software package.

The simulation uses a series of data files corresponding to the land surface at each 1,000-year interval between 20 ka and 5 ka, inclusive. These are derived from the files created by the BRITICE project, with a reduction in resolution and the removal of modern sandbanks the only forms of further processing. These are used as the base data for the regional map, with the addition of glaciers which were digitised from Clark et al, 2022. The data points around the selected location are passed to the local simulation and act as a base for the landscape, which is procedurally downscaled (Contreras et al., 2018). The features mapped within the data package are then embossed onto this landscape and a brief fluid simulation is run over the resulting surface to identify areas liable to forming wetlands or rivers.

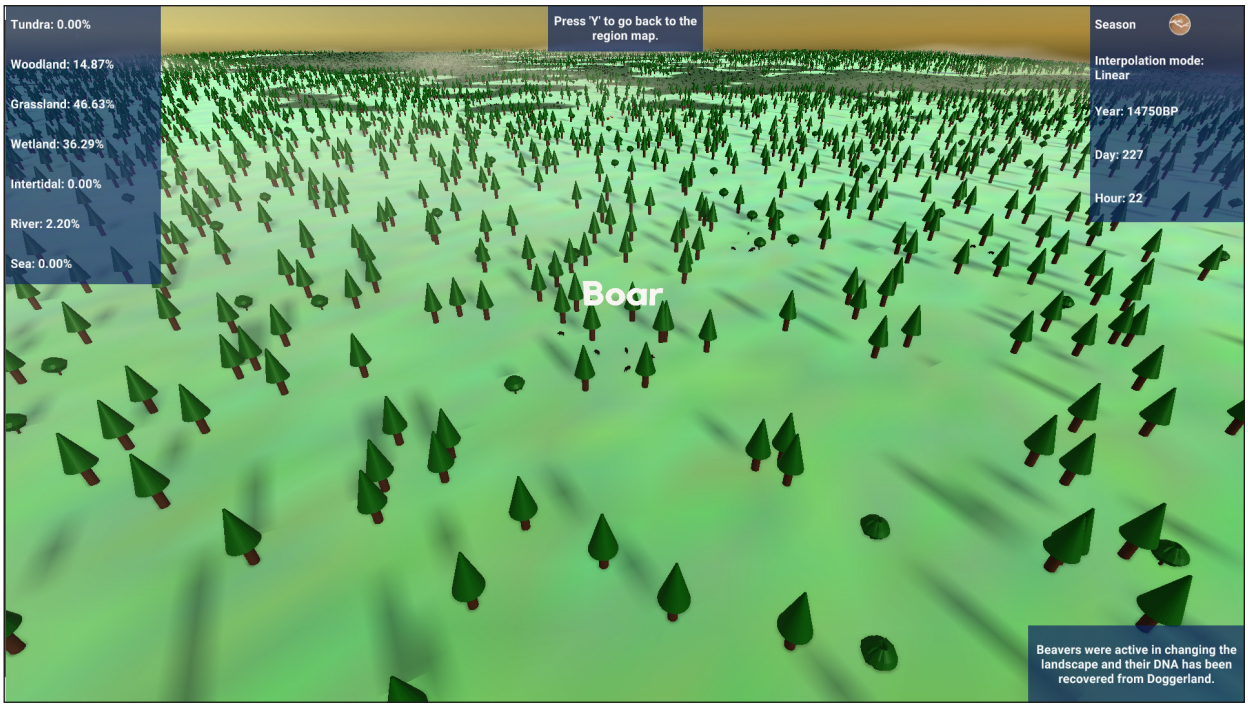


FIGURE 12_08
The local simulation, showing a largely forested environment containing some boar.

Depending on sea level, morphology and the results of this fluid simulation, the landscape is split into the following categories:

- Sea
- Intertidal zone
- Marsh/Wetland
- Grassland
- Woodland
- Tundra
- River

Trees are added to woodland areas and animals are placed within the landscape in suitable locations. Within the Exhibition version of the simulation, these are:

- Boar
- Arctic Fox
- Aurochs
- Elk
- Beaver

In the Exhibition version of the simulation, the animals and humans do not move or exhibit any other kinds of behaviours. Within the Home version, these animals, along with any human inhabitants, forage for food and react to the changing seasons.

12.9.2 Accessibility

A key aspect of the design of the simulation is the accessibility of both the software and the data. Itch.io was chosen as a distribution platform due to its position as a significant host of small to medium scale software. Software on Itch.io is findable and the interface is straightforward to navigate. The software itself is designed to be easy to install and use. It is delivered as a zipped file structure which needs only unzipping and clicking on the executable programme. No other software packages are required, and the software can be used with either an X-box compatible controller or a standard keyboard. Both the font and colour scheme of the user interface elements can be toggled.

Producing software that is easy to use lowers the barriers to interaction with both the simulation and the base data. Although the data package files are available in formats which can be easily loaded into GIS software for further analysis and integration with other data sets, the ability to navigate the collected data sets within the simulation allows users unfamiliar with standard GIS software access to the data. With one click to download the simulation, one click to unzip and a double click to run, the user can be looking at, and navigating through, the data with only four clicks. This has obvious benefits for uptake by the general public but will also increase usage among researchers, not all of whom have the technical skills or time to handle a GIS project.

12.9.3 Open Access Archiving

The GIS data within the Unpath'd Waters data package will be archived with the Archaeology Data Service. The simulation software is available on Itch.io for the duration of the platform. The source files are available on Github[112].

112 https://elfdev001.github.io/

13. Voyages of Discovery 4 – New Opportunities

Alongside our three main Voyages, we also took the opportunity to explore a number of other potentials and issues relating to the core objectives of Unpath'd Waters. This chapter summarises these.

13.1 Visualising National Records: Unpath'd Waters and the English National Marine Heritage Record

Raghdaa Eissa & Hefin Meara, with Frankie Lau, Historic England

13.1.1 Introduction

Historic England's National Marine Heritage Record is an extensive text-based dataset on the marine historic environment. The Unpath'd Waters project provided an opportunity to explore alternative forms of dissemination of this data, with a focus on story-telling and the use of visual aids to provide interesting and interactive ways to engage with what can otherwise be perceived as dry and unengaging data. This has the dual benefit of providing an eye-catching way to draw the attention of non-specialist users, but also an opportunity to detect patterns in the data that would otherwise be hidden away.

During the course of the Unpath'd Waters project Historic England has been working on the redevelopment of its National Marine Heritage Record (see **Section 3.1)** using an instance of the Getty Conservation Institute's Arches open-source cultural heritage inventory platform. Arches[113] is a graph-based database, with information held in a semantically rich manner. The Historic England team have created bespoke data models suitable for holding information on the marine historic environment. The design of these models has been an iterative process, and the Unpath'd Waters GIS and visualisation strand of work has served as a testing ground for what information should be held in structured fields and controlled vocabularies. This will ease the automation and creation of specific visualisation methods for sharing data.

13.1.2 Design of Mariner Data Models

The development of the storymaps and web visualisations based around voyages and wartime incidents has highlighted the need for additional indexing fields, to allow for straightforward exporting of data from the National Marine Heritage Record (NMHR), for direct ingest into the visualisation software. Data models have been expanded to allow for the recording of voyages other than the final voyage. This is useful for recording notable voyages, such as Charles Darwin's voyages on board the *Beagle*, which ended its life as Coast Guard Watch Vessel No. 7 and lies buried in a mud berth on the River Roach on the Essex coastline[114].

The increased complexity of the data models is further highlighted in the split of shipwreck related information into two distinct models, one for the shipwreck site on the seabed, and one for the vessel from which the wreck is derived. Recording the information for the vessel as a separate and distinct entity, allows for the enhancement of records with information relating to floating vessels. This is particularly helpful for building linkages between national bodies such as Historic England, who have curatorial responsibility for wrecks on the seabed, and National Historic Ships UK, which advises on matters relating to historic vessels in the UK, and curates data relating to the National Historic Fleet.

113 https://www.archesproject.org/
114 https://historicengland.org.uk/listing/the-list/list-entry/1467785?section=official-list-entry

Previously it has been difficult to compare the significance of floating vessels with their submerged counterparts. Improvements to the data structure delivered through the development of Mariner allow for improved comparisons between the two types of heritage assets. This is demonstrated by the timeline showing the various voyages undertaken by HMS *Warrior*[115] created as part of the Unpath'd Waters project.

The development of stories and visualisations relating to the First World War has highlighted the need for improved linkages between shipwrecks and the vessels responsible for their sinking. The new data structure specifically allows for the capture of associations such as "sunk by" and "sailed in convoy with". Enhancing the data structure in this way allows for more detailed relationships to be recorded and enables detailed visual representation to be built using the minimum of data enhancement prior to ingest into the visualisation software. Its application has allowed for the accurate spatial depiction of German U-boat losses and their victims, allowing for previously unexplored patterns to be established (see below).

The development of the storymaps and visualisations has identified key fields which need to be incorporated into the Mariner data export products, to allow ingest into the visualisation software without requiring an additional data cleansing stage of work. This will be incorporated into the Mariner system as the Historic England team develop custom reporting and data export tools.

13.1.3 Utilising GIS Technologies to Showcase HE Marine Data Through Web Mapping Applications

Unpath'd Waters offered Historic England's GIS Team the opportunity to test some novel approaches to visualising, using maps, charts, plots, and animations. These visual displays of information communicate data relationships and data-driven insights in an engaging and easily understandable manner. Data collections included NMHR records, marine geophysical survey data, and data outputs of specific projects (e.g. the Heritage Harbour Inventory project (Cattermole, A. 2023). Data visualisation products were produced to showcase this varied data, including storymaps and web visualisations. Development of specialised applications or widgets allowed for visualisation of the data. A map-slider enabled the overlying of contemporary mapping with historic mapping and sea charts. Bathymetric data was used to create simple models of shipwreck sites, and fly-through animations were recorded to illustrate these models.

Web mapping applications were built using ESRI technologies, a leading GIS platform. ArcGIS Online (AGOL)[116] is used to build the web apps, including Dashboards[117], StoryMaps (SM)[118], Experience Builder (ExB)[119] in addition to Map Viewer and Scene Viewer[120]. Additionally, ArcGIS Pro[121] is employed for data preparation, processing, and analysis before sharing to AGOL.

Following cleaning and preparation, data is then shared as one or more feature layers, to ArcGIS Online. Feature layers act as a base for creating web maps and web scenes that are then included in AGOL apps: Dashboards, ExB and SM. These three apps usually interlink together **(FIGURE 13_01)**.

These applications are designed to help users explore and understand the temporal aspects of historical marine data, as well as the patterns, trends and insights behind historical events. Timelines and other visualisation techniques are utilised to present the data. Examples of different ways of visualising data are shown below.

---

115 https://www.nationalhistoricships.org.uk/register/501/hms-warrior

116 AGOL: A cloud-based GIS that enables organisations to collaborate and manage their data.

117 Dashboards: An online app within AGOL where web maps, lists, charts, gauges and indicators are integrated together in one screen

118 StoryMaps: 'a story authoring web-based application that allows you to share your maps in the context of narrative text and other multimedia content.' ESRI Documentation

119 ExB: An online app that allows the user to build web mapping apps that displays 2D and 3D data

120 Map Viewer and Scene Viewer: web mapping tools that allows the user to create, style and share 2D and 3D maps respectively.

121 ArcGIS Pro: a full-featured professional desktop GIS application

Timelines

Vessel voyages are included in the vessel records in the NMHR or can be documented in books and research reports. This kind of data is in the form of coordinates and place names. Timelines can be a good visual interpretation of these voyages as they can transform dry raw data into engaging narratives that show the user the rich history beyond numbers. Timelines give the user the opportunity to visualise the vessel's journey, itinerary, historical context, and significant events.

One of the ways explored to plot timelines was creating a 3D scene with 3D icons related to the corresponding events. **FIGURE 13_02** shows an example of a timeline created to showcase the last few days preceding the loss of the SM UC-70 – a German U-boat – in British waters. Other types of media can be integrated to timelines to enrich the narrative such as photos and videos.

Temporal Data – German Submarines Lost in British Waters and Their Victims

To test this approach, we used research undertaken by Historic England to mark the centenary of the First World War, including various projects commissioned in relation to the marine historic environment (see for example Firth 2014): records relating to the shipwrecks of that era are particularly well represented in the NMHR. Special focus was placed on the First World War and the analysis of ship losses over the years, the wrecks of German submarines, and the wrecks of civilian vessels of all nations lost during the course of the war. Various visualisation techniques were used to illustrate the extent of the damage they caused to British navigation.

The map in **FIGURE 13_03** shows an overview of the spatial distribution of German submarines and their victims lost in English waters. The geographical scope of submarine warfare in the area can be seen when both the submarines and the vessels they targeted are shown on the map. The visualisation also shows the overall intensity of the attacks on English coasts.

Further visual representations included:

- a 3D chart was created representing each submarine as a vertical bar whose height corresponds to the number of victims claimed by that submarine, thus highlighting those that posed the greatest threat to British shipping.
- A collective mapping app which pinpoints the locations where these submarines were lost in addition to the locations where they successfully targeted other vessels. This provides a spatial context for submarines operational areas and their potential and helps to spot areas that were of high risk for shipping.

Such examples can offer new approaches to understanding the impact of German submarines on British navigation during the First World War.

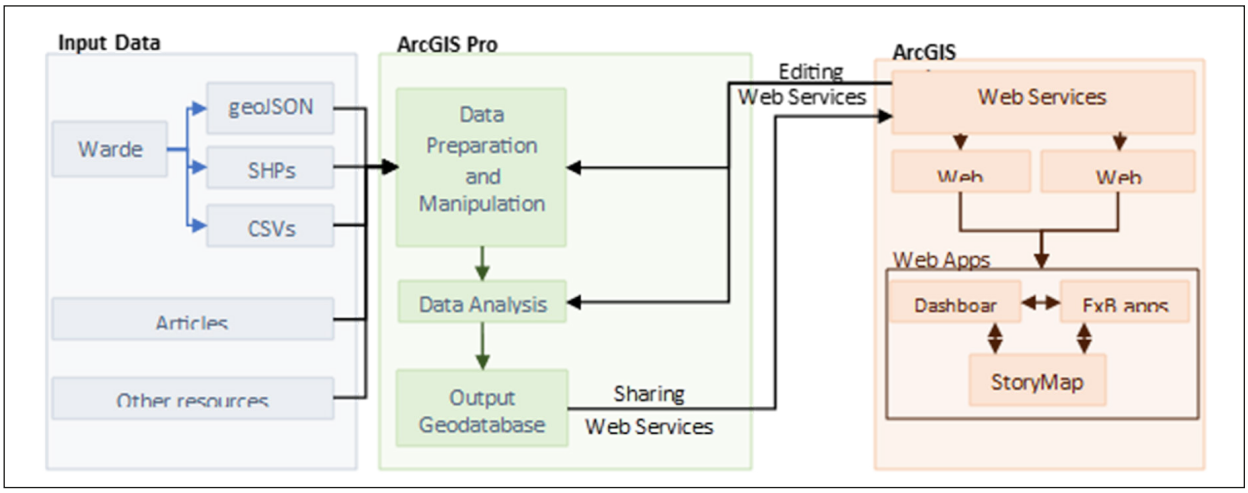


FIGURE 13_01
Workflow for producing the web apps. Data is exported from Warden in formats that can be imported in ArcGIS Pro. Articles and other resources are used to add to the database and further elucidate the data.

FIGURE 13_02
A screenshot from the UC70 timeline.

FIGURE 13_03
Map of German submarine locations and associated losses.

We also experimented with Heatmaps. More than 1,800 vessels were lost in English waters during the First World War. Locations with a higher concentration of shipwrecks are shown with a more intense heat (a brighter colour) instantly identifying the most heavily affected regions. The heat map **(FIGURE 13_04)** illustrates very clearly the incredibly high impact of the German U-Boat campaign on shipping along the east coast of England.

Dashboards and Statistics

Dashboards can be used to effectively consolidate spatial and temporal data, making it accessible and easily interpretable. **FIGURE 13_05** showcases a dashboard application that combines a map showing the locations of First World War shipwrecks along with a graph illustrating the number of vessels lost throughout the war period in one screen. This combined view allows users to not only see where shipwrecks occurred but also to understand how the rate of sinkings changed over time.

These resources are not yet available online as the links to the underlying data cannot yet be published. However, Historic England has archived them and is actively considering how they might become features of the Mariner system and the National Marine Heritage Record data upon it, once it has been formally published.

Trialling a Virtual Museum

We also explored development of a virtual museum to showcase these storymaps and data visualisation tools. This trialled how a collection – England's NMHR – might be shared and experienced by users in a playful and fun environment, an innovation for a non-museum government agency.

Each wall of the Virtual Museum resembles a section of the web mapping applications. The gallery of photographs link to their corresponding apps, virtual experiences or relevant links. The initial prototype version of the virtual museum was developed using BabylonJs[122]. The user is able to move around the virtual environment and explore the content freely using a web browser only. There is no requirement for specialist plug-in software.

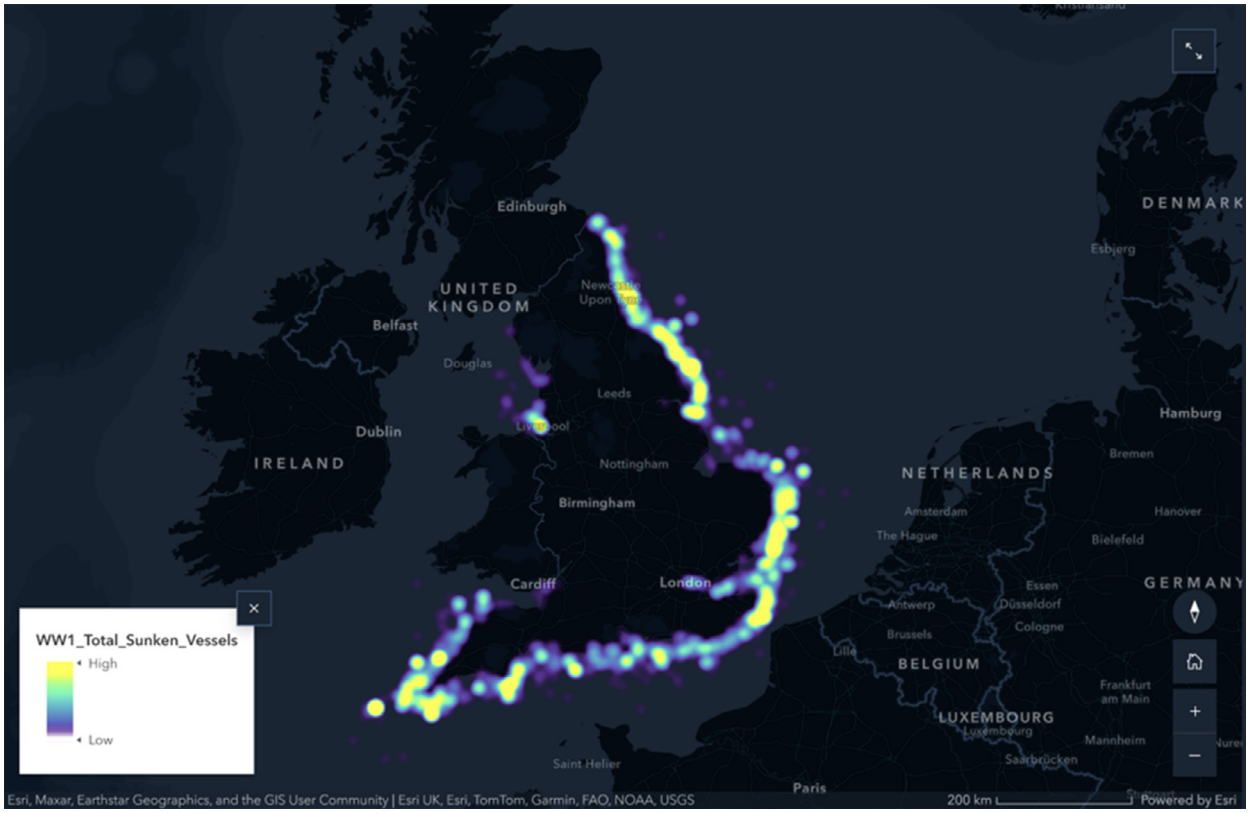


FIGURE 13_04
Heat map showing most affected areas of the British coast during the First World War.

122 https://www.babylonjs.com/

For every item in the Virtual Museum gallery, an info box can be opened for a brief text about that item. When clicked, each item photograph opens its relevant link: a StoryMap, a virtual experience, listing entry on the National Heritage List for England, and so on. These links open as an overlay over the current page, or as new tabs depending on the content.

The main hall can be viewed in virtual reality (VR) mode, which gives the user a more immersive and engaging experience. Although the website (see **FIGURE 13_06)** is not yet fully accessible at time of writing, future efforts will focus on enhancing accessibility to ensure that all users, regardless of their abilities, can seamlessly interact with and benefit from the content.

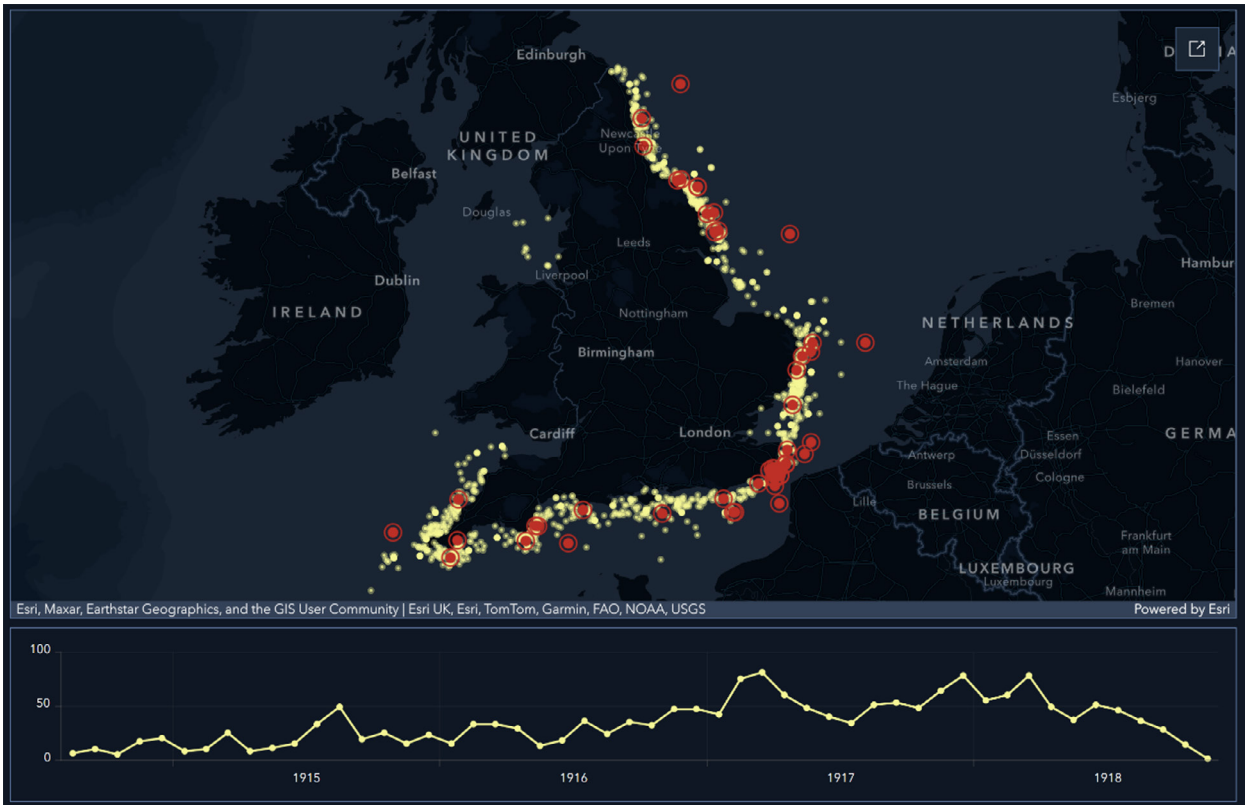


FIGURE 13_05
First World War Shipwrecks over time.

FIGURE 13_06
Prototype entry page for virtual museum.

13.1.4 Developing Spatial Depictions for Wrecks Whose Precise Location is Unknown

This technical case study sought to resolve issues of spatial depiction for shipwreck sites whose actual location on the seabed is unknown. We used the English NMHR which contains over 1,200 such 'Named Locations'. Original pre-GIS records assigned the position verbally, as described in the loss accounts. The positions can range from relatively precise features (eg "Gull Rock, off Lundy Island, north Devon"), less-well defined (e.g. "Goodwin Sands, off Kent") to very vaguely defined (e.g. "Off Beachy Head").

With the adoption of a GIS system, our initial solution was a polygon of 500m radius. This emphasised the imprecise nature of these positions while enabling spatial searches. Although this worked well for wrecks lost off a particular seabed feature such as a rock/reef, for the losses with vaguer descriptions of their place of loss this is much less useful.

We experimented with the Arches platform used for Mariner, which allows for the recording of 'Places'. These can be specific locations or vaguer descriptions, making this an ideal way to describe these imprecise marine locations. The existing MEDIN gazetteers for 'sea areas', 'sea features' and 'coastline features'[123] were used as the starting point to explore multiple ways to link 'Named locations' within NMHR. We converted 'Named location' points into polygons which could integrate with the seabed features identified in the MEDIN gazetteers. A pilot study area of 8,000km2 off the Norfolk coast was chosen as it comprised numerous named locations based on a mix of approximate locations, identifiable seabed features (such as sandbanks) and coastal places. Five methods were developed to test the best approach to tackle this problem. These were:

- Tessellation Polygons
- Thiessen Polygons
- Thiessen Polygons, alternate method
- Raster Analysis
- Buffer Areas

The specifics of each approach are detailed in https://doi.org/10.5281/zenodo.14840745**.**

The five approaches trialled have demonstrated the complexity of the data and has shown there is no single process that can be used to automate the mapping of the NMHRs named location data to the MEDIN gazetteer for marine areas. We do know that none of the approaches above can be fully automated. Manual verification and adjustment must be made at various stages. An approach, or a mix of approaches, will be chosen for further development, but the Unpath'd Waters research has laid the foundations for this.

Conclusions

The data visualisation and GIS research undertaken during the Unpath'd Waters project in support of the development of the Historic England's NMHR has showcased the richness and complexity of the data already held. It has provided clear pointers to where data could be held in a better structure to allow visualisations to be constructed with the minimum of additional data wrangling.

As a direct result of this work, new structured data fields have been created to record information on previous voyages, relationships between attackers and victims during wartime incidents, and many other areas. This has fed back directly into the development of the new shipwreck data model structure for the English marine record. It is hoped that the successes of the Unpath'd Waters project will allow for further standardisation between the various national inventories of the UK home nations.

---

123 https://portal.medin.org.uk/portal/start.php?details&tpc=010_0cd97ef56ca-933ce4e1c48b4f5d374fc; https://portal.medin.org.uk/portal/start.php?details&tp-c=010_3940e3af8c1c3dba5807a23d7899b547; https://portal.medin.org.uk/portal/start.php?details&tpc=010_e2a9309c06bddcb7ff15863b40798bc9

13.2 Testing Artificial Intelligence on Messages in Bottles

13.2.1 Introduction

This report details the analysis and enhancement of the "Messages in a Bottle Dataset" (MiB), a collection of newspaper articles recounting messages found in bottles during the 19th and 20th centuries. The dataset, created by the late Ed Cummings, hosted by the Nautical Archaeology Society, and included as part of Unpath'd Waters, contains a listing of bottles containing a message from a distressed vessel, recovered by chance throughout the 19th Century and recorded in the British press. Moving records of the last moments of a ship before its loss, written in haste by crew or passengers with little hope of salvation, these messages provide a unique insight into shipwrecks and seafaring stories.

The dataset was converted from a static PDF into a machine-readable CSV, enabling analysis with Natural Language Processing (NLP) tools. This process identified key entities such as ship names, dates, and locations. However, it also revealed significant limitations due to the inconsistent detail in the records. Off-the-shelf NLP tools were used, and while these accelerated the process, the results required significant manual intervention to correct errors and refine the extracted data.

Despite these challenges, the dataset contributes valuable narratives about the maritime world, emphasising the importance of expert curation. It highlights the potential of MiB as a source of engaging human stories about maritime life and loss. The stories it contains, even the outright falsehoods, are uniquely engaging and can be used to establish a range of different narratives that would tie into areas of significant public interest. These are most notably the process of shipwreck, maritime crime, and stories of the sea and seafaring in the 19th and 20th centuries.

The case study also underscores the limits of machine learning tools in handling heritage data without expert oversight. The findings demonstrate the need for more structured, reliable maritime records to fully realise the potential of linking diverse datasets and enhancing our understanding of maritime history.

The overall outcome from this work is the contribution of an engaging, partly fictitious, collection, with flaws and thin records initially masked by the evocative nature of the stories themselves. However, it makes a meaningful contribution to the work of Unpath'd Waters through the demonstration of Named Entity Recognition, and the role of domain experts.

13.2.2 Methods

PDF to CSV

The data, initially provided as a PDF file with complex structure and formatting, including non-standard fonts, was converted to CSV (comma delimited) file format. This conversion makes the dataset machine readable and therefore able to be processed by a suite of python-coded tools. The conversion, involving manual identification of each field before automated conversion, was not reliably readable by the programme created to convert the text, resulting in a messy output file that had to be manually checked and cleaned to ensure fields were split out correctly.

Enrichment and Extraction

Key fields were then established: 'What', 'When', and 'Where' in the form of Name of Vessel, Date of Event, and Location or Co-ordinate of shipwreck event, and 'People'. The latter differentiated between groups such as 'Master', 'Owner', 'Crew', and others such as connected family members or onshore individuals not present at time of the MiB creation. Running NER threw up issues requiring manual checking, for example: synonymity between ship names and people names, and lack of clarity on roles of different named individuals. Fully manual extraction was required at times.

We used 'Flair', an open-sourced Natural Language Processing framework by Zalando Research (see Akbik et al. 2019). Specific entities were extracted for columns headed Person (PER), Location (LOC), Organisation (ORG). Since ship names are highly variable (shipowners using a variety of parts of speech as names), a 'Miscellaneous' column was established. 'When' used the original dataset's dating information.

Finally, 'where' was established by extracting co-ordinates and Place Names (where either were given). The spatial data was both complex and inconsistent: records may reference home ports, bottle findspots, location of onshore family/owners etc). Therefore, all entities tagged as 'location' by Flair were run through a second stage of process, testing corollaries such as 'to', 'from', or 'off' to provide a greater level of control.

13.2.3 Results and discussion

Extracting Information

During entity extraction a total of 5886 entities were identified. The spread of these is set out in **TABLE 13_01**.

Miscellaneous	Person	Location	Organisation	From	To	Off	Coordinates (Lat, and Lon)
1329	1067	2426	627	160	86	146	45

TABLE 13_01
Named Entity Recognition outcomes for Messages in Bottles collection.

The organisation of data into a CSV with location data enables display in a variety of geographical information packages. An example output in google maps is given here **(FIGURE 13_07)**. This also helps to highlight some issues around automatic extraction of location-based data, with locations used in very different ways across records.

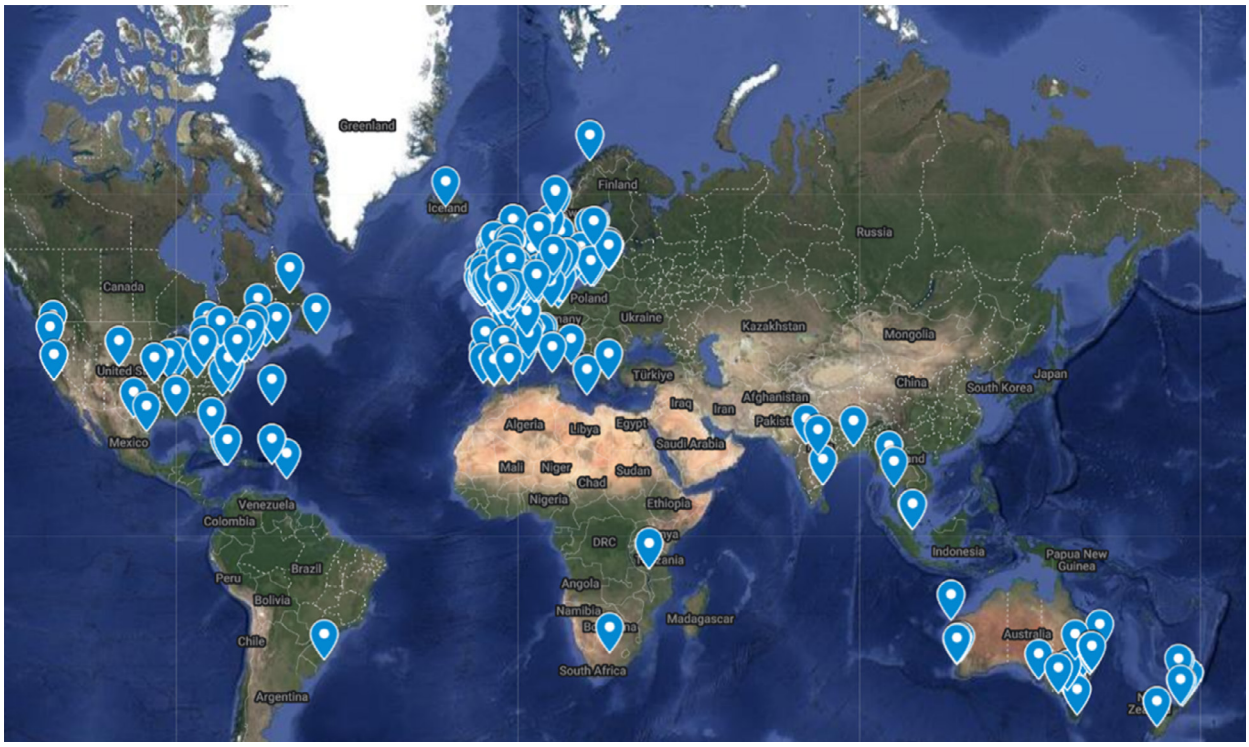


FIGURE 13_07
Distribution of location-based data from MiB Named Entity Recognition.

Challenges and Opportunities

The MiB work serves as a clear case study that demonstrates the value of converting datasets from static resources (in this case a PDF) to more versatile formats like CSV. The underlying dataset has the potential to contribute narratives that speak to a distinctly human existence at sea and the process of loss, wrecking, and the end-of-life circumstances of a ship. This is also an excellent dataset to foreground discussions of unreliable narrators/witnesses and wider themes of 19th century wrecking, and a maritime environment where alongside the better-understood world of ship operation, shipbuilding, and trade there exist hoax, and falsehood. Therefore, the MiB has the potential to inform on the wider maritime world by providing an example of this behaviour.

There are however significant issues to connecting this dataset to its full potential.

One challenge is the character of the dataset itself. Some records have considerable detail and context which enables ML tools to identify different entities easily and provide information that can be used to extract meaningful information. Other records are much thinner and lack specifics. There is no way to resolve this using ML Extraction tools as these can only be used to draw out information that is already available in the MiB.

Another challenge lies in the fact that a number of the messages are proven hoax or fabrication – some indeed have contemporary annotations from newspaper editors stating so. It is therefore very hard to determine what proportion of the dataset relates to authentic accounts of sinkings. These potential issues highlight the role of an expert. Records like these are made more effective through the curatorial input of specialists who have studied and understand the nature of shipwreck and loss recording in this period. Without this input the dataset risks being presented as a factual recounting of hundreds of ship losses with all the same potential to inform on real world events as other key, more strictly maintained, loss lists such as the Lloyd's List casualty returns.

The majority, however, are likely to be examples that are genuine, last-ditch, messages recounting the loss of a ship at a time when no ship to shore communication existed.

A further challenge is connecting the MiB record to other maritime records, archives, datasets, or collections. This is the single biggest issue to the MiB. A dataset with good linkage potential is that of the Lloyd's Register of Shipping (LRS), this contains a record of every ship surveyed for entry into their register (then used for purposes such as insuring cargo, establishing a ship's condition and character, and providing owners with a guide to the state of their vessel). However, it is very hard to say a ship in MiB is the same as any ship in LRS. To achieve this effectively requires matching more than just a name, as names for ships are not unique and there can be many ships with the same name afloat at any one time. Unfortunately, there are only a handful of fields that are comparable between shipping registers (of any origin, not just the LRS) and the MiB.

One good case study of successful linkage is worth presenting, however. On 20th July 1843 the paddle steamer *Pegasus*, en route from Leith to Hull, struck Goldstone Rock as she was passing between the Farne Islands and the mainland. At least 43 of the ?57 people aboard perished. The sinking was recorded in the Standard newspaper on 24th July. In October 1843, the message in the bottle was picked up at Wabourne, on the Norfolk coast, some 220 miles southward. Published in the Hull Advertiser and Exchange Gazette on 27th October, it stated "*PEGASUS, God help us! She is sinking! The bottles empty, will swim, and we also into eternity! Farewell! Elton*"[124]. The story of the *Pegasus*, told in marvellous detail by Jane Bowen[125], includes a reference to another MiB, not in the Unpath'd Waters dataset, which read: "*Pegasus steamer, to Fern Islands, night of Wednesday, July 19th, 1843. In great distress; struck upon hidden rock. On board fifty-five persons, vessel must go down, and no Grace Darling*." This bottle was found on the Dutch coast in early November. The aforementioned Elton, author of the MiB was Edward William Elton, a famous actor[126]. The approximate wreck site itself is recorded both on the NHMR for England and Canmore, although the site is not 100% confirmed[127].

---

124 https://unpathd.ads.ac.uk/resource/feb1e982fd732ec412146715156c6b7b-76812c92241a60f4c6d36010cd6f353f

125 https://www.islandshirearchives.org.uk/wp-content/uploads/2018/09/The-Pegasus-story.doc

126 https://en.wikipedia.org/wiki/Edward_William_Elton

127 https://unpathd.ads.ac.uk/resource/feb1e982fd732ec412146715156c6b7b-76812c92241a60f4c6d36010cd6f353f

Where the objectives of Unpath'd Waters are concerned, this dataset demonstrates the effectiveness of off-the-shelf NLP tools, in this case Flair. However, the results also demonstrate the continued role of expertise and human review in ensuring the outputs reflect the information contained in the dataset. It is possible to use this dataset to show what is possible, but it is far more useful to use this as a case study of the limits of these tools and the need for a better overall approach to the recording and structuring of data in all records. Such an approach would create opportunities to truly link datasets through fields that would make such linkage more certain and therefore any further work better able to take advantage of an expanded maritime story.

13.3 The Analogue-Digital Connector: Approaches to Analogue Archives

The Unpath'd Waters team wanted to consider the 'gap' between existing digital collections and analogue (ie physical) collections. We knew there were numerous marine heritage collections that lay beyond the digital barrier but which could certainly enhance the concept of a UK digital collection. We also knew that no metric exists by which to measure the breadth, depth or character of this gap. This is important because digitisation is increasingly a part of museum and archive strategies but at the same time there is little strategic overview of priorities which could help manage limited resources. The Analogue-Digital Connector (ADC) was conceived to consider the challenges that would exist to crossing the gap, and to establish whether Unpath'd Waters could provide one approach to prioritising how such analogue collections might be unlocked (regardless of whether they relate to maritime heritage or any other cultural themes).

13.3.1 Targeted Archive Survey

A survey targeted five diverse critical case- and information-rich maritime collections known to be important for wreck research because they evidence the diversity and randomness of collections relevant to wrecks; and exhibited a variety of constraints affecting physical and part-digital collections. The surveys aimed to ascertain characteristics, aims, user requirements and conditions, benefits and constraints, especially digital ones. They were:

- University of Portsmouth Map Library. Created from the 1960s, this includes 20,000 maps, especially O.S. Hampshire and Isle of Wight 1:2500 County Series (unavailable digitally), Admiralty Charts and some Europe and world maps (200 digitised)[128].
- Portsmouth Royal Dockyard Historical Trust (PRDHT) Collection. This has been assembled since 1982, comprising 1,000s of artefacts, especially 200+ unique handwritten Dockyard and local MoD Outstation Rates of Pay Books 'Rate Books' c.1870–1963 and Hurt Books 1930s–1980s (potentially 500,000 names). Also 1,000s of photographs, negatives, slides, ships' drawings, tools, industrial and non-industrial work items[129].
- Gosport Diving Museum and the Historical Diving Society Collection of 9,000 items: reference library, archives, diving equipment[130]. The object records of the collection have been added to the Museum Data Service, launched in 2024[131].
- University of Newcastle Marine Technology Special Collection, assembled since 2010, holds records of British shipbuilding, marine engineering, ship repairing, shipbreaking industries and associated publications[132].

128 https://library.port.ac.uk/maps.html
129 https://portsmouthdockyard.org.uk/
130 https://www.divingmuseum.co.uk/; https://www.thehds.com/
131 https://museumdata.uk/object-search/?q=Diving%20Museum&collection[]=Diving%20Museum
132 https://archiveshub.jisc.ac.uk/search/locations/81d1460a-645f-3c83-b547-0d8f-f6a9b46e; https://archiveshub.jisc.ac.uk/search/archives/d13c89bd-cf95-39c3-8974-3ae0e481158f; https://www.ncl.ac.uk/mediav8/engineering/files/Periodicals%20Histories%20M-compressed.pdf

- Naval Biographical Database. Begun in the 1990s, it currently connects 300,000 dates, 35,000 individuals, c.7,000 ships, sourced from TNA, BL, NMM and other archives[133].

The details of the survey findings are contained in the supporting report at https://doi.org/10.5281/zenodo.14837162.

13.3.2 Challenges and Potential

An expert researcher symposium – the Digital and Physical Maritime Collections Symposium – held at the Mary Rose Museum in 2023, evaluated ADC's surveys. Thirty participants from across the heritage sector attended three wreck presentations and eight focus groups. The symposium reviewed the survey findings and explored:

- Barriers to access – the case for change.
- Prioritising – the criteria for making choices.
- Recommendations – towards a UK digital collection.

Barriers to Accessing Analogue (physical) Collections

The symposium was extremely helpful in articulating the range of barriers which exist to unleashing the research potential of our analogue collections. We were able to summarise these challenges as follows:

- **Skills:** user search skills/confidence; understanding of archival processes; archive language (archaic/non-native languages); archive terminology (technical, complex).
- **Knowledge:** inability to assess what is in collections (ie physical metadata).
- **Logistics:** user travel distance/geography; accessibility (ie lack of adjustments for disabilities or impairments); type of access (security, opening hours, booking time, pencil/photograph); time requirements for completing a search (often unknown at time of access); deficient or missing catalogues; limited or non-existent curatorial support.
- **Financial:** Paywalls; licensing, lack of available funds for research.
- **Legal:** constraints on subsequent use; sensitive documents; licensing and copyright issues on re-use.

Not all of these will be eliminated through development of a UK digital collection, but many could be alleviated. There is a clear case for pursuing a digitisation strategy.

Prioritising Digitisation

It is clear we cannot digitise everything simultaneously. There are two ways of responding to this situation. The first is to take a passive approach, working only to ensure that wherever digitisation takes place, it follows good data management practices. The second is to advance a strategic approach to prioritisation which could guide funding bodies in determining what to do early on. This has to be neutral on the issue of content (there can be no way to compare the intrinsic value of marine collections against the value of fine art collections, for example).

133 https://www.navylist.org/

The symposium considered such criteria.

- **Funder mission:** Funders may have specific criteria to be met which will influence what can and cannot be digitised (although such criteria may be amenable to change – through approaches like TaNC).
- **Repository infrastructure/capabilities:** Organisations holding collections may lack digital management software to realise the value/ leverage of what they have, constraining entry into any strategic initiative.
- **Collections at risk:** This would take a conservation/preservation approach, digitising the most threatened/fragile archives first. Threats could be related to condition, location, or even geopolitical issues.
- **Collection popularity:** This would privilege those physical archives most accessed or most in demand. However, it was noted that a source may become popular because it is digitised.
- **Collection educational value:** This would focus on archives which relate to curricula or educational strategies.
- **Collection commercial value:** This would privilege archives which could then generate income for sustaining further digitisation programmes.
- **Collection significance:** This would establish some significance characteristics (such as are used in other areas of cultural prioritisation e.g. collections accreditation, historic building listing etc). It raised interesting questions related to decision-making, national vs international views, and changing viewpoints across time.

This element of the symposium was deemed particularly fruitful by the Unpath'd Waters team and we propose that this could form the basis for a strategic approach to a UK digital collection. We therefore return to this in **Chapter 17**.

14. Setting Sail – The Unpath'd Waters Navigator

Scott Carballo, Maria Cotuna and Stuart Jeffrey, Glasgow School of Art;
with Sara Perry and Katrina Foxton, UCL and MOLA

Our challenge for WP4 was how to co-design and co-create research and engagement access for new audiences. We looked to diversify audiences, improving cross-collection and cross-disciplinary research through co-designing novel interfaces with integrated maritime datasets, specifically through immersive systems. We engaged with three user-groups to explore:

1) What new affordances do integrated maritime datasets offer cross-disciplinary researchers?
2) Can modes of navigation be co-designed to counter the complexity of multiple datasets, from multiple sources and in multiple formats (2D/3D) which work for both research and public audiences?
3) Can we reach audiences that do not traditionally engage with these data but could directly participate in the design of access modes that encourage their future engagement?
4) Can the technical challenges posed by User Generated Pathways (in this project these are termed 'Curated Voyages', discussed below) through the Unpath'd Waters datasets be meaningfully addressed via immersive interfaces?

This chapter gives an overview of our approach and learning, from co-design methodology development, the co-design process and its outcomes, the integration of the co-design outcomes into the Unpath'd Waters Navigator development process. It also covers the technical development process itself, highlighting technical issues that arose, how these were overcome and where they require further development and recommendations for future actions in a further iteration of immersive systems that address the research questions above.

Fundamental to this work was alignment with the Unpath'd Waters project values co-designed by all project partners in the value-setting exercise discussed in **Chapter 6**. We directly engaged with new potential audiences, and it was crucial to the design and delivery of the work package that this engagement aligned with both ethical good practice and with project values. This entailed close working on the co-design process with colleagues working on audience mapping and engagement, and critical reflection on the evaluation processes and what we learnt from these with regards potential future work.

14.1 The Co-design Process

Immersive Systems Design is becoming increasingly pervasive as a medium for cultural heritage (Holloway-Attaway & Vipsjo, 2020; Bruno et al., 2016) and has also begun to explore the possibilities of aiding visually impaired (VI) users' vision and digital experience (Thevin et al., 2020; Lahav et al., 2008). VR's recent proliferation in the commercial sector, and increasing affordability, has broadened access and public awareness of the technology. It offers an exciting way of engaging with our datasets both as a form of data visualisation for research, and also as an appealing tool for public engagement. We wanted to investigate the technology's affordances in accessing datasets and linking them with multimedia as a way of promoting heritage research/engagement, as well as its potential as an accessibility tool for the visually impaired.

We aimed to co-design a novel immersive system (the Unpath'd Waters Navigator) with integrated datasets through three user test group case studies. Our objectives were to create a tool that would actively help to:

- Diversify audiences engaged in marine heritage.
- Improve cross-collection research.
- Investigate new affordances of immersive systems in accessing and displaying collections.
- Our three segmented target audiences were chosen to address these objectives directly:
- Non-coastal communities (NCC): Heritage users who do not traditionally see themselves as the audience for maritime assets. Galloway Glens Landscape Partnership participated.
- Cross-disciplinary Maritime Researchers: professional researchers engaged in maritime disciplines (science and culture) (CDMR). For this we welcomed an academic cohort from the Universities of Bradford and York.
- Visually Impaired Persons (VIP): General public with visual impairment who face accessibility issues with traditionally designed immersive systems. For this group we engaged with VocalEyes, VICTAR and Glasgow Disability Alliance.

14.1.1 Definition of Co-Design

The definition of co-design that we used was outlined at the beginning of the project by Manuela Ritondale:

"It is the process of collaboratively designing products or services with service-users, service-deliverers and service-procurers. This approach goes beyond consultation. Indeed, all stakeholders affected by or attempting to resolve a particular challenge build and deepen equal cooperation. A key tenet of co-design is that users, as 'experts' of their own experience, become central to the design process and help to define and find solutions for problems creatively" (see for example WACOSS[134], Co-Create[135])

Co-design methodology has been utilised across many research fields and professional sectors. Scholars debate its definition and uses but generally agree on its focus on user involvement from the very beginning of the process (Steen, 2013). The methodological framework for the co-design process has been heavily informed by literature on participatory design in heritage (Jeffrey et al., 2020; Bruno et al., 2016). However, it also draws on influence from the emerging field of immersive systems and Human-Computer Interaction; as well as perspectives on co-design with visually impaired participants. Immersive systems which have been co-designed have required bespoke methodological frameworks given the unique challenges of designing highly technical digital resources with non-technical audiences (Holloway-Attaway & Vipso, 2020).

Co-design projects from across the disciplines often draw on the scholarship of Elizabeth Sanders and Pieter Jan Stappers. They recognise the difficulty in presenting a sole definition for this method, given its broad range of applications. Co-creation, say these authors, can refer simply to 'any act of collective creativity, i.e. creativity that is shared by two or more people.' Co-design, on the other hand, refers to 'to the collective creativity of collaborating designers... [the authors] use co-design in a broader sense to refer to the creativity of designers and people not trained in design working together in the design development process' (Sanders and Stappers, 2008). Indeed, co-design projects involving persons with visual impairments stress the need to tailor the process to the needs of the co-designers, given that traditional co-design methods are overwhelmingly visual in nature (Magnusson et al., 2018; Cullen & Oussama, 2018).

---

134 https://www.wacoss.org.au/wp-content/uploads/2017/07/co-design-toolkit-combined-2-1.pdf

135 http://www.cocreate.training/2019/03/15/the-co-create-handbook-for-creative-professionals-is-now-online/

14.1.2 Methodology

Within the heritage sector, the use of interactive digital and immersive technologies is becoming increasingly commonplace (Holloway-Attaway & Vipsjo, 2020; Bruno et al., 2016; Chapman et al., 2006). Some digital heritage projects are also using co-production and participatory design methodology in order to ensure that communities are engaged from the outset (Cruikshank et al., 2016; Jung & Dieck, 2017; Jeffrey et al., 2020). Our methodology was designed to align with accessibility advice gathered by the Unpath'd Waters team from organisations who care for visually impaired persons. Creating an immersive system which can be used by the visually impaired is a uniquely challenging experience, given the wide range of visual impairments. The limited scholarship on immersive systems for the visually impaired stresses the necessity of understanding the specific needs and concerns of the VI community (Kim, 2020; Thevin et al., 2020).

The co-design process has been iterative from the outset. Co-design scholars (Sanders & Stappers, 2014; Bratteteig et al., 2012) point to the generative process at the front end, which informs and inspires later design choices. Open-ended questions are preferred in the earlier stages in order to inspire creativity and remain attached to the principles of 'mutual learning', and more intricate and technical activities were gradually introduced as the design progressed. Applied Thematic Analysis (Guest et al., 2012) has been used as a data analysis tool after each iteration of the co-design process. This was facilitated by the careful production of transcripts of each session in its immediate aftermath.

14.1.3 Recruitment and Consultation

Recruitment for our three segmented test audiences was informed by the audience-mapping research of WP5 (Perry et al., 2024). Gatekeeper organisations were used to recruit the NCC and VIP test groups (Galloway Glens Landscape Partnership and VocalEyes, respectively). The CDMR cohort were recruited through academic networking with Unpath'd Waters partners[136]. We undertook consultations with VIP-aligned charities and professional organisations (VocalEyes, VICTAR and Glasgow Disability Alliance). Consequently, a professional workshop facilitator was hired to oversee in-person work with the VIP cohort to ensure the physical space was accessible and the activities were VIP-friendly. The consultation also profoundly affected user interface design and technical development, specifically that the Navigator should be designed as a fully usable experience for VI users, as opposed to a heritage tool which includes VI features. This decision was made with equity in mind and led to the exclusion of several functions for sighted users (outlined below).

14.1.4 Adapting the Values to the Co-design

We used the values **(Chapter 6)** for rethinking research objectives, and adapted each value to the unique context in which we were working, considering critically how the values were applied. The values were adapted as follows:

- **Equity.** Honouring audiences' actual search criteria; designing in the face of entirely conflicting opinions.
- **Connecting with people on their own terms.** Designing for visual impairments first; struggling with how to communicate about technical outcomes when there is no prior experience about what to expect.
- **Empowering through collaboration.** Grappling with the dynamic between Unpath'd Waters team's own empowerment and whether our co-designers are truly being empowered by maritime data/R&D infrastructure initiatives.
- **Sustainability.** Impossibility of pursuing rural collaborations using public transport or of useful online co-design meetings where participants need access to dedicated support or technology.
- **Constructive.** Recognising that VR may not be a good solution for any audience in terms of accessing these data.

136 VIP and NCC recruited co-designers received spending vouchers for each session they attended.

- **Adventure.** Encouraging a shift in perception about the technology leading to incorporation of new design decisions later in the process – e.g. our NCC group wanted to be able to lift things up and put them in a pouch when exploring, in order to refine searches, and this led to the platforms which are used in the Navigator.

14.4.5 The Workshops

Stage 1: Pre-design/Generative Phase

Introductory co-design workshops **(FIGURE 14_01)** were held to familiarise participants with the project and co-design process, and to generate initial ideas for the Navigator. These also facilitated discussions on heritage, shaping themes for search mechanisms and curated voyages. Key learnings from the workshops informed future co-design and technical development. Common themes incorporated into search functionality across all groups included:

- A 'sense of place' in research (e.g., search by shipping district).
- Coastal/landed perspectives (e.g., location-based searches).
- Technology's role in maritime heritage.
- Integration of materials and cargo in research.
- Insights from the VI group's first VR experience revealed preferences for high-contrast environments, seated/static experiences, and immersive soundscapes for better immersion. VI participants liked being 'transported' with spatialised audio.

FIGURE 14_01
Workshops in progress during co-design of the Unpath'd Waters Navigator.
Clockwise from top left: NCC3, VIP1, VIP1, NCC2.

Stage 2: Early Demos/Low-Fidelity Prototyping

Building from Stage 1, sessions introduced participants to virtual reality technology and the Unpath'd Waters datasets through demonstrations of VR and the Unpath'd Waters Portal by team members, and included: group discussions on how the Navigator's user interface (UI) might look and feel; concepts for the presentation of data in virtual reality; and initial ideas for curated voyages and display of multimedia content, through the creation of low-fidelity prototypes. Key insights were:

- Request for tutorials at the start of the VR experience to aid those unfamiliar with the technology (NCC).
- Suggested adding more content to complement search functions, addressing the lack of multimedia in Unpath'd Waters metadata (NCC).
- Enthusiasm for VR's potential but sceptical of its effectiveness as a research tool (CDMR).
- Recommendation of data refinement features, such as filtering datasets by region and time period, especially for pre-historic data lacking detail (CDMR).

Stage 3: High Fidelity Prototypes and Technical Interactions (NCC and VIP only)

The CDMR group requested to skip this stage until a full prototype was ready for testing. This stage featured more technical interactions with high-fidelity prototypes, shaped by earlier feedback and designed to highlight proposed functionalities of the Navigator. They also included test rooms which tested audience preferences on a range of interactions:

- Interactive search rooms to test a range of functions – movement vs teleport, spatialised audio, grabbing icons, controller use, webpage/browser use, settings menus (NCC group)
- Interactive search rooms testing range of functions/VI accessibility options – settings menus, conducting searches, viewing results, controller use, audio descriptions, colour schemes (VIP group)
- A settings menu as the first interaction to allow users to tailor their experience (NCC and VIP group)

Recommendations arising from this testing included:

- Preference for a bird's-eye view for viewing data points and search results (NCC group)
- Recommended a streamlined, fragmented settings menu for accessibility (VIP group).
- Proposed a 'quick settings' menu for on-the-go adjustments (VIP group).
- Requested improved audio voiceovers (VIP group)
- Requested enhanced brightness and contrast options (VIP group).

14.1.6 Co-design Key Findings and Design Cues

The overall results of the work in Stages 1–3 informed key principles of design.

Settings design

Settings menus were key in the design of the Unpath'd Waters Navigator. The VIP group viewed the customisable settings as a key accessibility component, allowing VI users to use the application in parity with sighted users – tailoring the visual effects to their own impairment/preferences. The NCC group viewed the ability to customise various settings as a means of overcoming challenges of acclimatising to immersive technology. The CDMR group expressed a desire for granularity in settings, particularly relating to turning effects on and off.

The settings menu in the Navigator currently allows for customisation of:

- Text size
- Text colour
- Text panel colour
- Sound Effects adjustment
- Sound Volume adjustment
- Image Settings
- Brightness (with Colour filter) – Allows user to introduce additional luminosity and a colour filter over whole screen.
- Colour adjustments – Allows user to define look and feel of application and improve readability by adjusting saturation and exposure effects.
- Vignette – Allows user to define their own field of view. Allows better visibility for those with peripheral/central vision impairments.

The VIP group revealed that they needed these settings at the very start of the experience, offered in three stages (Text/Audio/Image settings) to avoid overwhelm with too many options. A 'quick settings' menu, accessible at any time would allow users to refine 'on the go' **(FIGURE 14_02)**.

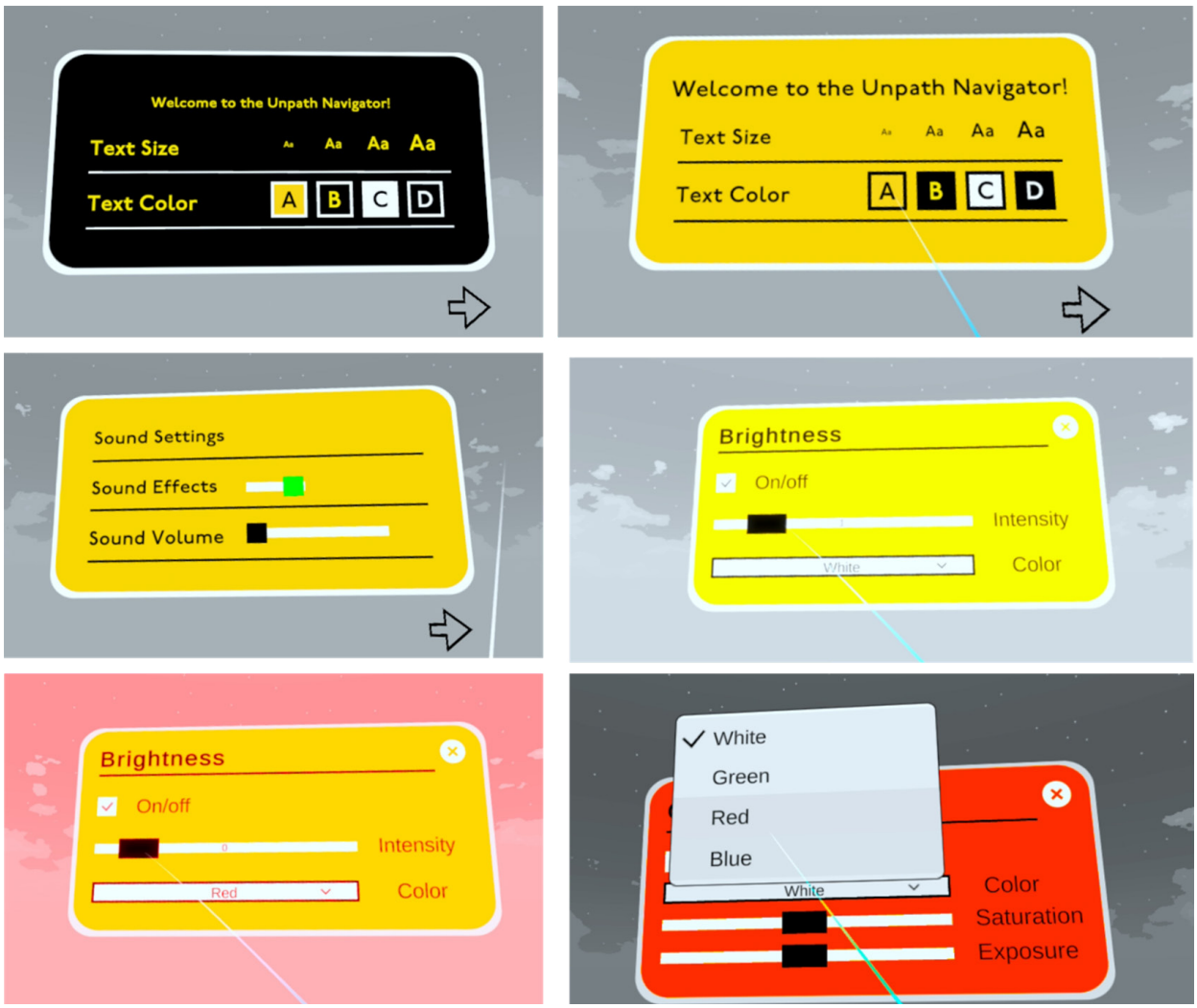


FIGURE 14_02
Examples of the multiple levels of initial settings for the Unpath'd Waters Navigator, primarily derived from the co-design process with the VIP group.

Barriers to Maritime Heritage

Two of the groups outlined what they felt were the key barriers to maritime heritage which prevented people engaging with it.

In the NCC group, participants made many meaningful observations on maritime heritage which helped in the later design of the Navigator's content:

- 'Propensity for tragedy' in maritime heritage – records of shipwrecks are records of tragedy.
- Difficult to engage with maritime heritage as not openly visible – ships also operate outside of domestic theatre; physical heritage records do not tell the whole story of a ship's lifespan.
- Land-based/site-based/ancestral history often carries a personal connection to heritage users and is more relatable to those engaging in research outside of maritime professions.

For the VIP group, their observations were centred around accessibility in heritage more generally:

- Audio descriptions users have used in the past have not been comprehensive enough. Voice-overs should be more than instructional – VI heritage users benefit from describing objects and providing extra context.
- Past heritage experiences have been most interesting when there is something to do. Interaction is beneficial.
- Placement of text and objects is important as many VI users need to move closer (or zoom in). Many heritage assets place text panels and pictures in inaccessible places.

Data Searching and Visualisation

Investigating how data could be searched and displayed in VR was a key component of all three test groups' activities. The way each group or individual participant approached data visualisation developed throughout the co-design process. We began in the early sessions with conceptual discussions, before providing demonstrations of the Unpath'd Waters Portal and VR technology. This was further developed through testing interactions and allowing participants to experience different search environments and search functionalities.

Current keyboard and mouse functionality is not an optimal format in immersive spaces. Free-text search functionality was tested and rejected by all groups. VIP accessibility was the chief concern, but other groups noted that text searching diluted the immersive experience. A more interactive and streamlined format was desired. The consensus was that distance-grabbing objects and placing them on a platform was the easiest, most 'embodied' and most fun way to search through the database. Three platforms were included to allow for granularity in searches (i.e. refining by subject, location, record type) where users can place their own combination of pre-defined search queries. These search terms were co-designed, incorporating direct suggestions (e.g. searching by cargo or material) and drawing inspiration from heritage themes.

Free input for searching and in-VR keyboard input were found to be unsuitable for VIPs, lacking fluidity for most users. Displaying external links via web windows were excluded as they required pre-loaded URLs with no further navigation, limiting flexibility. Accessing information via URLs requires Wi-Fi and relies on an unsatisfactory third-party browser. This capability was therefore not built into the Navigator. This is a key insight for future design.

The design of the results room was also a key feature in co-design activities. How users navigate the immersive space with plotted data points, and refined these results, was discussed at length among all groups. Locality /regionality was important to CDMR and NCC users, as was the ability to explore results. The map format was viewed as the most accessible and recognisable for users, and most conducive to exploration. The plotting of results based on their geographic coordinates was heavily favoured; as was displaying results vertically according to time period. This creates a visually stimulating immersive experience, but can also be altered to a bird's-eye view to help streamline research. Results are also refined through interaction by highlighting using the controller rays.

Reconciling Conflicts in Co-designer Feedback

Throughout the co-design process there was the need to reconcile conflicting or contradictory feedback on various issues, within individual groups or between groups. To resolve these, VIP accessibility was adopted as the main design priority. For example, 'drifting' was favoured by some participants as a means of traversing the virtual environment but created difficulties for those with physical balancing issues: teleporting was therefore viewed as a safer option (and easier for managing users in an exhibition context, as they can be seated). When conflicting suggestions were made but did not impact on this first priority, we adopted majority consensus; where this was not possible, the most realistically deployable solution for technical development was favoured.

Perceptions of VR as a Heritage Tool

Perceptions of VR technology evolved across all three test groups as the co-design process progressed. This is encouraging for future development, but it should be noted many users can experience motion sickness and nausea when using VR.

The CDMR group provided encouraging feedback on the use of VR as a research tool. This group had been generally sceptical of VR's application for research purposes at the early stage of the design process, but participants who attended the final testing session reported feeling encouraged by the prospects of the technology as a research tool.

Multiple participants in the NCC group reported having misgivings about the technology at the outset. While participants recognised VR's potential, some of the older participants were reluctant to engage with the technology and felt that it was not suited to their own levels of digital competence. However, this was overturned after gradual exposure to VR, and participants all reported increased digital confidence and a positive view of the technology's potential as a heritage asset.

Discussions with VI participants were encouraging. A key objective was to enhance access to heritage specifically for VI users. Participants reported that they felt this had been achieved and were particularly pleased with the spatialised audio and the accessibility options added to the Navigator. One severely visually impaired participant in particular was pleased that we had implemented these options after she reported feeling 'transported' to a different environment in the early sessions, as a result of multisensory engagements. We made a conscious decision throughout the process to include multisensory feedback where possible for VI users.

Additional Co-design Considerations

With the permission of the participants, we have kept an audio-visual record of all of our co-design sessions. Online sessions have been recorded via the Zoom application. The in-person sessions were filmed. These films have been used for generation of transcripts for analysis and reporting; and also for inclusion in the Navigator itself via a Curated Voyage. Many of the most consequential adjustments made throughout the process have been made to accommodate use by the visually impaired community. These decisions have been informed by our VIP consultation and feedback from our VIP co-designers. They include:

- The whole application should be fully accessible for VI users, as opposed to containing some standalone VI features or curated voyages.
- Visual and audio settings should be customisable for individual visual impairments and should be the first interaction when users start the Navigator.
- High contrast search environment (black & white) with vibrant colour on icons.
- Simplified User Interface and graphical style.
- Voiceovers must be clear and detailed, and include environmental description, instructions, and audio prompts. VIP users wished to avoid patronising or overly sympathetic tones.
- Controls must be as simple as possible and the application should be usable with one controller. Vibrations for tactile feedback should be included.
- Users must be static (preferably seated) when using Navigator – many VIP users require assistance moving around physical space, this should not be compounded by asking them to move physically when they are in an immersive environment.

14.2 Understanding the Co-design through the Values Framework

The co-design process was evaluated against the Unpath'd Waters Living Values framework (see **Chapter 6**) for two principal reasons. First, the conscious adherence to the values framework provided a guided approach to engaging with both the research and our target audiences. Second, the evaluation outcomes form part of the Unpath'd Waters project deliverables, helping us to provide evidence of what works for future development of a national collection. We identified five areas where we believe the active use of the Living Values framework and evaluation based upon it beneficially supported the co-design process (aside from the technical development itself).

14.2.1 The Beneficial Relationship Between 'Connection' and 'Collaboration' Values

The workshop enabled CDR co-designers to 'spark' ideas as part of a vision of a collaborative, interdisciplinary approach. This sparking may have been increased by context: CDR co-designers highlighted that being in each other's physical presence contributed positively to the workshop. Indeed, there were instances in the workshop where 'sparking' was encouraged through non-verbal cues and gestures, which were then shared and reflected back by others, such as this example of a CDR co-designer in dialogue with Unpath'd Waters (WP4 and WP5) colleagues:

> CDR: "I just had a dream [gestures with her hands above her head/in front of face] envisioning […] peeling off palimpsest. Like sheets of tracing. Yeah, that'd be amazing."
>
> WP4: "Yeah, gesture recognition. Yeah, literally. Literally[!] […]"
>
> WP5: "Like "…" [mimics gesture of CDR#1]".

Where 'sparking' manifested, multiple other values also manifested (per our coding) in quick succession, usually following a challenge, which thereafter led to discussions animated with ideas. We refer to these instances as 'Values-rich Conversations' (VRCs). These emerged within the format of a structured conversation (i.e., our evaluation questions at the end of co-design workshops) and were focused on a specific 'design problem' related to the Unpath'd Waters Navigator. VRCs seemed more likely to occur if the environment for the conversation is curated around the needs of the audiences, as opposed to completely 'free flowing' – and this becomes important when codesigning with audiences who are being introduced to new problems. In short, VRCs are the consequence of successful achievement of 'audience-centredness' (value measure 2.3). Herein, audiences are able to meaningfully engage with the topic at hand on their own terms (our Connection value), they work together in talking through challenges associated with the topic, and from there collaborative intent manifests or future forms of collaboration take shape, often leading to design solutions.

Fostering an environment for creativity to emerge amongst the group required careful logistical consideration of 'audience-centeredness' (i.e., achieving both accessibility and inclusivity per Perry et al., 2024). We can see clear evidence of this manifesting in the workshops, although we had not necessarily reflected on the importance of the creative environment as a precursor to both connection and collaboration. In retrospect, fostering an environment for creativity to emerge could become a future values measure.

14.2.2 The Beneficial Relationship between 'Connection' and 'Adventure' in Community Partnerships

Our workshops with VIP and NCC co-designers provided further evidence of our 'Connection' value in action. We aimed to assess with these co-designers to what extent the workshops felt 'made for them'. Unlike the CDR co-designers, who conduct heritage research as part of their everyday professional practice, NCCs and VIPs ostensibly require greater support – certainly, the VIPs presented very specific barriers – and Unpath'd Waters team members themselves required support to ensure we were ready to connect with different people on their unique terms. Our efforts to connect with them were mostly recognised by the co-designers, and that these efforts also impacted on the types of conversations that were had.

Among the more prevalent values, 'Adventure' was most obvious – indicating particularly a high level of perspective changing, wonder and curiosity **(TABLE 14_01)**.

Values	Targeted	Challenges	Achievement	Comment
EQUITY	34	27	45	High instances but notable overlap with Adventure. Measure 1.1 not viable.
CONNECTION	49	52	30	High instances. Measure 2.1 not viable.
COLLABORATION	35	22	56	High instances. Measure 3.3 not achieved to fullest extent.
RELIABILITY & SUSTAINABILITY	5	12	1	Low instances. All measures unviable and difficult to gather.
CONSTRUCTIVISM	12	4	4	Low instances. All measures unviable/difficult to gather. Overlap with Connection value.
ADVENTURE	29	35	78	High instances. Overlap with Equity value.

TABLE 14_01
Results of all coded measures – with 'Adventure' measure 6.1 being the most evident across the project and specifically within codesign workshop data. Numbers relate to the number of times specific responses were coded to each category. Colours provide a simple heatmap view of those data (green = high, red = low).

Quotes coded to this value demonstrate that the taking on of new ways of thinking can be a positive experience:

> "This is the first time, I'm glad I came, and it's to try the headsets and see what it's like or how everything a visually impaired person would experience [in] virtual reality". VIP co-designer (coded to achievement of Adventure measure 6.1)

> "Just thinking about like how many different aspects there are to maritime heritage and it's really broadened my knowledge I guess, or scope?" NCC codesigner (coded to achievement of v6.1 and V2)

These (and other) quotes emerged in the context of a Values Rich Conversation, where a challenge (being 'out of one's depth') is overcome leading to multiple instances of referring to other Unpath'd Waters values. It also demonstrates overall, how 'creating a really good environment' (a clear reflection of the efforts of the Unpath'd Waters team towards audience-centeredness) can enable participants to influence one another by sharing their different perspectives.

The data suggest that we were generally successful in creating spaces for people to speak freely, and for them to reflect on others' experiences (even as they dealt with their own challenges). This is arguably also an achievement in 'Equity'. The positive environment needed for such experiences to emerge is arguably another measure that, in the future, we might add to our accountability matrix: i.e. we might define a measure related to 'Enabling a Positive Environment'.

In short, our efforts to achieve the 'Connection' value – i.e. to foreground audience-centeredness – were an important catalyst for our 'Adventure' value, especially as it relates to new perspective taking **(FIGURE 14_03)**. We begin to see, then, how values might influence practice as a 'workflow' (i.e. with one value – 'Connection' – being a prerequisite for those that might follow).

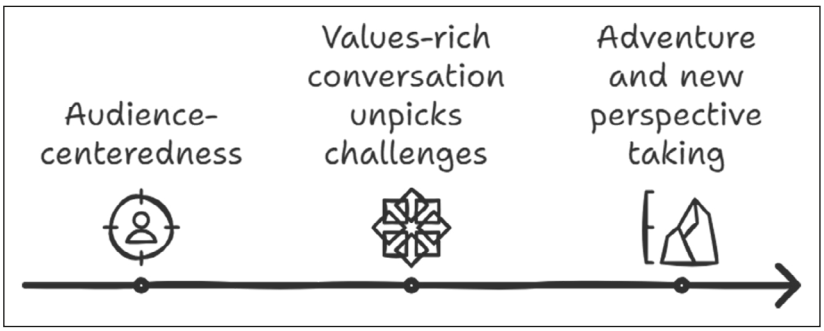


FIGURE 14_03
Diagram indicating the 'flow' of values: if audience-centeredness is achieved, values rich conversations can unpick challenges and Adventure and new perspective taking can arise.

14.2.3 Enabling Independence

One code not accounted for in our existing values was the concept of 'Enabling Independence', which manifests especially in people's descriptions of how they wish to search for new information and to experience heritage data. 'Rabbit-holing' and 'serendipity' were common terms used, and certain quotes indicate individual desires to 'go about their own way' through the data:

> "So, I just follow my nose and I find rabbit holes to go down and just whatever takes my fancy. And I'm not doing it for a particular purpose other than my own interest." NCC co-designer 1

> "… but I prefer these things, to do it myself." VIP co-designer 1

Enabling opportunities to explore on one's own terms, rather than relying on full, curated narratives (which may limit exploration) is important and can facilitate our concern for 'Adventure'. It can also support audiences whose independence is especially important for them; enabling such independence (which may be precluded within 'digital access to heritage' contexts and beyond) is connected to our 'Equity' value in a more general way than our measures currently capture.

14.2.4 'Boundary Setting' and 'Honesty'

'Boundary setting' (managing expectations) and 'Honesty' (being truthful about opinions) were recurrent themes in our data, particularly in our co-design activities. Both may be indicators of our 'Constructiveness' value, although in its original conceptualisation we had not considered how to track constructiveness via co-design sessions. Boundary setting emerged as a key topic in relation to managing conversations about what could or could not be achieved within the project. It was especially important in relation to co-designing with VIPs who have been historically underserved by archaeology and heritage. We found evidence of VIPs and other co-designers recognising the limitations of the project and the technology, particularly of the Navigator, and equally, managing the Unpath'd Waters team's expectations. Going forward, we might better apply a more systematic coding approach to reveal where boundary-setting has occurred or where honest reflections have manifested, to document future areas for design interventions.

14.2.5 Digital Confidence in Co-Design Workshops

To testify to our 'Connection' value, we sought to track 'digital confidence' in the use of VR technology amongst our three key audiences. Our rationale was that in supporting people's confident engagements with digital technologies, their ability to connect on their own terms would be simultaneously positively affected.

Three digital surveys were sent out at different stages of the project. Digital Confidence questions were drawn from other comparative studies (Freeman et al. 2018, Lessiter et al. 2018). The results indicate that a majority of co-design participants had had no or little experience with VR at the start of their involvement with Unpath'd Waters but did have confidence in other forms of technology. Importantly, there was a general trend across our audiences towards greater digital confidence after the first workshops and towards greater understanding of VR in the Navigator.

Our NCC, VIP and CDR co-designers also spoke of their increased confidence in using VR:

> "… the trying of the hardware [was] less challenging than I was expecting, because I'm not very good at hand eye coordination. I'm not a really a visual person. Yeah. And yet once I took to it like a duck to water but it wasn't as scary as I thought it would be." NCC co-designer

However, some acknowledged that they were not able to experience all aspects of the Navigator, e.g.:

> "I understand what the headset [was], but still I would like to know more about it – I feel that I am [not] 100% satisfied, want to know about it. I got the impression… e.g. what is a mobile phone...I can say, but with virtual headset about 60–70 % knowledge. Some features I'm still not aware of." VIP co-designer

We suggest that these digital confidence findings indicate that our 'Connection' value has been achieved to an extent (which we attribute to the efforts made to create an audience-centred space where people can connect on their own terms).

14.2.6 Somaesthetic[137] Evaluation Co-design – Unpath'd Waters' Sensory Emojis

Research was undertaken on how best to work with VIPs to enable them to connect on their own terms during the evaluation process. We uncovered a lack of inclusion of VIPs in the design of evaluation techniques across all sectors. This is no small oversight: at the time of writing, there seems to be no existing attempt at 'audience-centeredness' with VIPs in relation to evaluation. A new form of methodology to evaluate our outputs was co-designed with our VIPs, in order to increase accessibility of evaluation for other audiences too.

Methodology

Several workshops were designed which adopted the approaches of Höök (2024), seeking to break down the dualism between sensory (bodily) and intellectual (mind) experience. Based on our previous audience mapping research (Perry et al. 2024), we wanted to explore beyond visual/textual forms of evaluation and instead explore what it means to be 'emotionally' aware of the impact of these outputs. We proceeded in several phases.

1. Design of a workshop to enable a more sensory-based evaluation of exhibitions.
2. Co-design workshop between Unpath'd Waters team members and invited VIP co-designers.
3. Review of workshop to agree on next steps.
4. Emoji design session between five VIP co-designers, a graphic designer, and three of the Unpath'd Waters team.
5. Design of emojis by graphic designer.
6. Consultation with VIP co-designer to finalise emojis.
7. Prototype emoji tiles created with talking tiles and additional 'tactile boards'. **(FIGURE 14_04).**
8. Emojis tiles trialled with visually impaired co-designers as an evaluation technique for the Navigator. **(FIGURE 14_05)**

137 https://www.researchgate.net/publication/281115499_Somaesthetic_Design

FIGURE 14_04
Sensory emojis: each emoji is inserted onto a ‘talking tile’ which audibly describes the image.

Photo courtesy of Seamus Ryan Photography.

FIGURE 14_05
Image of one of Unpath’d Waters VIP co-designers using Sensory emojis during the final evaluation workshop.

Findings

The emojis invoked mixed reactions, but with evidence of much promise. One VIP participant did not feel able to use them, but overall mentioned that they were a "good idea" and stated that they could be used for a younger generation. Other reactions suggested very positive potential. This development was vital for our values of 'Equity' and 'Connection', neither of which can be achieved by using standard forms of evaluation. Standard approaches systematically disadvantage those with inclusion and access needs (see Perry et al. 2024).

We did see criticism of – or disengagement from – the emojis (5 of 12 people), yet participants still indicated they could be useful, and the amount of detailed feedback gathered from the VIPs suggests that this method is highly engaging, including as support for other audiences including non-English speakers and young people.

In some cases, VIPs responded to our questions with a 'journey' of emotional reactions to the Navigator – using different emojis to tell their story about the different aspects of their experience, e.g. at first panicked (sardines tin) then afterwards relieved, and curious to be learning (Roundabout), etc. This is an important finding: capturing emotional changes during an experience could help gather feedback on individual journeys through exhibitions (rather than focusing only on summative experience), as well as illuminate areas during design phases where there is heightened sense of 'risk' (which then hopefully can be mitigated).

Further consideration is however needed.

- **Quantitative approaches:** Several VIP participants wanted to work with the emojis in a more 'numerical' format, such as a Likert scale or a sliding scale. This could capture a range of potential engagements with the same emojis, and it may address a concern that some emojis seemed too positive, none seemed neutral, and only a few captured negative experiences.
- **Reducing mental load:** One participant asked if use of conventional emojis would better help to reduce mental load on people, as opposed to the more cognitively challenging Unpath'd Waters bespoke emojis. VIPs spent lot of time trying to work out what the emojis meant: brief audio descriptions could be replaced with one-word explanations to provide a 'shorthand' term for the emotion/value.
- **Tactile boards:** The use of tactile boards caused confusion. Four of respondents noted that the sensory components did not relate to the emotions or values that were represented in the emoji. One suggestion was that the emojis themselves become tactile – e.g. a boat should be designed to feel like a boat – rather than be sat next to tactile materials.
- **Broader representation in the emojis:** The group made a decision to colour all emojis featuring human forms in 'emoji yellow', so that the icons were recognisable as emojis. The lack of diversity was flagged by one VIHP participant during evaluation. One person could not relate to the slim young lady on the inflatable ring, asking for a gender neutral, and non-sexualised icon. Another queried the partnering of the cannon emoji with 'happy' connotations because it is a weapon.

This constructive feedback (which also contributes to value measure 6.2 – 'embracing failure') will be used in future development.

Overall, this value-led practice had demonstrable benefits, particularly in relation to working relationships with VIPs. Despite the fact the emojis received mixed reactions, and some people were frustrated as a result, all VIPs gave their feedback openly and some gave very positive input about the nature of the work (even if they had been critical, of either the Navigator or the emojis – or both). In other words, values-led practice produces positive outcomes even if the output is far from perfect. Using our values framework to track the values at play, we can account for this impact.

14.3 Development of the Unpath'd Waters Navigator

This section outlines the technical specifications for the development of the Unpath'd Waters Navigator (hereafter referred to as the Navigator) arising from the co-design process. The technical elements and the delivery schedule of the Navigator can be found in https://doi.org/10.5281/zenodo.14851860.

The designed immersive Navigator application was developed in Unity and optimised for Oculus Quest 2. We developed our application using Unity version 2020.3.12f1. The Oculus Quest 2 was chosen for its widespread use, excellent cost-to-performance ratio, and the appeal of a standalone device. Newer models, like the Oculus Quest 3, were not yet available during our development.

The Navigator uses data from multiple integrated maritime datasets. The data was collated in an SQLite database (derived from the RDF hosted in ARIADNE and queryable via the Unpath'd Waters Portal) and further refined by adding custom columns that allow for tagging by theme, gross subject and location (Land/Sea). These classifications were identified as areas of interest during co-design and were populated by the project team via machine learning (see section 7.2 of this document). These themes include: People, Migration, Slavery, Crew, Cargo, Material, Technology, Warfare, and Destinations. The gross subject columns are: Plane, Submarine, Cargo Ship, Passenger Ship, War Ship, and Artefact. For location, the defining categories are Land/Sea and the Shipping Forecast Regions: Fair Isle, Hebrides, Malin, Rockall, Shannon, Fastnet, Lundy, Plymouth, Portland, Irish Sea, Wight, Dover, Thames, Humber, Tyne, Forth, and Cromarty.

The organisation of the data significantly influenced the design of the application. Top-level categories break down into more detailed subcategories, allowing users to search the database by theme, gross subject, location, or a combination of these criteria, accommodating searches with up to three terms. The application employs an 'INNER JOIN' query, displaying results only when they meet all specified search criteria.

Visually, this concept is represented as a virtual room where users are surrounded by 3D icon-like models corresponding to each potential search term. Users can select and place these 3D models onto a virtual platform in front of them, effectively adding each term to their search query. Once the query is defined, the results are displayed on a 3D map of the UK and surrounding seabed as Aggregated Data Points (ADPs). Users can navigate between ADPs using in-app locomotion. Selecting an ADP provides additional information based on the maritime datasets available.

14.4 The Curated Voyages

VR can integrate multiple data types, including video, 3D audio, 3D objects, in addition to text and 2D images. Indeed, failure to integrate these data types would limit any proposed VR system, as the full potential of an immersive space would not be realised. However, these data types are not currently available or accessible in virtual reality. They are yet to be linked to aggregated data points or addressed as DOIs. Due to problems associating rich data and multimedia content with individual records, we sought to overcome these limitations by curating multimedia content on certain maritime themes to highlight specific routes through the Unpath'd Waters datasets while also realising the full potential of immersive systems.

To fully realise this potential, we curated multimedia content offered by several Unpath'd Waters partners (and some outside sources). Partners were able to offer rich and varied resources from their institutions' digital libraries. They also offered many research themes which aligned with our research themes. However, we were keen to further adhere to a 'user-generated' design ethos and return to our co-design partners. We were also conscious of maintaining the Unpath'd Waters Living Values, particularly 'collaboration' and 'adventure' (see **Chapter 6**).

Therefore, we worked in collaboration with our co-design partners to build voyages that reflected their interests, rather than the professional and academic priorities represented by partner suggestions (or indeed our own aspirations), although we remained keen to highlight the work of our Unpath'd Waters partners, incorporating narratives and content where possible.

The following Curated Voyages were included in the Navigator at the close of the project[138].

- Dumfries and Galloway in the Napoleonic Wars.
- Women and Shipping in the 20th Century.
- Submerged Landscapes of the Mesolithic.
- The Co-Design of the Unpath'd Waters Navigator.
- Creative Soundscapes.

Multimedia content was required from outside sources in order to demonstrate the full potential of a maritime immersive system. This was one of the more challenging aspects of implementing the Curated Voyages. Copyright issues, particularly with video content, prohibited inclusion of large amounts of rich content initially thought to be available. Approaches to large archive holders revealed insurmountable copyright or charging constraints. The rich content which could be incorporated was that provided by Unpath'd Waters partner institutions.

14.5 Recommendations

Through the Unpath'd Waters Navigator, we achieved our aim of co-designing an immersive system to display integrated multimodal heritage datasets. However, there are some functionalities which were desired at the outset of the project which could not be incorporated. Some rich content associated with individual records cannot be displayed in the application. This is due to the absence of workable web viewers in Unity, and the disconnect between Unpath'd Waters metadata and records archived in national repositories. Links between Unpath'd Waters metadata and individual records are not present within the proposed national collection dataset beyond basic record information held on the Unpath'd Waters Portal. All associated content, such as pictures, videos and additional curatorial information, is still held in digital infrastructures curated by other organisations. We offer some important recommendations in approaching the development of a national collection.

14.5.1 Data Linkage

Rich content that can be meaningfully associated with an aggregated data point should be referenceable via DOI and linked via RDF in the datapoint (e.g. image data, 3D data, video/audio, text data) which represent the actual research resources, could be linked directly with the ADP metadata. This could include data held outside of the institution curating the base record, linking to data in other memory institutions, museums, galleries, and archives. It is not yet clear if the CIDOC CRM or any RDF predicate set has the richness to capture these relationships – or if they can be generated automatically (i.e. using ML or similar).

Although this iteration of the immersive was developed to be explicitly 'stand-alone' due to issues of latency and concerns over internet access at exhibition venues, in future it should still be possible to query the ADPs live (e.g. via the Unpath'd Waters portal), although this would require a mechanism whereby record enhancements (such as those described in **Chapter 9**) are integrated (or better, linked) to the aggregated maritime dataset.

The Unpath'd Waters Navigator also does not include functionality to share, create user generated pathways or follow-up on research outside of VR. This was flagged as highly desirable functionality (CDMR and NCC groups) but would require substantial server-side infrastructure (including moderation) to implement. However, it would also transform the dataset into working research and/or personalised work space. It would only make sense to create this functionality if the above point on addressable rich data was also addressed.

A very interesting suggestion to arise from the CDMR group was the potential for generating search themes on the fly, i.e. the immersive space not only allows exploration of the aggregated datasets but allows the specification of a new 'theme' – this would require much more, and quite complex integration of the immersive querying system and the enhancement work tested by Unpath'd Waters.

---

138 Details can be found in the accompanying Zenodo report https://doi.org/10.5281/zenodo.14851860

However, as an approach this could have enormous potential in further transforming the immersive from a passive to an active research environment, especially if it encompassed the rich datasets as discussed above. This is an exciting new technical research avenue that has arisen directly and unexpectedly from the wishes of co-design partners.

14.5.2 Navigator Design and Enhancements

With data limitations in mind, investigations into the affordability of virtual reality as a heritage tool have yielded encouraging results. The burgeoning market for VR and increased capabilities of headsets since the Unpath'd Waters project began means that future projects will be able to build on this work to produce further achievements. For example, native text-to-speech readers have now been incorporated into the Meta software since the release of the Quest 3 headsets, a feature that was unavailable during the co-design of the Navigator and that is useful for VI use.

Having additional time and resources to build on our successes would also mean that sharing research, saving research for future use, and collaborating with colleagues are features that could be incorporated into a virtual reality application. These functions were requested by both CDMR and NCC test groups on multiple occasions. However, they require a much larger back-end infrastructure in technical development and could not be achieved in this phase.

Meta XR SDK should be considered in future iterations due to its new features, including voice assistive technology. This advancement could significantly streamline the development process by enabling text-to-speech (TTS) capabilities, eliminating the need for (much) traditional voice recording, however VIP feedback on automated voice technology, was not all positive, they found automated voices distancing and preferred fully human voices/inflection.

14.5.3 Practical Co-Design Recommendations

Although the co-design process for Unpath'd Waters was highly successful, resulting in very valuable insights for further immersive developments, for future co-design activities, we would recommend adding additional time for workshops when using VR, particularly with the VI community – this reflects the learning process in navigating and manipulating objects in an immersive environment which is not a process that can be easily short cut.

An additional time constraint was the simultaneous evaluation of the co-design methodology and audit of values alignment with the actual co-design process. This is obviously valuable work, but future co-design exercises should perhaps deal with this in a separate phase. A caveat to this recommendation is that there is no sense that all lessons from the co-design methodology development/process have been fully analysed, nor are they likely to be entirely universal and each group of co-designers needs to be responded to individually by the co-design team. Different audiences may require different approaches (as per our project values).

Appropriate software to allow for VR streaming is also essential (Oculus developer accounts are required for streaming via link cable). Wi-Fi access is essential for workshop activities and researcher demonstrations.

15. Circumnavigation – Testing the research

The various reactions set out in the preceding chapter, and the insights gained from their co-design and local evaluations needed to be tested more broadly. As part of WP5 (led by MOLA and National Maritime Museum), we therefore instigated a small-scale but geographically widely distributed exhibition programme and undertook formal and structured evaluations of the audiences' response to this. The following sections set out this process and our findings. The exhibition sought to explore audience reactions to the following products: the Unpath'd Waters Portal (see **Section 8.7**), the Needles Voyager (see **Section 10.2.3**), the Doggerland Simulation (see **Section 12.5**) and the Unpath'd Waters Navigator (see **Chapter 14**).

15.1 The Exhibition Programme

To respond to the need to "develop more inclusive public access through major research-driven public-facing outputs", we gathered research-driven public facing outputs from the range of project products; designed more inclusive access to them (or from the inventory came up with a range of models of access which have greater inclusivity at its heart); and trialled these outputs publicly to gather feedback.

The two main delivery tools were a touring exhibition at eight museums, and an associated exhibition on the Maritime Archaeology Trust's Discovery Bus at six sites. The content of the former varied according to available museum space. A full display **(FIGURE 15_01)** comprised of:

- Four pull-up banners.
- Unpath'd Waters Navigator.
- Three touchscreens featuring the Needles Voyager and/or Doggerland Simulation and/or Unpath'd Waters Portal.
- A poster asking for feedback via a QR code or pre-printed feedback forms on a table.

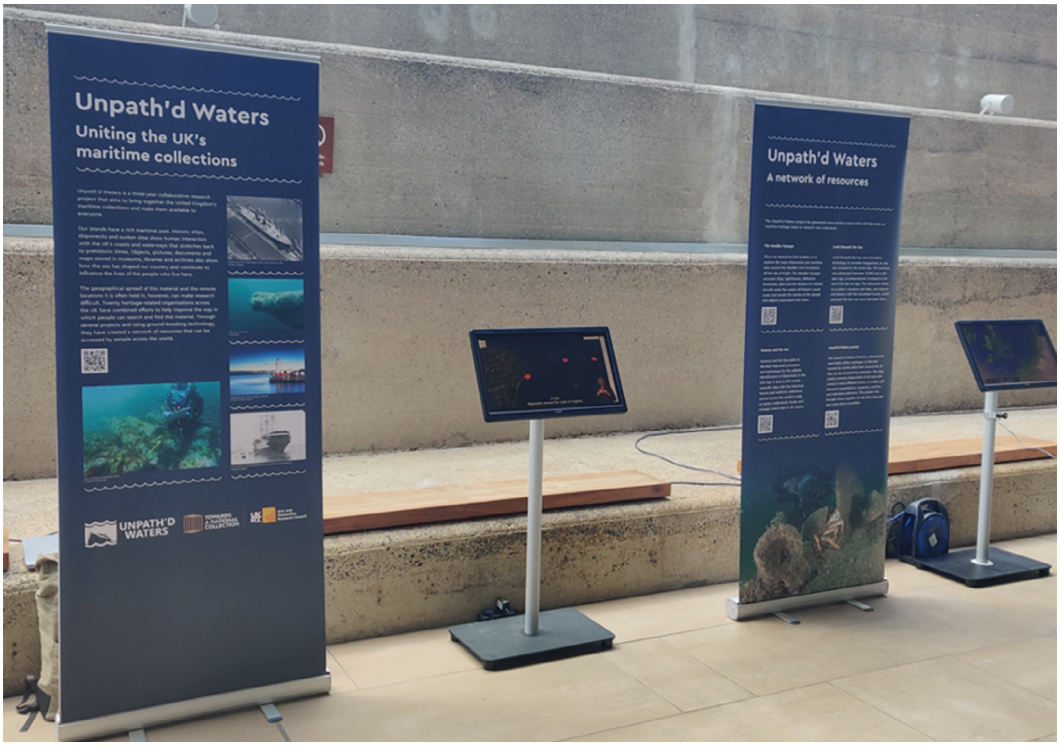


FIGURE 15_01
Static exhibition set up under the Cutty Sark.

The content for the Discovery Bus was comprised of:

- Six A1 posters to present the aims and outputs of the project. The subject of the fifth poster was chosen depending on the location of the bus. The sixth poster encouraged visitors to take selfies and share them on social media.
- Four x pull-up banners on display outside the bus presenting the aims of the project and its main outputs.
- The Needles Voyager.
- The Doggerland Simulation.
- The Navigator, with viewable screen mirroring the view inside the headset.
- Large TV screen playing the Unpath'd Waters Portal video and other video provided by Project Partners.
- On the front railing of the bus was a 3D-printed map of the Irish seabed together with a panel showing the sonar data used to produce it.
- 3D models of three shipwrecks found in the Irish Sea were placed on the central table with a handling collection of archaeological artefacts ranging from prehistoric hand axes to First and Second World War finds.
- A child age-appropriate dig box with hidden artefacts.
- Child age-appropriate diving gear dress-up.
- The front of the bus was fitted with a header banner displaying the name of the project **(FIGURE 15_02)**.
- A4 poster asking for feedback either via QR code or pre-printed feedback forms.

FIGURE 15_02
Discovery Bus test set-up at the start of the travelling exhibition.

Reflecting the variety of components within the touring exhibition, offering both digital and physical activities, we designed surveys which could be answered both digitally, by scanning a QR code, or by hand, via a printed form.

The programme commenced in May 2024 and concluded in September 2024. The full itinerary was as follows:

Discovery Bus

- Time and Tide Museum, Great Yarmouth, 26–27 July
- National Museum of the Royal Navy, Hartlepool, 29–30 July
- Discovery Point, Dundee, 2–3 August
- Scottish Maritime Museum, Irvine, 5–6 August
- House of Manannan, Isle of Man, 9–11 August
- Southampton Sea City Museum, 22 August

Static Displays

England

- Cutty Sark, Greenwich, 27 May–5 June
- Chatham Historic Dockyard, Medway, 10–28 June
- Southend Central Museum, Southend, 3–10 July
- Time and Tide Museum, Great Yarmouth, 15–28 July

Scotland

- Scottish Maritime Museum, Irvine, 22 July–9 August
- Scapa Flow Museum, Orkney, 6 August–30 September

Wales

- Amgueddfa Ceredigion, Aberystwyth, 17–29 June

Northern Ireland

- Tower Museum, Derry, 27–30 June

15.2 Values-Based Audience Evaluation

We used our Values Framework to shape the evaluation of public reception of the Unpath'd Waters touring exhibition. Our interest was two-fold: to assess whether what we had created provided evidence that we had achieved the goal of develop more inclusive public access through major research-driven public-facing outputs; and to assess whether Unpath'd Waters outputs were aligning with our values. An additional aim was to use the results to inform future approaches to values-based practice.

Inspired by our VIP co-designers, we adapted both our emoji-inspired approach and our overarching values-based evaluation questions into a survey that could be completed digitally (by scanning a QR code) or by hand (on a paper form) to assess the displays.

The Values Framework which we used (and to which we refer below) is set out in **Chapter 6**.

15.2.1 Audience Evaluation Methodology for the Exhibition and Discovery Bus

We chose a simple, one-page feedback form composed primarily of Likert-scale questions and some free-text questions. Such a form would be familiar and useable to audiences without supervision and explanation, but also easy to complete on a crowded Discovery Bus. It could be printed too, and hence did not necessarily have to rely on a strong phone or Wi-Fi signal.

The printed and digital questionnaires were nearly identical. Either version could be completed in approximately three minutes. We utilised emojis throughout the questionnaires, aligning them with maritime themes and with an aim to avoid 'happy, 'sad' or other emoji facial expressions that reduce the complexity of people's experiences to singular, simplistic emotions, and to support respondents who may be dyslexic.

Each question was complemented with an emoji that related directly to a word or meaning/feeling within each sentence. To increase ease-of-use, we made most of the questions quantitative, linked to a five-point Likert scale (strongly disagree – disagree – neither – agree – strongly agree); all of which were associated with their own unique maritime-themed emoji **(FIGURE 15_03)**. A handful were free-text.

The decision to deploy both text and associated emojis simultaneously, and to offer the questions in Likert form, was motivated by the range of conflicting meanings associated with different emojis, and our concern to try to mitigate potential confusion in order to meaningfully interpret the data. For example, we might consider the various interpretations of life rings: being in a situation where you need a life ring may a 'disagreeable' circumstance, but if you are drowning and are tossed a life ring then this is an 'agreeable' circumstance, as it is if you are learning to swim and are given a life ring to practice with. The emojis were limited to the exhibition questions only, rather than for collecting demographic questions related to age, gender, and location.

The Needles Voyager was treated slightly differently. As it was exhibited in multiple locations beyond the touring exhibition and Discovery Bus alone, its evaluation was in-built: a questionnaire accessible from the home page of the portal took users to a digital feedback form. The questionnaire was available digitally and in paper form.

15.2.2 Results of Audience Evaluations of the Exhibitions

We estimate that the Unpath'd Waters touring exhibition and Discovery Bus reached a minimum of 6,624 attendees in total **(TABLE 15_01)**, and the Needles Voyager had 3,414 unique visitors.

Visitor numbers for the Discovery Bus are an approximation based on staff hand counting. The exact visitor numbers for the touring exhibition were submitted by the host institutions. Chatham Historic Dockyard and the Scottish Maritime Museum, Irvine were unable to provide numbers in time for this report.

FIGURE 15_03
Screenshot of the first four questions at the start of the paper/digital survey for the Unpath'd Waters touring exhibition and Discovery Bus with embedded emojis.

Venue	Paper forms completed	Digital forms completed	Audience feedback rate
Chatham Historic Dockyard	0	0	N/A
Southend-on-Sea Museum	0	0	205 visitors = 0%
Time and Tide Museum, Great Yarmouth	0	1	1556 visitors = 1%
Scottish Maritime Museum, Irvine	0	3	N/A
Scapa Flow Museum, Orkney	10	3	3,923 visitors = 0.3%
Discovery Bus – Great Yarmouth	11	1	95 visitors = 12%
Discovery Bus – Hartlepool	24	0	220 visitors = 11%
Discovery Bus – Dundee	26	0	140 visitors = 18%
Discovery Bus – Irvine	21	2	130 visitors = 17%
Discovery Bus – Isle of Man	18	0	325 visitors = 5%
Discovery Bus – Southampton	6	7	30 visitors = 43%
Totals	**116**	**17**	**6,624 visitors = 2%**

TABLE 15_01
Number of audience evaluation responses by venue.

A total of 17 digital questionnaires were submitted online on Survey Monkey to which we added the results from 116 paper questionnaires from the Discovery Bus. Free text questions were individually typed in and tagged by subject being commented upon, for example feedback about a piece of technology was tagged 'Tech', comments about Doggerland were tagged 'Doggerland', etc.

In total, 133 questionnaires were collected across eleven venues, with an average response rate of only 12 forms per venue. Put differently, only 2% of visitors (a conservative estimate since we do not have complete information on attendance figures) are represented in the evaluation, meaning our interpretations should be approached with caution. We do not have data for Unpath'd Waters first exhibition at the Cutty Sark, as the evaluation method was still in the process of finalisation; however, Combey and Choong provided anecdotal feedback (see **Section 15.2.5**).

In relation to the Needles Voyager, 99 online questionnaires were completed, giving an audience evaluation feedback rate of 2.8%.

Achieving Audience-centeredness (Connection Value)

Seeking to understand the extent to which audiences felt Unpath'd Waters exhibitions were connecting with people on their own terms (value measure 2.3), we variously asked whether the displays felt 'tailor made' for them (Needles Voyager questionnaire, see **FIGURE 15_04**) or whether the exhibition was relevant to things they 'care about' (touring exhibition and Discovery Bus, see **FIGURE 15_05**).

In terms of the former, the majority felt uncertain about whether the Voyager felt 'tailor made' for them, although an equal amount agreed or strongly agreed. In contrast, the vast majority of respondents who visited the exhibition or Bus (92%) agreed or strongly agreed that the displays were relevant to what they cared about. However, it is important to note that, based on in-person observation, respondents were not necessarily just commenting upon Unpath'd Waters exhibition content: e.g., some were likely reflecting on the Discovery Bus in its entirety, which included content beyond Unpath'd Waters alone.

Achieving Adventure

To understand whether the exhibitions lived up to our concern for adventure (value measure 6.1), we queried people about what they found most curious **(FIGURE 15_06)**. This was an open-ended question whose responses were coded thematically into five categories: Technology, Doggerland, Shipwrecks, Artefact Handling, untagged. In total, 116 people replied to the question, as set out below.

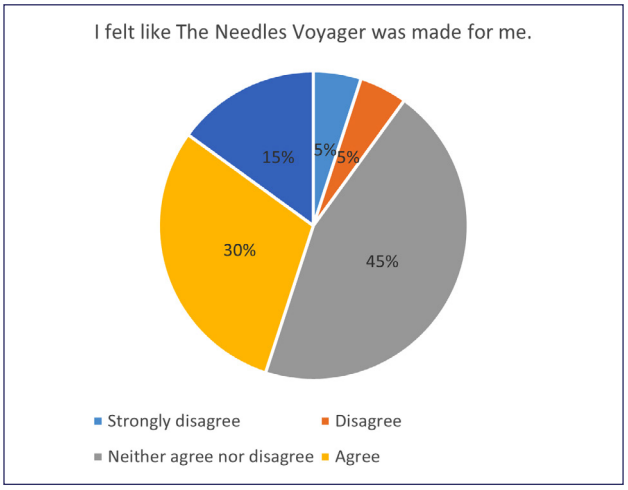


FIGURE 15_04
Pie chart showing answers to Likert Scale question 'I felt the Needles Voyager was made for me' based on 99 individual respondents.

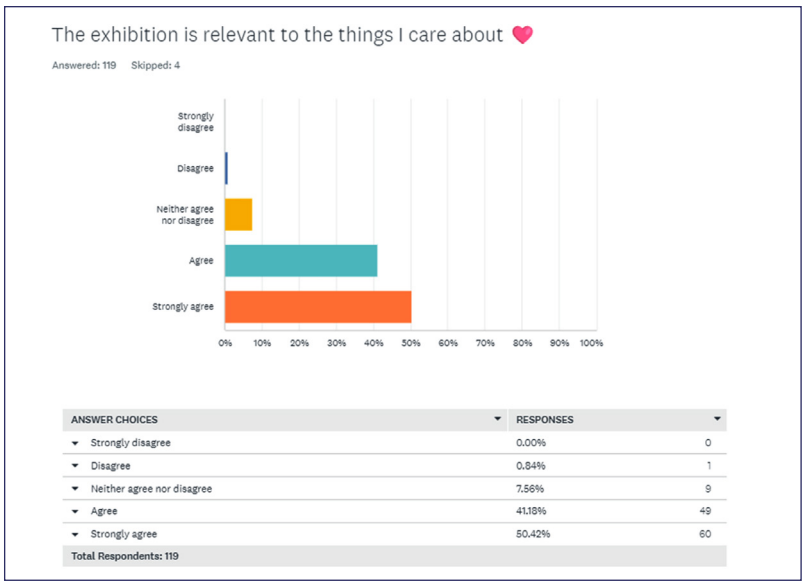


FIGURE 15_05
Screenshot of the results from the feedback question 'The exhibition is relevant to things I care about'.

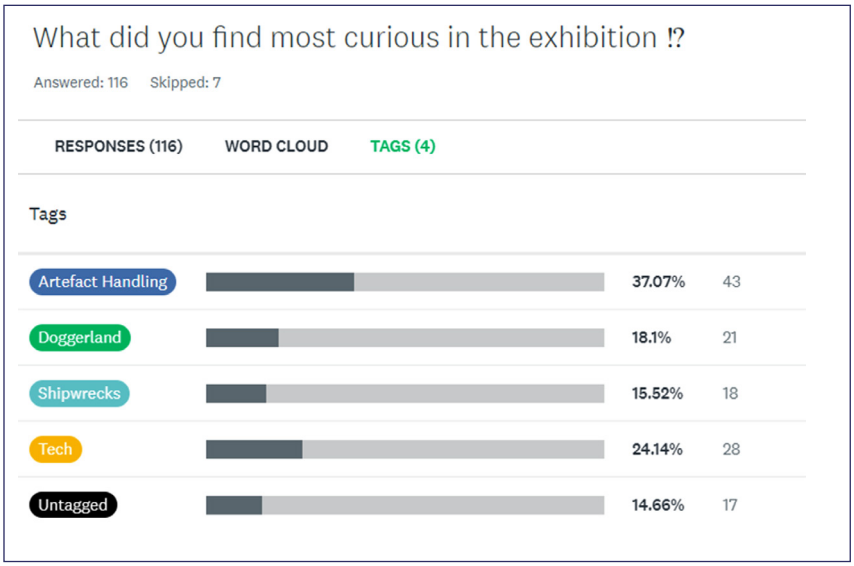


FIGURE 15_06
Screenshot of the answers for the 'What did you find more curious in the exhibition' question once all answers were categorised under five tag themes.

Artefact Handling vs Digital Technology

The main aim of Unpath'd Waters was to explore new and current technologies to assist in the accessibility of maritime heritage. Both the touring exhibition and Bus therefore relied significantly on technology and Wi-Fi connectivity to deliver a full package of activities to their audiences. However, these digital collections are directly related to physical objects. The Discovery Bus also offered artefact viewing or artefact handling opportunities, and although these had not been actively designed into the wider exhibition programme **(FIGURE 15_07)**, it was significant to us (and we suggest to TaNC) that, without prompt or direction the artefacts made a strong impression on the visitors. Almost 40% of survey respondents pointed directly to the artefact handling collections on the Discovery Bus as holding the most curiosity for them.

Various arguments could be made as to why handing artefacts proved to be the single most popular response, including:

- Most curious equates to least familiar technology: Where many people have access TVs, phones, and touchscreens today most of this technology is familiar, and hence may not elicit a feeling of curiosity. In contrast, unlabelled artefacts from random parts of a ship, pre-historic animal bones or even a 3D printed ship may be considered 'curious' and evoke questions from audiences.
- Placement of the displays: The artefact handling collections on the Discovery Bus were physically placed front and centre on a specifically designed table. A consequence of this is the artefacts were always inspected by audiences first before any of the touchscreens or other technical equipment was explored. It is possible that the technology itself was potential access barrier, whereas displayed artefacts are more immediately viewable and accessible.
- Curiosity is kindled by deeper conversations with people: With the handling collections on the Discovery Bus, where people had questions about the materials, the staff were present to probe them further: 'what do you think it is? what is it made of? How would you use it?' The observations made by the team on the Discovery Bus suggest this human engagement helps to evoke more curiosity.

FIGURE 15_07
The Discovery Bus with visitors exploring the handling collection.

Despite artefact handing and digital technology being two very different public engagement tools they can also complement each other in the same space **(FIGURE 15_08)**. For example:

> "The artefacts were great to give context but the VR system was brilliant at bringing the history alive." 46–55 year old female, living 11–20 miles away, visiting the Discovery Bus at Irvine.

Doggerland vs Shipwrecks

Shipwrecks are a dominant narrative of the Unpath'd Waters project and its exhibition content. We know **(Chapter 10)** that the Needles Voyager provided a new or different experience for 82% of users, with 92% exploring new stories within it. For example:

> "I will be looking into the shipwreck database for more info. It will help with my research." 36–45 year old female, living 6–10 miles away, visiting Orkney static exhibition.

FIGURE 15_08
Young people engaging with the Unpath'd Waters Navigator and Doggerland Simulation.

Overall, however, wrecks appear to evoke less *curiosity* compared to the Unpath'd Waters Simulation display of prehistoric landscapes under the North Sea, known as Doggerland. The Discovery Bus team observed strong enjoyment by all age groups of the Simulation and the questionnaires indicate people's interest in the significant change in sea level over time, and how mainland Britain became an island. For example:

> "I found [most curious] the shipwrecks and seeing how the UK became an island." 19–25 year old male, living 1–5 miles away, visiting the Discovery Bus at Great Yarmouth

> "The use of the X-box controller for the land formation changes over the past 20,000 years – very interactive and simple controls." 26–35 year old male, living over 20 miles away, visiting Orkney static exhibition.

Doggerland represents a critical link in understanding the prehistoric human experience in Europe, shedding light on how ancient populations adapted to changing climates and landscapes. It could be argued that the Doggerland inundation is a more relatable subject matter for current audiences who are more exposed to living in a world of sea level rise, compared to shipwrecks which don't resonate with audiences in the same way. For example:

> "How the land has changed over time and will continue to. Makes me feel very small and fleeting!" 26–35 year old female, living over 20 miles away, visiting Orkney static exhibition.

> "Our connection to Europe via Doggerland. I'm from Lincolnshire and don't know as much about this as I should!" 26–35 year old male, living over 20 miles away, visiting Orkney static exhibition.

Furthermore, despite the Simulation being characterised by a fairly basic set of graphics, users expressed no issues with its look and tended to explore the landscape and time periods as much as they did with the Needles Voyager.

Achieving Equity

In line with our Equity value (as reflected in value measure 1.1) we sought to understand how audiences might have engaged with Unpath'd Waters in ways they did not expect, via querying whether 'the exhibition was different from others' they have experienced before. Virtually all respondents to the questionnaire agreed or strongly agreed (98%) with the statement.

As stated earlier, there is some crossover between Equity (in the taking on of new experiences/stories) and Adventure (in terms of experiencing wonder, curiosity and perspective taking). As part of the latter (value measure 6.1), we queried whether audiences were 'inspired to learn more about parts of the exhibition'. Responses were equally encouraging with 92% agreeing or strongly agreeing. As part of the same measure, we asked whether audiences would 'be thinking about what [they] experienced today for a while'. Again 92% agreed or strongly agreed with the statement.

Overall, the results above and below indicate that the Equity and Adventure values were achieved through the exhibitions' thought-provoking content. The data suggest that audiences were encouraged via the exhibition to dive deeper into the content via a range of activities.

Improvements

Fifty-nine respondents to the touring exhibition and bus questionnaires reflected on how we might improve the displays. A majority offered praise: 'I don't think any improvements are needed'; 'nothing, the exhibition was amazing'. However, equal to praise were comments which focused on the technology within the exhibition: 'VR could be better' or 'I found the VR confusing' or 'the VR was very un-user friendly so could be improved'.

Without more in-depth questioning of respondents, it is difficult to understand precise concerns around the VR. We suspect that users may not have been aware that the Navigator was designed for visually impaired people, with simplified graphics and navigation. Moreover, the intent of the Navigator itself – as an experimental mechanism for connecting and searching maritime heritage data – does not necessarily match with popular hype about VR's capabilities. We might speculate, then, that users had expectations for a form of immersive experience that was never the aim of the Navigator.

15.2.3 Characteristics of the Responding Exhibition Audience

Age

Interestingly, the majority of survey respondents to our evaluation of the touring exhibition and bus were under 16 years old. This is an encouraging finding as it suggests that the questionnaires themselves (perhaps owing to the use of emojis) appealed to young audiences who often are not represented in exhibition evaluation results. Of 128 respondents, 38% identified as 'under 16', 16% as between 16–35, 28% as between 36–65, and 20% as 66 or older.

The youth representation in our data is especially significant when compared with programmes that were designed to appeal to similar audiences. For example, Thames Discovery Programme's recent River Recoveries project saw 98% of all applicants aged 18 or above (52 of 53), and the CITiZAN initiative saw only 5% aged 'under 16' (40 of 870). At the same time, we note that the Unpath'd Waters touring exhibition and bus were on display during the school summer holidays, which could account for increased traffic from children. But it is still unusual and unexpected for so many children to be willing to fill in feedback forms, and we see a potential here for further research: it is possible our emojified questionnaires actively invited younger opinions and offered greater comprehension for those young audiences.

In contrast to the touring exhibition and bus, youth response to the Voyager questionnaires was negligible: 5% (4/83). The largest age group identified as 66 or older (17 of 83 responders, 20%); whereas the majority (50%) identified as 36–65 **(FIGURE 6_36)**. The age profile here better matches that of people who are most likely to visit heritage sites.

Accordingly, our results hint to us that 'emojified evaluation' may be more accessible to those with visual impairment, more attractive to a younger audience, and potentially also easier to navigate for a neurodivergent audience, including those with dyslexia. We see significant promise in this line of enquiry given the range of potential people it might positively impact. Given the range of needs and abilities in this group, the use of emojis was seen as a meaningful way for the young people to engage with a questionnaire in a familiar, simple, quick way. All respondents, indeed, processed the questions quicker than anticipated and gave more considered thought to their answers than expected.

Gender

Respondents to the touring exhibition and bus questionnaires were majority women (55%), with 43% identifying as male, and none identifying as non-binary or non-conforming. In contrast, respondents to the Needles Voyager survey were nearly equally split (51% men, 48% women). The 'traditional' maritime heritage audience inclines towards men (e.g. CITiZAN's audiences comprised 61% men), so in this sense the data suggest the Unpath'd Waters exhibition was able encourage more participation from women than is typical.

Reasons for such gender representation are impossible to discern, but we might speculate that the diverse nature of the exhibits in the bus and touring exhibition helped attract a different audience; these included more complex, varied narratives than we might see in usual maritime displays.

Ethnicity

We did not collect ethnic data in the touring exhibition or bus questionnaires as we sought to prioritise our focus on values rather than quantify people's cultural backgrounds. However, the Voyager's questionnaire posed the open-ended query 'My ethnicity is?' with no prompts or tick boxes, to which 45 people replied. Notably, no one identified as any ethnicity other than White (58% of respondents), and all bar one respondent described themselves as British, English, or from the United Kingdom. We have to assume from these data that there may have been no non-white users of the Voyager who replied to the questionnaire.

This high proportion of white respondents reflects the 'traditional' audience for heritage sites in the UK (UK Government 2020). Note, however, that our work on People and the Sea targeted diverse groups within their public participatory activities to encourage equity of voice in the project (for more see **Chapter 10**).

Geographic Location

The Needles Voyager questionnaire provided information on the location where users were accessing the platform. It was viewed 8,496 times by 3,414 unique visitors, 2,220 of which were accessing the Voyager from the Hampshire and Isle of Wight Area. However, given the Solent-centric location of the sites featured in the Voyager, and the Southampton based operations of the Maritime Archaeology Trust, including its Isle of Wight based museum The Shipwreck Centre, it is perhaps not surprising that 52% of the respondents to the evaluation came from the south coast of England. Outside of the UK, several other viewers of the online portal were based in Europe with digital visitors coming from Austria and the Netherlands.

For the touring exhibition and bus, a total of 130 respondents provided details on how far they had travelled to visit. The results demonstrate a significant proportion (61%) had travelled over 20 miles.

15.2.4 The Effects of the Values Framework on Unpath'd Waters Audiences

We acknowledge that the complicated nature of the many outputs of Unpath'd Waters, which are displayed not only in the touring exhibition and bus, but also online via the Voyager, and which have been pilot tested in multiple locations, means that the coherence of this evaluation can be queried. We had to repeatedly adapt the questionnaire to different circumstances; we struggled to collect evaluation data from some locations; and we were unable to conduct systematic observations or interviews at exhibition sites, hence we cannot validate or confirm the questionnaire data, meaning that our findings are shallow – we cannot delve deeper into their implications.

Nonetheless, in organising our approach around Unpath'd Waters values, we are able to reflect upon the exhibitions' relationships to equity, adventure and connecting with people on their own terms.

The overwhelmingly positive responses to the relevance, memorability, inspiration and difference of the touring exhibition and bus suggest that we have been successful in connecting with people on their own terms, and in activating equity and adventure. In some cases, we can claim minimal impact of Unpath'd Waters overarching design on these results – e.g. artefact handling. Yet we can see promising results in terms of demographics, with an inordinately high response rate from young people, as well as evidence of a slightly more diversified gender representation at the touring exhibition and bus than is usually the case for maritime heritage. In relation to the former point, we believe our concern to design evaluation differently (based on the findings of Perry et al. 2024), to foreground audience needs in line with our Connection value, led to unexpected levels of engagement from yet another audience that is often underserved (young people).

15.2.5 Unpath'd Waters Team Observations and Reflections

The experiences of the Unpath'd Waters exhibition organisers (Combey and Choong), while anecdotal, also provide valuable insights. These backed up the evidence of the interest of young people in the Simulation, possibly drawn by the X-Box controller; noted the number of international visitors to the display and products; and noted the interest of other 'non-Unpath'd Waters' host museum staff in visiting the exhibition. The QR codes appeared to be used by older adults (50s +), and individuals took pictures of the displays to look at in more detail at home.

The Navigator had rather mixed reactions with most not wanting to trial the headsets due to reservations about unfamiliar technology; some however were fascinated, enjoying a prolonged (20–25 minute) session during which they tried out nearly every function. Responses to the laptop demonstration of the Needles Voyager were good, several people aiming to access and explore it further at home. Most of these said on first impression it looked very easy to use with information and images attractively presented.

The execution of the exhibition programme itself had very positive outcomes. One of the most positive was the relationships that developed between the project and the host institutions. Smaller local government-run institutions were glad to have new content and were very flexible in accommodating the quick turnaround and occasional logistical unpredictability of a discovery and research focused project. The amount of collaboration and personalisation that we managed to accommodate for these hosts within the project period indicates that with more time, these displays might have been developed further and allowed for even greater dissemination of the work of Unpath'd Waters and further broadening of our working relationships.

The timescale of Unpath'd Waters presented challenges for the exhibition programme, most particularly that of designing displays while some outputs were still in development. The Navigator with its necessarily long gestation period is a good example of this. This necessitated a great deal of planning to accommodate for every possible output, rather than refining the exhibition in terms of audience accessibility. A consequence of this was the reliance on traditional forms of presentation such as the display banners. This was unfortunate in terms of the project's aims of reaching out to visually impaired audiences, for while we benefitted from their input very late in the design process, the displays were not as impactful as we desired in regard to this important audience group.

The displays received a lot of interest from visitors and staff at the host locations, including from some representatives of the project's target audiences. This was notable given that half of the displays took place out-of-season. The digital heritage focuses of the Doggerland simulator and Navigator were key in providing variety to a traditional museum offering.

16. A Profitable Venture – Highlights and Impacts

The core aims of the TaNC programme were:

1. Carry out **world-class interdisciplinary research in key thematic areas**, relying on original ways of discovering and using collections.
2. **Grow and diversify audiences** by introducing the public to new ways of engaging with the collections, including major research-driven public-facing outputs, addressing virtual and in-person audiences.
3. Devise **technological and organisational solutions to the barriers between online collections and catalogues**, including beginning to establish, as far as is possible, harmonised standards for data, cataloguing and metadata to facilitate interoperability across collections
4. **Deliver benefit not only to the collections of Independent Research Organisations, but also to collections and other heritage organisations** of varied scale and geographic location, including organisations beyond metropolitan centres.
5. Create a **sound evidence base for the future development of a virtual 'national collection'**, for example through informing UKRI infrastructure investment planning and digital investment decisions within culture and heritage organisations.
6. Produce **evidence-based policy recommendations to inform the delivery of the relevant DCMS strategic objectives** and those of the devolved nations.

In this chapter we review the key highlights and impacts of the work undertaken during Unpath'd Waters, organised against the first four of these primary objectives.

The fifth objective has been addressed in the preceding chapters, and with some forward-looking in **Chapter 17** below. For the sixth objective, our policy recommendations were submitted and incorporated in the document 'Unlocking the potential of digital collections: a call to action'[139], although we address some of those that we made but which were not included there in **Chapter 17** below.

16.1 World-class Interdisciplinary Research

Two of our Voyages, Science and the Sea **(Chapter 11)** and Lands Beneath the Sea **(Chapter 12)** formed the core of our interdisciplinary marine research. We also assert that our work on Values **(Chapter 6)** represents an important step forward both in terms of project development and audience evaluation.

16.1.1 Science and the Sea

We have demonstrated the potential for combining digital scientific (ocean sciences, environmental and meteorological) archives and datasets with historical collections to identify wrecks. While the approach had already been proven (McCartney 2022), Unpath'd Waters has developed the model further by combining a wider range of digital collections and experimenting with new forms of modelling to further assist identification. It is increasingly possible without very expensive diving missions (human or ROV) to propose or correct vessel IDs.

We have also combined heritage and non-heritage data to begin to develop a preservation model for wrecks. While tests at a more local scale would be worthwhile and the refinement of existing, or introduction of new datasets will improve the model, we have for the first time a proof of concept for understanding risks to the preservation of wrecks. This will be of benefit not only to heritage managers, but to consideration of environmental pollution risks.

139 https://zenodo.org/records/13838916

16.1.2 Lands Beneath the Sea

- A better baseline for research into the palaeolithic and Mesolithic
- Increased access to the datasets via the Simulation
- Engagement with interdisciplinary researchers in associated fields (Quaternary science, sea level studies etc)

The Unpath'd Waters Simulation has been a clear success in terms of interdisciplinary research. We have been able to combine and visualise collections of processes, rather than objects. The medium to long term impact of both the Simulation and the data package are of course uncertain, but the short-term impact has been noticeable within the research community, with users within and around the Submerged Landscape Research Centre using the software as a quick method of examining the changing land and sea levels of the southern North Sea.

Although the accompanying data package is used within the simulation as an input, it is a valuable research output in itself. The data created as a part of Unpath'd Waters represents the most complete map of Doggerland yet created, drawing on and serving geologists, oceanographers, climatologists, archaeologists, glaciologists and more. This emphasises both the inter and multi-disciplinary nature of the project and simulation's role as an innovative data – and collections – integration tool.

The potential impact of accessible simulation software of this kind is hard to measure due to the limited number of comparable examples. The stand-alone nature of the software is deliberately similar to that found in the computer entertainment industry. Games with explicit or implicit archaeological content have many times the number of downloads of even the most widely used archaeological simulations. Rare examples include Ancestors: Stories of Atapuerca (Rubio-Campillo, 2020) and Unreal World, both of which have been downloaded in numbers far exceeding the most successful academic archaeological simulations (e.g. Janssen 2009, including its precursor and successor). We hope therefore that our approach will stimulate greater cross-over between gaming technologies and cultural heritage.

16.1.3 New Environments for Research

Use of the Navigator and VR provided interdisciplinary researchers with new ways of visualising (and presenting) data. Our CDMR group agreed that their appreciation of the technology as a research tool developed throughout the project, and original scepticism was alleviated after demonstrations and direct use of various prototypes. After seeing the (near) final iteration, they were very encouraged in the results room where the data was plotted by location and also situated on the Z-axis by time period. They enjoyed being taken away from the 2D research mindset. They were also encouraged by VRs potential to bring research (or heritage experiences) to life without having to travel – which is one of the benefits of the technology more generally. The virtual environment is closer to a real-world experience than a 2D screen. They also appreciated the potential for VR as a public engagement tool, as outreach activities are increasingly important for academics and heritage professionals.

16.1.4 Values-based Research

Another interdisciplinary impact of Unpath'd Waters arose from our novel work on values-led approaches to evaluation and consortium integration. Our values **(Chapter 6)** have demonstrably positively affected some aspects of the project's research and most aspects of its community-based partnerships. We feel confident in asserting that values-led research, practice and analysis has led to deeper understanding of effective forms of collaboration, a much-sought-after behaviour within research programmes.

Careful attention to values led multiple sub-teams within Unpath'd Waters onto trajectories that they might not otherwise have pursued, from development or reuse of specifical technical features/tools to whole new lines of enquiry, such as emoji-based evaluation in response to the inequities embedded in traditional evaluation practice. Indeed, Barrie-Smith has gone on to incorporate this emojified evaluation technique into another project (beyond Unpath'd Waters) with young people aged 18–19, all Not in Employment, Education or Training (NEET), and all with various levels of education and neurodiversity. We witnessed the organic emergence of values advocates, who sought to engage with or promote the values of their own accord and who, in so doing, helped to shape how we conduct conversations about values and how we can embed them into everyday practices.

The values also forced attention onto wider infrastructural problems which threaten these values (e.g. sustainability), and which need attention at a programmatic level beyond Unpath'd Waters (and indeed TaNC) alone. And at the same time, they spurred on the development of wider networks and experiments (e.g. through the VIHP) to fill in gaps in the existing research base. It is difficult to imagine that such an array of outcomes could have been actualised without concerted focus on values-based practice.

16.2 Growth and Diversification of Audiences Engaging with Collections

The Unpath'd Waters Navigator opened access to visually impaired people many of whom had not been able to engage with marine heritage collections previously. It engaged with communities not used to connecting with the coast and the sea. The hackathons run at the University of Portsmouth brought non-heritage designers and problem-solvers together. Of the estimated c 10,000 people who saw the touring exhibition, only about 2% responded via the feedback systems we deployed. Nonetheless, we saw an unexpectedly high response from young people, and gained a sense of the overall motivations and reactions of the respondents which can be summarised as:

- New understanding – the discovery of something entirely unknown previously.
- Enhanced information – the response to combined collections and consequent greatly increased exploratory routes.
- Combined media – the power of word, audio, image, video reaching different people in different ways and eliciting different responses, especially in relation to wrecks on the seabed.
- The power of people-centred stories, created by the hook of the wreck or artefact but leading to the people whose lives revolved around or were touched by them.
- Provoking by proposing new narratives – the ability for combined collections to trigger new ways of thinking about the past.
- The non-heritage value of heritage – heritage as inspiration, heritage as environmental lobbying.

16.3 Solutions to barriers between online collections and catalogues

16.3.1 Controlled Vocabularies

Unpath'd Waters led directly to the creation of an agreed UK wide controlled vocabulary for vessel types for the first time. Definitions for Scottish periods were published as URIs via the Perio.Do service, and for the first time an archaeological periodisation was agreed and published for the whole island of Ireland. The lack of UK wide subject vocabularies for vessel types was an initial challenge but was created during the project. The Getty Art and Architecture thesaurus provided a common spine for partner-specific subject vocabularies, although it was unable to deal with the granularity needed for vessel types. Overall, the process followed in order to add partner data to the portal, increased the FAIRness of UK maritime data. For the ADS, the Unpath'd Waters portal provided a testbed for the approach that will be adopted in the next generation of ArchSearch during 2025, and for the portal and catalogues for the Heritage Science Data Service within RICHeS.

Getty AAT does not yet have the level of detail required for detailed classifications (e.g. down to object/artefact level). This presents a challenge in capturing more collection-specific subtleties within a nationally searchable database and could be a fruitful area for further research.

16.3.2 Metadata, Ontologies and Linking

Unpath'd Waters successfully adapted the ARIADNE ontology, the AO-Cat, itself a subset of the CIDOC-CRM, to create a maritime-specific instance, the UO-Cat. Research undertaken into the aggregation of heritage data in the preceding European funded ARIADNE and ARIADNEplus projects provided a firm basis for linking datasets in Unpath'd Waters and was easily adapted for the specific case of UK maritime heritage, demonstrating its wider applicability. UO-Cat was also found to be a good fit for the MEDIN metadata standard. The identification of What, When and Where properties was achievable for all the datasets provided to the project, and proved to be a powerful search combination, demonstrating the importance of the spatial as well as the temporal dimension for heritage data sets.

It was relatively straightforward to implement a UK maritime specific instance of the ARIADNE portal, creating an interoperable cross-search linking partner-provided datasets and metadata records. The portal was launched in Year One and proved itself to be a stable and intuitive user interface as more datasets were added. Although for Unpath'd Waters this was done manually via loading of XML files to the aggregation system, the architecture also supports use of APIs, and OAI-PMH harvesting could be employed to keep the data catalogue up to date.

The ontology worked well for static heritage assets but was unable to deal with the concept of voyages and the fact that maritime vessels can move and change identity. This was tackled by the English Mariner data schema, which evolved during the project informed by Unpath'd Waters research. The fact that the Unpath'd Waters data sat within a wider ARIADNE triple store with four million resources provided a solid demonstration of how Linked Open Data solutions can support a national collection, situating spatial or thematic subsets of data within wider collections. That the Unpath'd Waters metadata could also be surfaced in several search portals, each with different audiences, but without duplication or redundancy, illustrates how multiple shop windows could be provided onto a national collection.

16.3.3 Use of AI and Machine Learning

The enhancement work undertaken for this project has helped to deliver significant outcomes and impacts. Specifically (and discussed in more detail in Pink et al. in press), for the national inventories, it is now possible, for the first time, to bring them together allowing us to understand aspects of the unified record that were previously impossible to explore, including:

- Which records relate to physical objects,
- which to documentary evidence,
- what their distribution in time and space is,
- Analysis of period of construction of wrecks across UK waters,
- Identification of craft type for both documentary and physical wreck remains.

Just as importantly, we have explored the challenges related to the use of AI/ML in integrating and making accessible our cultural collections. Our work on messages in bottles has shown the potential of hitherto un-accessed collections to contribute narratives that speak to a distinctly human existence at sea and the process of loss, wrecking, and the end-of-life circumstances of a ship. But it also demonstrated the complexities and challenges inherent in use of ML and the fundamental need for a human in the loop.

Critically our use of AI has demonstrated both its strengths and weaknesses. Its strengths related to resolving inconsistencies in data creation and storage practices, enhancing records where their 'thinness' prevented linking. In essence this was helping us to address historical differences in metadata creation. This delivers on the core objectives of TaNC to enable datasets to be joined and linked – without this work it would not have been possible. The weaknesses are less to do with AI (as it is a tool) and more to do with the materials (what we were asking the tool to work with) and heightened expectation due to increased AI capabilities and media coverage. Early in the project it became apparent that datasets were highly inconsistent, highly variable an

d had received different levels of investment and curation. We knew at the beginning of the project that AI systems require high-quality, interoperable data to function effectively (Artificial Intelligence Index Report 2024) and that addressing this gap would be our greatest and most immediate challenge. During conversations with colleagues over the course of this project, and throughout the process of addressing inconsistencies and gaps caused by periods of underfunding of posts connected to metadata generation within Unpath'd Waters, the place where AI might have the biggest impact in the future became clear. The role of AI may well be in helping us to resolve past inconsistences and funding gaps, but it is also clearly to support those working in the sector today. AI tools to help in the creation of rich metadata will be an important part of this. This would improve the raw digital material of our national collections and make them more linkable – it will allow AI then to do more effective work for us.

16.4 Deliver Benefit to the Collections of Heritage Organisations

Evident benefit has been provided to the four home nations (and Isle of Man) marine heritage inventory managers. The work on integration, enrichment and aggregation made possible through our use of machine learning and named entity recognition and presented via the Unpath'd Waters Portal has driven rich conversations between the home nations about the future of their separate inventories. For Wales, the Unpath'd Waters project has demonstrated the ability to accurately extract field-specific information from text descriptions, demonstrating the potential to upgrade records with new fields, e.g. ship-type, in the future. This has the potential to allow better accounting for aspects such as the overall numbers of certain ship-types, which in turn will allow indicators of archaeological significance, e.g. rarity, to be better appreciated. The Isle of Man was inspired to create a marine heritage inventory for the first time to document and reveal more about the maritime heritage of the Isle of Man through data and the stories told through its collections and the Irish Sea wreck sites. The project will make an important contribution to the data and digital legacy at Manx National Heritage in its telling and monitoring of maritime history. Unpath'd Waters has directly influenced the design of Mariner, the new platform for England's marine heritage inventory, while Northern Ireland is currently undertaking a review of its marine heritage records and will be updating them in-line with the recommendations of the Unpath'd Waters project.

Unpath'd Waters assisted Mary Rose Trust in identifying one key area of digital collection development and to enhance their use of FAIR principles for digitisation. The project facilitated a valuable development of professional networks between the National Maritime Museum and several medium and smaller sized institutions that have a great deal to contribute to the UK heritage space, as well as strengthening their existing relationships. The exhibition outcomes have confirmed that to forward the idea of a "national collection", it is essential to recognise it is not just a matter of artefacts and records, but the people who maintain and experience them. The exhibition generated significant interest from many hosting institutions and audience members in future developments and how Unpath'd Waters would influence these. Several hosting institutions (Cutty Sark, Chatham Historic Dockyard and the Tower Museum, Derry) have decided to keep their banners on show to continue promoting the work and achievements of the project for the next few years.

At a broader level, Unpath'd Waters has undoubtedly led to a better shared understanding of data qualities across collections owners and managers, thus enabling trust and better understanding of the capabilities, potential and challenges of different collection types.

16.5 International Inspiration and Media Engagement

Unpath'd Waters provided an excellent platform for international engagement and inspiration for follow-on funding and media stories.

Unpath'd Waters represented Towards a National Collection at the high-profile launch[140] in December 2023 of the Prime Minister's Council for Science and Technology report on Creative Industries (of which heritage science, and thus a substantial part of Unpath'd Waters' work, is a key component). The report identified TaNC as positioning "…the UK as a leader in digitisation, extending the value and impact of its cultural assets".

140 https://www.youtube.com/watch?v=u0-uCIiE8Hs

Unpath'd Waters was formally endorsed by the UN Decade of Ocean Science for Sustainable Development 2021–2030 – the Ocean Decade – as a Decade Contribution[141]. This endorsement signifies global recognition for the progress that Unpath'd Waters is making towards three Ocean Decade Challenges:

- Challenge 8: Create a digital representation of the ocean
- Challenge 9: Skills, knowledge and technology for all
- Challenge 10: Change humanity's relationship with the ocean

The project has also helped to secure significant follow-on funding for other research into our marine and maritime heritage. One notable example is SUBNORDICA: Beyond Submerged Landscapes – Defining Human Response to Postglacial Sea-level Rise and Climate Change, based in Belgium, a six year project worth a total of €13m, of which c €7m is allocated to the University of Bradford[142].

The project also led to a national media story in November 2024 when the use of connected collections as part of Work Package 3.2 allowed us to propose the identification of the HMS *Stephen Furness* (see **Sections 11.2** and **11.3** above). The story was covered in national broadsheets and web outlets[143] and on national and local radio, and was selected as one of UKRI's twelve impact stories for the festive season of 2024. Other media stories are covered in **Appendix A**.

141 https://historicengland.org.uk/research/current/discover-and-understand/coastal-and-marine/unpathd-waters/news/endorsement-by-un-decade-ocean-science-sustainable-development-2021-30/

142 https://www.bradford.ac.uk/news/archive/2023/university-of-bradford-wins-7m-grant-to-hunt-for-lost-civilisations-beneath-baltic-and-north-sea.php

143 https://www.telegraph.co.uk/news/2024/11/05/first-world-war-hms-stephen-furness/; https://www.bbc.co.uk/news/articles/cq528ql6yego

17. Beyond the Horizon – Recommendations

Beyond delivering against the core objectives of the project, Unpath'd Waters also surfaced some recommendations for the future. These recommendations are aimed at the future of marine and maritime heritage collections, the future strategy for moving towards a future UK digital collection, and the future of collaborative research programmes.

17.1 Recommendations for Developing a UK Digital Collection

17.1.1 Collections Development

The following recommendations are provided by way of support to those wider policy recommendations issued through the TaNC programme in November 2024[144].

- **Discovering collections:** The scoping of any follow-on activity from TaNC should be clear about the degree to which focus is placed on metadata or rich datasets. Both are needed to unleash the potential of a true national collection and a clear criterion-based strategy will be needed.
- **Authority and control:** The extent to and circumstances in which authority files and controlled vocabularies should be imposed is a complex ethical and technical issue relating to potential end-use and end-users of collections. A strategic approach will be needed to ensure a balance for different kinds of collections. This will have international implications.
- **Artificial Intelligence:** Given the rapidly expanding capabilities of AI, the need for tracking of how outputs and labels have been created will be essential, especially for collections used for legislative or strategic management purposes.
- **Dynamic data:** Some collections are designed to grow and change (e.g. national inventories). Others are static (e.g. a historical collection of objects). Efforts to enhance the former will require workflows that allow enhanced data to feed back into original repositories and be recognised there.
- **Connectivity and accessibility:** Formatting of new, future collections will be crucial in ensuring that the full range of abilities of users (for example the visually impaired) is built-in at the outset. This has significant implications.
- **Ethics:** related to connectivity, we recommend that human and more-than-human centred design is made a core component of any future national collection, at an infrastructure as well as collection level.
- **Inherent issues in collections:** collections created in the past use language and approaches rooted in that past. Linking such collections may surface difficult and inappropriate language and consistent approaches to this risk are required.

17.1.2 Digitisation of Analogue Collections

As part of our Analogue to Digital Connector work (see **Chapter 13**), we developed an initial consideration of how to prioritise the digitisation of analogue collections. We make two assumptions in proposing this. The first is that the fundamental value in digitally unlocking our collections to grow audiences, empower research, and drive economic growth is a given. Prioritisation is therefore not a simply binary 'do' or 'don't do'. Instead, it is 'do first' or 'do later'. The second is that individual organisations will continue to digitise using their own criteria: the prioritisation approach we suggest is complementary, supporting funding organisations who have a choice in which collection(s) to address next.

144 https://zenodo.org/records/13838916

We recommend that the TaNC programme offers some basic advice to all funders and supporters of digitisation of collections.

This advice should draw from the criteria that were identified at the expert symposium (see **Section 13.3**), but also from the range of existing published criteria and approaches that are used by principal archive and collection organisations. Here we draw on the significance criteria for archives published by The National Archive[145], and also adopted for museum collections in Significance 3.0[146], and on digitisation guidance published originally by Culture24[147].

The significance of a given physical collection can be (and may well already have been) assessed against the following basic criteria:

- **Provenance:** who created, collected and has used the collection.
- **Rarity:** whether the collection is unique or unusual, and if it is a particularly fine example of a collection of its type.
- **Condition and completeness:** whether the collection is intact and in good condition, and if its condition can say anything about its history, ownership or use.
- **Historical, cultural or scientific meaning:** how the collection tells the story of particular people, groups, organisations, events, places, beliefs, or practices; whether it has special historic or cultural interest for an audience, region or community; whether and how it could be used for academic research; and whether it enriches or fills in gaps in other collections.
- **Sensory and emotional impact:** whether the collection has strong visual/sensory impact or evokes a strong personal or cultural response; and whether the language, format, technique, design or style reflect outstanding creativity or innovation.
- **Marketing and exploitability:** whether the collection could support marketing, income generation or profile-raising.

But the decision to digitise any collection which is able to demonstrate significance is a further consideration. Here it is possible to apply further tests based on our Analogue to Digital Connector work **(Section 13.2)**. For example:

- **Retention of faithfulness:** does digitising carry across sufficient of what makes the collection significant?
- **Removal of barriers:** does the proposal eradicate or reduce existing barriers to access (such as logistics, legal issues, etc)?
- **Preservation:** does digitising help to secure fragile or vulnerable collections for the future?

More work would be required to establish how helpful this recommendation is, but we are convinced that would be effort well spent.

145 https://www.nationalarchives.gov.uk/archives-sector/grants-and-funding/records-at-risk-grants/how-to-apply/assessment-criteria/
146 https://collectionstrust.org.uk/resource/reviewing-significance-3-0/
147 https://digipathways.co.uk/what-should-i-digitise/

17.1.3 Programme Infrastructure

These recommendations may assist in structuring future investment opportunities.

- **Research Council funding equity.** The very positive innovation seen in the TaNC programme of including Collaborating Organisations as part of the research ecology created many benefits to Unpath'd Waters. However, the stance taken on their funding created difficulties where they, several being small-scale charities, could not claim overhead costs. This seems unfair and unnecessary and should be reviewed.
- **Supporting smaller organisations to become FAIR.** While national heritage bodies involved in the Unpath'd Waters consortium had a good understanding of FAIR and had implemented many of the principles, partners representing smaller organisations or projects within academic departments had more of a learning curve. Most were able to work through the process with much of the data they had hoped to include, which resulted in both heightened awareness of what implementing FAIR Principles actually entails, and the importance of FAIRness on their practices and workflows going forward, and this should be supported in any move towards a UK digital collection.
- **Develop programme-level values.** Drawing on our work on values-led project development and evaluation, we suggest that funders, whilst not prescribing values or enforcing them upon new projects, should undertake their own values setting process in order to fully understand the logistical commitment here and to set a precedent for subsequent organisational behaviours.
- **Training support.** Funders should be made aware of any appetite for training required in novel areas for which no consistent track record has yet been developed, which they then could support as part of any project.
- **Climate impact and carbon footprint.** Leadership, shared aims, and guidance should be provided by funders on how project teams can reduce carbon footprints from the outset of their project. Funders, in fact, should have their own clear commitments.

17.2 Recommendations for Marine and Maritime Collections

17.2.1 The National Records

A rich set of interchanges between those responsible for managing national inventories was provoked by the Unpath'd Waters project. This led to some broad recommendations which, if adopted, will help improve all four home nation inventories. These are:

Improving the Collections

- Provide persistent identifiers (PIds) to physical objects and documentary records of wrecks so as to allow for a vessel name to be allocated and reallocated across physical entities as information changes.
- Resolve default labelling. Where something is not known it should be labelled as such.
- Resolve false specificity in precision and accuracy in wreck location reporting.
- Recording depth/vertical extent of sites and wrecks in a consistent manner[148]
- Develop ways of spatially characterising significant marine landscape features (e.g. priority areas derived from Unpath'd Waters Simulation, coastal and intertidal peat data, and others) to allow their incorporation into management systems.
- Enhancement of event records (investigations, surveys, excavations and so on), and a closer relationship with the Archaeology Data Service's OASIS flowline which captures metadata on these events.

148 For example, https://medin.org.uk/sites/medin/files/documents/MEDIN_Schema_Documentation_3_1_2_brief.pdf

- Developing and publication of the spatial component, including spatial extents where known, of the Events module to better reflect the temporal history of wreck locations.
- Developing ship's biographies to more fully document the lifecycle of vessels from commissioning, construction and naming, through journeys to loss in addition to the rediscovery and recording of wreck sites.
- Using connected collections to identify environmental hazards of historic wrecks in marine inventories.
- Creation of linkages to historical collections (e.g. LRHEC or RNLI), allowing for a much richer and more compelling understanding of the stories of individual ships and people.

Improving Data Flows

- Closer exchange of information with the Admiralty's Centre for Seabed Mapping; the Wrecks Section of the UK Hydrographic Office; the Civil Hydrography programme; to ensure that newly discovered features on the seabed are incorporated into the record quickly.
- Improving information ingest and publication from large area surveys and targeted projects to ensure better decision making and stewardship of the historic environment by stakeholders from archaeologists to the offshore renewables industry.
- Enhancing the flowline of information with the commercial archaeology sector to improve how information from development-led work is captured within the record.
- Streamline data flows from citizen science data producers into the national inventories.

Equitable Handling of Citizen Science

- Give due acknowledgement in outputs to the origin of data sources created by 'citizen science' programmes, permitting each to be 'surfaced' as separate collection groups.

Raising Awareness

- Work with relevant governmental bodies on matters of mutual interest with regard to survey and spatial data management planning.
- Raising public awareness of marine heritage assets, in partnership with other key sector stakeholders (e.g. national museums, the higher education sector, relevant Non-Governmental Organisations), through research, virtual access, archive collections and educational and outreach activities.

17.3 Recommendations for Developing Values-led Projects

Values offer (a qualitative form of) self and group accountability, which – when applied critically – lead to greater efficiencies and collaboration within the team, greater innovation, and ultimately then to greater value-for-money and less wastage (of time and money). We make a number of recommendations based on our work:

17.3.1 Improving Collaborations Through Values

- Develop a project-wide and living values framework. There are significant cross-project benefits to be realised in proper preparation and implementation across collaborations, especially where different cultures of research or practice exist.
- Embed values frameworks by developing value advocates. Leads and PIs should aim to establish a team structure that nurtures value advocates across the project (not centred only in one work package) who regularly encourage or nurture values-rich conversations. Ringfencing time, money and expertise to create such advocacy roles would allow values leadership to be better distributed across the consortium, with advocates able to advise work packages more closely on values methodologies.

A proposed structure for a Living Values Framework Workflow is articulated in **FIGURE 17_01**.

- Define values early. It is imperative that the project defines values as early in the process as possible in order for colleagues to begin to plan their outputs in accordance with them. Use open values rather than closed (tick-box) values and consider audience-centring them.
- Ensure the framework is not unwieldy and overly bureaucratic. Reporting to numerous values measures is cumbersome and drains limited capacity, leading to a lack of understanding of required or desirable values-led practices.
- Recognise and account for programmatic and institutional operations which may sit in conflict with values. Values can easily and regularly be undermined by the everyday operational practices and policies of institutional partners. Hurdles in sharing technology or images, conflicting or exclusionary intellectual property, proformas that are inaccessible to people with visual impairments using screen readers; financial systems that will not allow simple forms of compensation via voucher, are all examples of barriers which can be removed early in any project.
- Simplify values recall. Values, associated action statements, and measures could be hard to remember. Ways of presenting the values as logos or graphics may be useful as shorthand. However, such visuals must be simply fashioned (to promote changeability) and designed with accessibility in mind.
- Hold teams to account. Values Advocates can help to mitigate negative or unconstructive behaviours which contradict the values, focus on positive reinforcement of the values, and identify persistent problems with project leads where escalation is needed. Audience-focused training across teams (e.g. in outreach or evaluation) may also help to embed more values-led practices.
- Adopt other organisational or community values. More work is required in considering how external values, held by our target audiences and external partners, could be integrated into our Values Framework. Early discussions with external partners to gain an understanding of their values, and how they hold themselves accountable to these could act as an 'icebreaker' introduction.

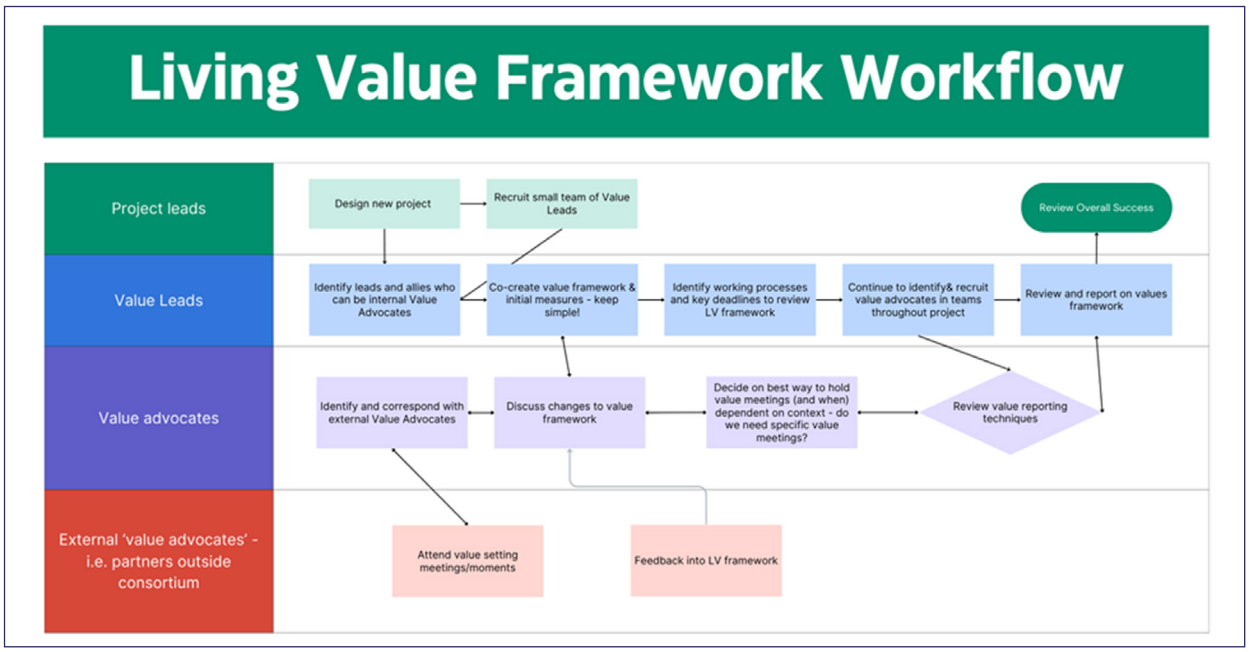


FIGURE 17_01
A proposed Living Values Framework Workflow which embeds internal and external Values Advocates into the process.

17.3.2 Shaping Public Engagement Evaluation through Values

Similarly, our work on values-led evaluation threw up some very useful recommendations for future projects considering this approach in the context of public events, trials or exhibitions.

- **Suites of simple guidelines.** Prepare resources at an early stage:
  - specific guidance around the audiences where the project has the least experience.
  - simple checklist type does and don'ts.
  - logos and infographics to add to PowerPoint slides on evaluation/measuring of our objectives.
  - impact measurement template.
  - evaluation tools.
  - link to relevant toolkits.
- **Training of team members in audience evaluation.** This will help to ensure more consistent administration of evaluation activities and better-quality data collection.
- **Smoothing the path for data-sharing.** GDPR and ethics also negatively impact on data sharing across work packages. Programme-level support is necessary in ensuring multi-institution projects can move data between partners to perform rigorous analysis.
- **Planning technological requirements.** The touring exhibition, bus and Voyager relied significantly on technology and Wi-Fi connectivity, but there were often issues with electrical links and internet which affected the visitor experience.
- **Delegate evaluation activities locally.** Exhibitions to be evaluated must have staff dedicated to conduct evaluation. Staffing must come from within museum teams in order to react quickly, to reduce carbon consumption and to offer context that only a local member of the institution can provide.
- **Experiment with 'audience-centred' evaluation methods.** Research investment must be directed towards evaluation methodologies themselves, rather than investing in other forms of innovation and carrying on with evaluative approaches we know both to be ineffective and to contravene our own values.
- **Bring research outputs directly to different audiences** (beyond existing heritage institutions). To truly reach out to new audiences and those who do not usually engage in heritage, the project needs to be more adventurous in its choice of exhibition locations. Examples of more diverse visitor spaces with larger footfall could be roadside service stations, supermarket car parks or transport terminals, amongst many other options.

17.4 Recommendations for Managing Large Consortia

There were several lessons learned which may help planning future consortia of this kind.

- The impact of recruitment delays should not be underestimated. It can't be helped if programme management staff move on but developing a backup strategy and ensuring 'desk instructions' are available will help in transitional periods.
- Recruitment delays within delivery teams also caused unsurprising knock-on impacts to the programme. While we managed this with a level of flexibility within the programme as a whole, there are limits to how far that can help. One strategy for replacement of staff was to recruit multiple short-term PDRA positions to support Co-Investigators, each with slightly different skill-sets. This made it easier to match the total skill requirements, rather than waiting an extended time for one individual who could cover every base. This strategy also saw an increase in Early Career Researcher involvement in the project.
- We did not calculate the capacity required for meeting times both within the project and beyond it (joining TaNC programme meetings for example). This was a capacity issue both in real terms (not quite enough Co-I time for example), seasonal terms (where Co-Is or Collaborating Organisation staff were committed to fieldwork, teaching or commercial work outside the project), and in terms of programming (where critical path tasks were required to be completed at the time of the meetings).
- It might be possible for UKRI to develop financial reporting templates which could be used to match the requirements of Final Expenditure Statements. That way, the in-flight financial reporting would more closely match the end requirements of any given project.
- Full-time administrative support should be costed when consortia are above a certain size.

Appendix A: Key Project Outputs

Online resources and products

Unpath'd Waters Portal:
https://unpathd.ads.ac.uk/

MAT Needles Voyager:
https://unpath.maritimearchaeologytrust.org/

Unpath'd Waters Doggerland Simulation: Unpath'd Waters, Undream'd Shores – Exhibition edition
https://zwack.itch.io/unpath-exhibition

Unpath'd Waters Doggerland Simulation: Unpath'd Waters, Undream'd Shores – Home edition:
https://zwack.itch.io/unpathd-home

Unpath'd Waters Navigator:
https://github.com/JFlint-Unpathd/Unpathd-URP-Explore

Unpath'd Waters website (now archived):
https://historicengland.org.uk/research/current/discover-and-understand/coastal-and-marine/unpathd-waters/

Guides and Workshop Reports

Marine Survey Data: A Guide to Good Practice:
https://doi.org/10.5284/3y3w-g262

Report: 'Ethics as Practice: Report on the 1st Discovery Project Ethics Workshop':
https://zenodo.org/records/13683142

Articles and publications

Article: 'The sunken treasure of the San José shipwreck is contested – but its real riches go beyond coins and jewels':
https://theconversation.com/the-sunken-treasure-of-the-san-jose-shipwreck-is-contested-but-its-real-riches-go-beyond-coins-and-jewels-225305

Article: 'How we discovered the wreck of a torpedoed British ship after a 109-year mystery:
https://theconversation.com/how-we-discovered-the-wreck-of-a-torpedoed-british-ship-after-a-109-year-mystery-225592

Article: How we found a long-lost first world war vessel beneath Irish waters:
https://theconversation.com/how-we-found-a-long-lost-first-world-war-vessel-beneath-irish-waters-243647

Article: 'Centring Audiences: What Is the Value of Audience Mapping for Influencing Public Engagement with Cultural Heritage?':
https://mola.iro.bl.uk/concern/reports/8834bc5f-feb1-4a04-8dc4-39c5c6b43a27?locale=en"

Article: (In Press) Modest Doubt: Enabling Discovery Across Maritime Heritage Records *Journal of Digital Humanities.*

Appendix B: Events and Consultations

Subject	Date	Estimated number of attendees/ responses
WP5 Values framework development		
Initial brainstorming workshop	8 Mar 2022	13
Consultation on draft values	Completed w/c 4 Apr 2022	13
Consultation with the Consortium on refined values	Completed 30 Apr 2022	76
WP5 Audience Mapping		
Consultation and data gathering with Unpath'd Waters Consortium	Apr - Jul 2022	76
Working with audiences		
WP3.1 Pilot student hackathon – task was to visualise biological research data, creating a visual immersive/interactive using genetic data from the Mary Rose	Jul 2022	15
Events		
Unpath'd Waters Consortium event, National Museums Liverpool	10 Nov 2022	35
UKRI leadership visit to Menai Bridge ocean research facility and vessel with presentation on Unpath'd Waters	1 Dec 2022	10
Talks & Conferences		
WP3.2 Science & the Sea (University of Bangor): public lecture by MJR at a Bangor U3A group meeting	25 Mar 2022	40
WP5 Audiences & Evaluation (MOLA): Transforming Collections Project Values Exploration Presentation, University of the Arts London	12 Apr 2022	50
WP3.1 People & the Sea (University of Portsmouth): Naval Dockyards Society Conference, National Museum of the Royal Navy Portsmouth: presentation by Antony Firth: Placing Warships: Reconnecting vessels and dockyards	9–11 Jun 2022	70
WP3.2 Science & the Sea (University of Bangor): presentations by MJR and JW at the Research Framework for the Archaeology of Wales mini conference	27 Jun 2022	40
WP3.2 Cylch Glasinfryn public lecture	12 Oct 2022	30
WP1 Unpath'd Waters portal previewed in CHNT keynote conference presentation, Vienna	11 Nov 2022	120

WP4 & 5: SJ and SP Invited panellists at ICOMOS-UK Digital Technology National Committee's Digital Technologies for Visitor Engagement with Cultural Heritage. Online.	29 Nov 2022	100
WP1 Aggregation & Characterisation (ADS, University of York): Hackathon, Linked Pasts Conference, York	29 Nov–1 Dec 2022	25
WG3.3 Invited lecture on Doggerland South Oxfordshire Archaeological Society	26 Jan 2023	70
WG3.3 Invited lecture to Intellectual Property Office. "Not drowning but waving". British Science Week lecture on theme of contacts (VG)	10 Mar 2023	105
WP3.3 Kiel Conference 2023: Scales of social, environmental and cultural change in past societies On course to drowned landscapes in the North Sea – cultural aspects, preservation potential and geoscientific challenges.". (VG)	14 Mar 2023	30
WP2 Discovery (University of Southampton), NLP workshop, Online	Jun 2022	35
WP2 Discovery (University of Southampton) TANC workshop (Greenwich) by F. Sturt	10 Dec 2022	40
"Why do we need real spaces for research using extended reality?": Introducing ARC-XR as a space for arts and humanities research with immersive technologies (Advanced Research Centre, University of Glasgow).	1 Dec 2022	20
Economic Growth & Cultural Tourism: XR Experiences, Produce, Sustainability (Advanced Research Centre, University of Glasgow	23 Jan 2023	40
WP1 Julian Richards presentation to University of York Dept of Archaeology research forum on UNPATH	24 Jan 2023	20
WP 3.2 Presentation to the World Ship Society (North Wales Branch) by Michael Roberts (20 attendees)	11 Mar 2023	20
Computer Applications in Archaeology – Amsterdam Keynote speech and other formal presentations	3–6 April 2023	250
WP2 Rewilding Later Prehistory	21 April 2023	60
TaNC Conference in the British Museum	26 April 2023	250
WP3.3 Megalithomania – Glastonbury – 6–7 May (VG)	6–7 May 2023	100
WP 5 Sara Perry delivered keynote speech for University of Southampton's Annual Post Graduate Research Days in which Unpath'd Waters' values were referenced.	May 2023	25
WP3.1 Conference: The Life, Times, and Heritage Futures of the Gloucester, a Seventeenth-Century Third-Rate Warship 12–13 May 2023 Norwich Castle. Attended by Ann Coats, Julie Satchell, Brandon Mason, Alex Hildred	12–13 May 2023	100
WP3.3 Archaeology Department Lecture – University of Vienna (VG)	21 May 2023	30
WP3.2 Public lecture North Wales Marine Conservation Conference, Marine Centre Wales, (MJR)	27 May 2023	30

WP5. Sara Perry delivered keynote presentation at Historic Environment Forum's Foresight Day, in which Unpath'd Waters' values were referenced.	June 2023	40
Unpath'd Waters Consortium meeting MRM Portsmouth	29 June 2023	40
WP3.3 Submerged Landscapes and Coastal Change conference – online – 28 June (PM, RH)	28 June 2023	50
WP3.2 Public presentation to the Cemaes Bay Historical Society on Unpath'd Waters and Irish Sea shipwreck identification by Michael Roberts.	7 July 2023	35
WP 3.2 STEM outreach event at Anglesey Sea Zoo, highlighting the Unpath'd Waters project and aspects of wreck identification to visiting teachers and pupils by Michael Roberts.	8 July 2023	20
WP4 Australia ICOMOS ACT Chapter – Public Lecture. Digital heritage objects: co-design, communities and significance	10–16 July 2023	50
WP3.1 UoP Student Competition	23 August 2023	20
WP3.2 Launch of the 'Beneath the Waves' app by Anglesey County Council in Holyhead, keynote public presentation on wreck identification and Unpath'd Waters by Michael Roberts.	20 July 2023	30
WP1 EAA, Belfast; presentation by Julian in session on controlled vocabularies, featuring their role in UNPATH	Aug–Sept 2023	40
WP3.3 AHRC CapCo showcase – University of Bradford	14 Sept 2023	30
WP 5 MAT: Attended UK Maritime Heritage Forum, Liverpool, 20–22 September. Andrew Choong gave a talk on UNPATH'D at the meeting.	20–22 Sept 2023	90
WP3.1 UoP Immersive Co-creation Subgroup and NAS Hackathon: Cross disciplinary co-creation workshop with UoP students to design immersive interface to connect heritage information of submerged and displayed wrecks Hollands 1 and 5.	23–27 Oct 2023	15
WP3.1 UoP Analogue-Digital Connector Symposium (Portsmouth) presented ADC findings from WP3.1 and 3.2's multibeam sonar verification of ambiguous wreck sites and collected 30 expert opinions re. What are the barriers to accessing non-digital collections? / How do we prioritise collections?	1 Nov 2023	30
WP 3.1 MAT Julie Promotion of Needles Voyager at Southampton University Hands on Humanities day using MAT Discovery Bus.	18 Nov 2023	20
WP1 Marine Alliance for Science and Technology in Scotland. Michelle Frost presented on Unpath'd Waters	5–7 Dec 2023	30
WP 2 Machine Learning and the Welsh Marine Record, HER Forum York (Jack Pink)	12 Dec 2023	35
WP 3.3 Council for Science and Technology Presentation: Prime Minister's Committee for Science and Technology Creative Technologies Showcase.	14 Dec 2023	60
WP 4 North of Scotland Archaeology Society meeting: Unpath'd update presented by Stuart Jeffrey	18 Jan 2024	30

WP5 Sara & Katrina co-hosted cross-TANC ethics workshop at the Wellcome Trust, with 5 presentations (one per project), followed by facilitated conversations. Stuart, Jack and Claire from UNPATH also attended. Sara & Katrina gave the UNPATH presentation.	23 Jan 2024	22
WP3.1 International Shipwreck Conference at Plymouth on Saturday 3rd Feb, Needles Voyager showcased on stand	3 Feb 2024	220
WP 3.1 Immersive Co-Creation Subgroup: presented the 2022 Hackathon results in 'Co-Creation of Immersive Maritime Heritage Interfaces through Interdisciplinary Hackathons' at Faro Convention International Conference 2024: Transforming through co-creation: participatory heritage practices tackling urban challenges, Porto, 29 Jan–2 Feb 2024 Claire Bailey-Ross and Tarek Teba	29 Jan–2 Feb 2024	15
WP6 Protected Wreck Association annual meeting on Friday 2 Feb. Unpath'd general Update presented by Hefin/Paul Jeffery; International Shipwreck Conference Plymouth (stand showcasing Mariner)	3 Feb 2024	40
WP 2 Confidence in marine record workshop, University of Southampton	15 Feb 2024	15
WP 3.2 M Roberts attended a meeting on Decommissioning of Offshore Structures and Ships in London	29 Feb 2024	45
WP3.2 M Roberts presented talks supported by an interactive 'sandbox' exhibit on Unpath'd Waters wreck research at the Bangor University Science Festival	8–9 Mar 2024	120 local school children for specific STEM activity (8th) and 500+ for the public engagement event (9th)
WP4 TaNC Discovery Project Webinar: Community Generated Digital Content & Co-Design Processes with Communities; SC Paper entitled 'Unpath'd Waters: The Co-design of the Unpath Navigator'. Online event facilitated by Historic Environment Scotland. Jonathan Combey presented as part of TaNC Discovery Project Webinar on UNPATH transcription methodology. WP 5	6 Mar 2024	70
WP3.1 Discovery Bus attended Aldworth School (Basingstoke) with Voyager available onboard.	11 Mar 2024	150
WP 3.2 M Roberts attended a UK Centre for Seabed Mapping meeting in London	11 Mar 2024	40
WP 3.3 Presentation by Rachel Harding to MSc Renewable Energy Students at University of Manchester – Titled 'What has archaeology got to do with the energy transition?', which included presenting the geological mapping and features database, plus information on the simulation and its potential uses for the windfarm industry to help with ground modelling and de-risking wind turbine placement.	17 Mar 2024	30
WP 6 Heritage & Education Centre (HEC) Stakeholder Get Together Lloyd's Register Foundation. Antony Firth presented	11 Mar 2024	30

WP6 Royal Society co-hosting an event with the UK Centre for Seabed Mapping in Ocean Science Antony Firth presented on Unpath https://uk-ndc.org/news/opportunity-for-ecrs-and-ecops-the-role-of-seabed-mapping-in-ocean-science/		50
WP 5 Sara presented at UCL open seminars on "What is the potential for designing new archaeological institutions?" referencing UNPATH in terms of values-led practice.	18 Mar 2024	40
WP 3.2 M Roberts attended and presented an exhibition on Unpath at the Coastal Communities event, 'Envisioning our tomorrow together', held at the Galeri, Caernarfon	26 Mar 2024	30
WP 3.1 Mark Beattie-Edwards and UoP Tarek Teba tested the Holland Prototype interactive at NMRN Submarine Museum with visitors and Meoncross Schoolchildren	April and May 2024	No figures available
WP 6 Poster on Unpath'd's Ocean Decade engagement on display at Ocean Decade conference Barcelona	April 2024	80
WP 1 JDR included UNPATH as a case study of the value of controlled vocabularies in a session at the SAA New Orleans	18 April 2024	20
UNPATH Glasgow Consortium Meeting	2–3 May 2024	30
WP5 Katrina Foxton, MOLA: Research ethics in multi-partner research projects: Lessons learned from the Unpath'd Waters values framework TaNC webinar	1 May 2024	109
WP 3.1 MAT Discovery Bus has attended a number of events to make the Voyager available to the public – Sholing Valley Spring Fayre (11/05), Bucklers Hard Conservation Day (12/05), Netley Schools Fair (22/06).	11and 12 May 2024 and 22 Jun 2024	100
WP5 Isle of Man: Maritime Matters. Navigating Our Way Through Unpath'd Waters – Andrew Choong Han Lin, Lancaster University	18 May 2024	15
WP 6 Unpath'd Waters Early Career Researchers at HE Swindon Office	23–24 May 2024	4
WP 6 Unpath'd Waters Early Career Researchers at Historic Environment Scotland	28 May 2024	4
WP 3.1 UoP Faculty of Technology Research and Innovation Conference: Session Engaging with stakeholders: Ann Coats, 'Digital and physical archives connect us to HMS Looe: built Portsmouth 1697, conveyed wartime Atlantic convoys, shipwrecked 1705 at The Needles.'	4 June 2024	60
Historic England Midlands Staff Forum: Unpath'd Waters presentation Marion Page	17 Sept 2024	41
WP 3.1 Unpath'd Waters People and the Sea Legacy Symposium at the Mary Rose Museum	4 Nov 2024	29
WP 3.2 Mathematics Expo at the House of Commons (Terrace Pavilion) present UNPATH and the use of maths to help model aspects of shipwrecks (BS, MR)	13 Nov 2024	80
Unpath'd Waters Consortium Meeting Manchester	19 Nov 2024	40

Exhibition		
Exhibition on Tour: Cutty Sark, Greenwich	27 May – 5 June 2024	90
Exhibition on Tour: Chatham Historic Dockyard	10 – 28 June 2024	No figures available.
Exhibition on Tour: Amgueddfa Ceredigion, Aberystwyth	17–29 June 2024	No figures available.
Exhibition on Tour: Tower Museum, Derry	27–30 June 2024	c 400
Exhibition on Tour: Southend Museums	3–10 July 2024	205
Exhibition on Tour: Time and Tide Museum, Great Yarmouth	15–28 July 2024	1556
Exhibition on Tour: Scottish Maritime Museum, Irvine Museum–	22 July– 9 Aug 2024	No figures available.
Exhibition on Tour Discovery Bus Time and Tide Museum, Great Yarmouth –	26–27 July 2024	95
Exhibition on Tour Discovery Bus: National Museum of the Royal Navy, Hartlepool	29–30 July 2024	220
Exhibition on Tour Discovery Bus: Discovery Point, Dundee	2–3 Aug 2024	140
Exhibition on Tour Discovery Bus: Scottish Maritime Museum, Irvine Museum	5–8 Aug 2024	130
Exhibition on Tour Discovery Bus: House of Manannan, Isle of Man	9–11 August 2024	325
Exhibition on Tour: Scapa Flow Museum Orkney	6 Aug – Sept 2024	3923
Exhibition on Tour Discovery Bus: SeaCity Museum, Southampton	22 Aug 2024	30
Web page		
Sessions per month composed of a healthy mix of visitors from search, referring websites and referring social media links.	1 July 2024–30 Nov 2024	600–800

Appendix C: Sustainability and Infrastructure Statement

Unpath'd Waters ensured that as much of the data as possible that we accessed will be secure in the long term. We have managed this in the following ways:

National Inventories

These are stored with the corresponding national heritage bodies (Historic England, Historic Environment Scotland, Royal Commission on the Ancient and Historical Monuments of Wales, and the Historic Environment Branch of Department of Communities, Northern Ireland. All follow the OAIS model and ADS and RCAHMW are able to assign Datacite DOIs to all data sets and reports but will also observe recommendations of the TaNC Persistent Identifiers Foundation Project.

For England, the National Marine Heritage Record is currently held within Warden, a bespoke database developed on the Getty Arches platform; in Scotland, Canmore is Oracle-based; in Wales Arches provides the front-end and Preservica is used to ensure long-term preservation and access; in Northern Ireland data is held on a SQL Server with public access provided by an ESRI web application.

ADS acts as a metadata broker for the maritime elements of the national monuments records of the UK home nations, allowing interoperable access to an aggregated marine record via national heritage interfaces (Heritage Gateway, Canmore, Coflein, ArchSearch etc), interdisciplinary portals (MEDIN), and an international showcase for the UK National Collection for Marine Heritage via ARIADNE, as well as a marine-specific instance of the latter (https://unpathd.ads.ac.uk/). These metadata use vocabularies that follow FAIR principles such as: Heritage Data vocabularies (https://www.heritagedata.org/blog/vocabularies-provided/), including those provided by the Forum on Information Standards in Heritage (FISH), Historic England (HE), Historic Environment Scotland (HES), and the Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW).

Archaeological Datasets

For other archaeological data collections which were generated during the project, the Archaeology Data Service (ADS) provides a long-term archival role, including for both the CITiZAN and Mary Rose data sets, and the MADU reports.

Shipwreck Surveys

These comprise 50+ newly interpreted sonar derived point cloud data sets of shipwrecks and the surrounding seabed in the central Irish Sea through the integration and correlation of national shipwreck databases with high-resolution multibeam sonar data. These outputs will be geo-referenced and facilitate the creation of high-resolution grid models to be used in conjunction with historical archives to support vessel identification and assessment of localised environmental conditions. Outputs from this WP will be made available through the cloud-based 'iMarDIS' data initiative hosted at time of writing by Bangor University, which will provide secure and free access (subject to registration) to raw and interpreted versions of the data upon request. The survey data will be processed and used to create GIS information which will be made available and stored in the ERSI shapefile format, whilst point data will be stored in CSV text file format. These data along with the associated metadata will be produced in accordance with the ADS guidelines. Positional data will be stored in ESRI shapefile format for use in GIS applications.

Additional site related geophysical and hydro-dynamical data from open-source data providers such as BODC and BGS together with outputs from Bangor based numerical oceanographic models will be used to support site specific assessments. These data are already held in NERC Data Centres and no further action is needed. The metadata for the 50 wrecks will be aggregated and made available within the Unpath'd Waters portal.

Unpath'd Waters Navigator

The Unpath'd Waters Navigator uses games engine development tools (Unity, Unreal). The co-design process generated an audio/visual record (mp3/mp4). The core digital output of this is a fully immersive interactive for exploring and analysing multiple cross-disciplinary, heterogeneous datasets, and amenable to translation to formats delivery across multiple platforms, standalone, web, mobile. The project files will be maintained in multiple formats by Glasgow School of Art after the end of the project. Coding and access to the Navigator is held on GitHub (see **Appendix A**) and made available as CC-BY-NC.

Unpath'd Waters Doggerland Simulation

The Unpath'd Waters Doggerland Simulation draws on remote sensing survey data provided by offshore development companies in the industry standard formats. Associated GIS data is stored in ESRI shapefile format, and archived, along with relevant metadata, with ADS. Coding is held on GitHub and made available as CC-BY-NC.

Other Datasets

UoP Immersives: Data, user requirements data, anonymised where necessary, will be openly available under a CC BY 4.0 licence.

MAT Needles Voyager: Observes ADS standards, keeping data open and interoperable, publication of lower resolution versions and optimised data for maximum public reach while maintaining high resolution data in open standards for long term archiving. Sustainability plans exist for Unpath'd Waters outputs. Digital publications utilise available web standards, e.g. HTML 5, JavaScript ECMAScript 6, to ensure long term compatibility and ease of maintenance.

Mary Rose Trust: Artefact data is currently available to download via sketchfab using a CC licence and can be included for aggregation within Unpath'd Waters. The MRT terms will be mapped to the AAT at a high level, but some of the maritime-specific terms are not yet available.

Holland submarine: visualisations will be maintained on web platforms by the University of Portsmouth, and NAS for five years after the project.

Audience evaluation: personal audience data will not be openly accessible, nor available to third parties, to guarantee participants' privacy, unless express permission has been shared by participants via informed consent. Where informed consent has been granted, and in line with the best practices set via MOLA's leadership of the NLHF-funded Archaeology Audience Network, anonymised and aggregate data will be made available by the ADS.

Appendix D: Project Contacts

General enquiries:
NationalSpecialistServices@Historicengland.org.uk

Communications:
marion.page@historicengland.org.uk

Related Annexes, Reports and Links

The following reports support the Unpath'd Waters project and give more details about the work done under the relevant Work Packages.

Work Package 1:
Integrating Collections: Research Report
https://doi.org/10.5281/zenodo.14793824

Work Package 2:
Searching and Linking: Research Report
https://doi.org/10.5281/zenodo.14851942

Work Package 3.1:
People and the Sea: Research Report
https://doi.org/10.5281/zenodo.14837162

Work Package 3.2:
Science and the Sea: Research Report
https://doi.org/10.5281/zenodo.14851758

Work Package 3.3:
Lands Beneath the Sea: Research Report
https://doi.org/10.5281/zenodo.14825454

Work Package 4:
UNPATH Navigator Technical Development: Technical Report
https://doi.org/10.5281/zenodo.14851942

Work Package 5:
Values-led Research and Audience Evaluation: Research Report
https://doi.org/10.5281/zenodo.14837533

Work Package 5:
Appendices for Values-led Research and Audience Evaluation:
https://doi.org/10.5281/zenodo.14837433

Work Package 6:
The National Marine Heritage Inventories of the UK and the Isle of Man: Research Report
https://doi.org/10.5281/zenodo.14840745

Work Package 6:
Experimental Public Value Evaluation of Unpath'd Waters: Evaluation Report
https://doi.org/10.5281/zenodo.14852011

Bibliography

Archaeological Diving Unit, 2001, Report No. 01/10 – HM Submarine *Holland No.5*

Akbik, A, Bergmann, T, Blythe, D, Rasul, K, Schweter, S' and Vollgraf, R, 2019, ‚FLAIR: An easy-to-use framework for state-of-the-art NLP'. In *Proceedings of the 2019 conference of the North American chapter of the association for computational linguistics* (demonstrations) (pp. 54–59).

ADS. n.d. 'The ADS and the FAIR Data Principles.' https://archaeologydataservice.ac.uk/help-guidance/data-reuse/fair-data/ Accessed December 6, 2021

Amkreutz, L, Cohen, K, Hijma, M, Odé, O (2022) Mapping a drowning land, in: *Doggerland. Lost World under the North Sea*. Edited by Luc Amkreutz & Sasja van der Vaart-Verschoof. Sidestone Press, Leiden

Barber, S T, 2018 ‚The zooniverse is expanding: crowdsourced solutions to the hidden collections problem and the rise of the revolutionary cataloging interface' *Journal of Library Metadata*, 18(2) pp 85–111

Binding, C, Charno, M, Jeffrey, S, May, K, and Tudhope, D, 2015 'Template based semantic integration: from legacy archaeological datasets to linked data', *International Journal on Semantic Web and Information Systems* 11(1) 1–29 https://doi.org/10.4018/IJSWIS.2015010101

Brandsen, A, Verberne, S, Lambers, K, Wansleeben, M, 2022, 'Can bert dig it? Named entity recognition for information retrieval in the archaeology domain' *Journal on Computing and Cultural Heritage* 15 (3), pp 1–18 https://dl.acm.org/doi/10.1145/3497842

Bradley, S L, Ely, J C, Clark, C D, Edwards, R J, and Shennan, I, 2023, Reconstruction of the palaeo-sea level of Britain and Ireland arising from empirical constraints of ice extent: implications for regional sea level forecasts and North American ice sheet volume. *J. Quaternary Sci*, 38: 791–805. https://doi.org/10.1002/jqs.3523

Breiman, L, 2001, 'Random forests' *Machine learning* 45, 5–32

Burton, A, 2014, *The Mary Rose Museum –The Story Continues...* Pitkin Publishing

Chapman, P, Conte, G, Drap, P, Gambogi, P, Gauch, F, Hanke, K, Long, L, Loureiro, V, Papini, O and Pascoal, A, 2006. VENUS, Virtual ExploratioN of Underwater Sites. *7th International Symposium on Virtual Reality: Archaeology and Cultural Heritage*', VAST.

CITiZAN, 2022, 'CITiZAN's Climate Change Pledge'. CITiZAN. [Online] Available at: https://www.citizan.org.uk/blog/2022/Mar/05/citizans-climate-change-pledge/ [Accessed 6th April 2023]

Clark, C D, Ely, J C, Fabel, D, Bradley, S L, 2022, BRITICE-CHRONO maps and GIS data of the last British-Irish Ice Sheet 31 to 15 ka, including model reconstruction, geochronometric age spreadsheet, palaeotopographies and coastline positions [dataset]. PANGAEA, https://doi.org/10.1594/PANGAEA.945729

Clark, C D, Ely, J C, Hindmarsh, R C A, Bradley, S, Ignéczi, A, Fabel, D, Ó Cofaigh, C, Chiverrell, R C, Scourse, J, Benetti, S, Bradwell, T, Evans, D J A, Roberts, D H, Burke, M, Callard, S L, Medialdea, A, Saher, M, Small, D, Smedley, R K, Gasson, E., Gregoire, L, Gandy, N, Hughes, A L C, Ballantyne, C, Bateman, M D, Bigg, G R, Doole, J, Dove, D, Duller, G A T, Jenkins, G T H, Livingstone, S L, McCarron, S, Moreton, S, Pollard, D, Praeg, D, Sejrup, H P, Van Landeghem, K J J, and Wilson, P, 2022, Growth and retreat of the last British–Irish Ice Sheet, 31 000 to 15 000 years ago: the BRITICE-CHRONO reconstruction. *Boreas*, 51: 699-758. https://doi.org/10.1111/bor.12594

Cortes, C, and Vapnik, V, 1995, 'Support-vector networks' *Machine learning* 20, 273–297

Dawson, E, Archer, L, Seakins, A, Godec, S, DeWitt, J, King, H, Mau, A, and Nomikou, E, 2020, 'Selfies at the science museum: exploring girls' identity performances in a science learning space'. *Gender and Education*, 32 (5) 664–681. [Online] Available at: https://doi.org/10.1080/09540253.2018.1557322 [Accessed 15th February 2023]

Dixon, C G, Sherry, H S I, Van Doren, S, 2023, 'Keeping Voices in the Room: Values Clarification in Codesign for Equitable Science and Technology Education'. *Curator: The Museum Journal*, 66 (1). [Online] Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/cura.12529 [Accessed 20th June 2024]

Dolcetti, F, Boardman, C, Optiz, R and Perry, S, 2021 Values-Led Design Cards: Building Ethically Engaged Archaeology and Heritage Experiences. *Sustainability*, 13 (3659) [Online] Available at: https://doi.org/10.3390/su13073659 [Accessed 2nd February 2022].

Finn, M, and Shilton, K, 2023, 'Ethics governance development: The case of the Menlo Report'. Social Studies of Science, 53(3) 315–340. [Online] Available at: https://doi.org/10.1177/03063127231151708 [Accessed 15th March 2024]

Firth, A, 2014, 'East Coast War Channels in the First and Second World War'. Unpublished report for Historic England. HE Project Number 6586, Fjordr Ref: 16131. Tisbury: Fjordr Limited https://historicengland.org.uk/research/results/reports/103–2014

Fish, B, and Stark, L, 2020, 'Reflexive Design for Fairness and Other Human Values in Formal Models'. Arxiv [Online] Available at: https://doi.org/10.48550/arXiv.2010.05084 [Accessed 2nd February 2022]

Foxton, K, 2018, Within the Walls Project: Comparing Heritage Values as Action within Council and Community Asset Transfer Practices, York, UK 2014–2016. PhD Thesis. [Online] Available at: https://etheses.whiterose.ac.uk/22113/ [Accessed 2nd February 2022]

Freeman, J, Lessiter, J, Borde, P, Kurta, L, and Brown, T, 2018, CreativeXR and the audience experience. [Online] Available at: https://www.digicatapult.org.uk/publications/post/creativexr-and-the-audience-experience/ [Accessed 15th February 2023]

Garcia Moreno, D, 2017, Origin and geomorphology of the Dover Strait and southern North Sea palaeovalleys and palaeo-depressions. PhD Thesis. University of Ghent. http://hdl.handle.net/1854/LU-8536549

Geser, G, Richards, J D, Massara, F, Wright, H, 2022, 'Data Management Policies and Practices of Digital Archaeological Repositories.' *Internet Archaeology*, no. 59 (March). https://doi.org/10.11141/ia.59.2

Gipsen, J, 2017 'Ethical tools for designers'. Ethics for designers. [Online] Available at: https://www.ethicsfordesigners.com/tools [Accessed 2nd February 2022]

Gray, C M, Hasib, A, Li, Z, and Chivukula, S S, 2022, 'Using decisive constraints to create design methods that guide ethical impact'. *Design Studies*, 79 (101097). [Online] Available at: https://doi.org/10.1016/j.destud.2022.101097 [Accessed 2nd February 2022]

Hildred, A (ed), 2011, The Archaeology of the *Mary Rose,* Vol 3 *Weapons of Warre* Mary Rose Trust

Holloway-Attaway, L, Vipsjo, L, 2020 'Using Augmented reality, Gaming Technologies, and Transmedial Storytelling to Develop and Co-design Local Cultural Heritage Experiences', *Visual Computing for Cultural Heritage* pp. 177–202

Höök, K, 2024, *Designing with the Body: Somaesthetic Interaction Design*. Massachusetts: MIT Press.

Janssen, M A, 2009, 'Understanding artificial anasazi'. *Journal of Artificial Societies and Social Simulation*, 12(4), 13.

Jeffrey, S, Richards, J D, Ciravegna, F, Waller, S, Chapman, S, Zhang, Z, 2009, 'The archaeotools project: Faceted classification and natural language processing in an archaeological context'. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 367 (1897), 2507–2519. https://doi.org/10.1098/rsta.2009.0038

Jones, M (ed), 2003, The Archaeology of the *Mary Rose,* Vol 5 *For Future Generations* Mary Rose Trust

Katifori, A, Perry, S, Vayanou, M, Antoniou, A, Ioannidis, I-P, Mckinney, S, Ioannidis, Y, 2020, *Journal on Computing and Cultural Heritage*, 13 (3). [Online] Available at: https://doi.org/10.1145/3382773 [Accessed 15th February 2023]

Kilgour, A and Lau, F, 2022, 'Opening access to our rich maritime heritage'. Historic England Research, Issue 22, https://historicengland.org.uk/images-books/publications/historic-england-research-22/he-research-22/

Lahav, O, and Mioduser, D, 2008, 'Construction of cognitive maps of unknown spaces using a multi-sensory virtual environment for people who are blind' *Comput. Hum. Behav*. 24, 3, 1139–1155. https://doi.org/10.1016/j.chb.2007.04.003

Leśniak, E, and Grzybowski, S J, 2021, 'The Role of Emoticons in the Comprehension of Emotional and Non-emotional Messages in Dyslexic Youth – A Preliminary Study'. *Frontier Psychology*, 12. [Online] Available at: https://doi.org/10.3389/fpsyg.2021.693287 [Accessed 8th August 2024]

Lessiter, J, Mitchell, S, Ferrari, E, Borden, P, Bakshi, H, and Freeman, J, 2018, Evaluating Immersive User Experience and Audience Impact. [Online] Available at: https://docslib.org/doc/1745147/evaluating-immersive-user-experience-and-audience-impact-report [Accessed 15th February 2023]

Perrault, R, and Clark, J, 2024, Artificial Intelligence Index Report 2024: https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf

Perry, S, 2022, 'Values: What does it mean to create values for a research project?' Unpath'd Waters [Online] Available at: https://unpathdwaters.org.uk/launching-unpathd-waters-living-values-what-does-it-mean-to-create-values-for-a-research-project/ [Accessed 27th June 2022]

Perry, S, Foxton, K, Gargett, K, and Northall, L, 2024, 'Centring audiences: What is the value of audience mapping for influencing public engagement with cultural heritage?'. [Online] Available at: https://doi.org/10.48583/m1ck-4z09 [Accessed 8th August 2024]

Pillai, A G, Sachathep, T, amd Ahmadpour, N, 2022 'Exploring the experience of ethical tensions and the role of community in UX practice'. *Nordic Human-Computer Interaction Conference*. October 8–12, 2022, Aarhus, Denmark. ACM, New York, NY, USA. [Online] Available at: https://doi.org/10.1145/3546155.3546683 [Accessed 2nd July 2023].

Pink, J, Singh, S, Chapman, A, and Sturt, F. (In Press) Modest Doubt: Enabling Discovery Across Maritime Heritage Records Journal of Digital Humanities

Popple, S, Lacedelli, S Z, Rees, A J, Prior, S, and Smith, M, 2023, 'Collaborative conversation as a method for exploring multiple perspectives on 'community' and forms of knowledge in the Congruence Engine'. *Science Museum Group Journal*, 18. http://dx.doi.org/10.15180/221809 [Accessed 8th August 2024]

Pritchard, M, and McDonald, K, 1987, *A Diver Guide, Dive Wight and Hampshire*

Rees, A, 2024, Action research, complexity, and the Congruence Engine project. 1st May 2024. [Virtual presentation] TaNC Discovery Project Webinar Series

Reimers, N, Gurevych, I, 2019, 'Sentence-bert: Sentence embeddings using siamese bert-networks'. https://aclanthology.org/D19-1410.pdf

Richards, J.D. 2023 'Joined up Thinking: Aggregating archaeological datasets at an international scale', *Internet Archaeology* 64. https://doi.org/10.11141/ia.64.3

Richards, J D, Jakobsson, U, Novák, D, Štular, B, and Wright, H (eds), 2021. 'Digital Archiving in Archaeology: The State of the Art' *Internet Archaeology* 58 (June). https://doi.org/10.11141/ia.58.23

Richards, J D, Jeffrey, S, Waller, S, Ciravegna, F, Chapman, S, Zhang, Z, 2011, 'The archaeology data service and the archaeotools project: Faceted classification and natural language processing' *Archaeology* 2, pp 31–56

Rubio-Campillo, X, 2020, Gameplay as Learning: The Use of Game Design to Explain Human Evolution. *Communicating the Past*, 45

Rutherford, A, Sichani, A-M, Foxton, K, and Perry, S, 2024 'Ethics as Practice: Report on the 1st Discovery Project Ethics Workshop'. [Online] Available at: https://doi.org/10.5281/zenodo.13683142 [Accessed 8th August 2024]

Shilton, K, 2013, 'Values Levers: Building Ethics into Design'. *Science, Technology, & Human Values*, 38 (3) 374–397. [Online] Available at: https://www.jstor.org/stable/23474474 [Accessed 2nd February 2022]

Shilton, K, 2018, 'Values and Ethics in Human-Computer Interaction'. *Foundations and Trends in Human–Computer Interaction*, 12 (2) 107–171. [Online] Available at: http://dx.doi.org/10.1561/1100000073 [Accessed 2nd February 2022]

Steen, M, 2013, 'Co-Design as a Process of Joint Inquiry and Imagination.' *Design Issues* 29, no. 2 pp 16–28 http://www.jstor.org/stable/24266991

Suissa, O, Elmalech, A, Zhitomirsky-Geffet, M, 2022 'Text analysis using deep neural net-works in digital humanities and information science' *Journal of the Association for Information Science and Technology* 73, pp268–287 https://doi.org/10.1002/asi.24544

Tennent, A J, 1990, *British merchant ships sunk by U boats in the 1914–1918 war*

Transfeminist Technologies, nd, The Oracle for Transfeminist Technologies. [Online] Available at: https://transfeministech.codingrights.org/ [Accessed 2nd February 2022]

Tudhope, D, May, K, Binding, C, Vlachidis, A, 2011, 'Connecting archaeological data and grey literature via semantic cross search'. Internet Archaeology 30 https://intarch.ac.uk/journal/issue30/tudhope_toc.html

UK Government, 2020, Heritage – Taking Part Survey. [Online] Available at https://www.gov.uk/government/statistics/taking-part-201920-heritage/heritage-taking-part-survey-201920 [Accessed 8th August 2024]

Vincent, C P, 1985, *The Politics of Hunger: Allied Blockade of Germany, 1915–1919* Ohio University Press

Williams, A, Nangia, N, Bowman, S R, 2017, 'A broad-coverage challenge corpus for sentence understanding through inference' https://aclanthology.org/N18-1101.pdf

Winfield, R, 2009, *British Warships in the age of sail 1603–1714*, Seaforth

Wright, H, Moore, R, and Evans, T, 2022, 'D5.15 Report on Opening Access to Research Data in the Archaeology Domain.' https://doi.org/10.5281/zenodo.6676395.

TOWARDS A NATIONAL COLLECTION

UKRI Arts and Humanities Research Council

Front Cover: A collection of rare ceramics found on the Josephine Willis which foundered off Folkestone Harbour on 3 February 1856. The wreck now forms part of another collection – one of England's officially Protected Wrecks.